INDUSTRIAL TILE AND PAVER APPLICATIONS TECHNICAL DESIGN MANUAL

LATICRETE Technical Services Department

Globally Proven Construction Solutions

Cover Photo: Vintage copper kettle in brewery - Belgium
Photo Courtesy of Tatiana Popova

Industrial Tile and Pavers Applications– Technical Manual

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Special thanks to Mr. Richard Goldberg, Architect AIA, CSI for his contributions to this technical design manual.

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Section 1: Introduction

1.1 Preface

LATICRETE International, a manufacturer of ceramic tile, stone and brick masonry installation systems, has long recognized the need for a technical manual to provide guidelines and recommendations for the design, specification, and installation of industrial ceramic, quarry and paver tile floor and wall installations. Technical advances in materials, manufacturing, and construction methods have expanded the role of this type of application ever since the development of adhesive mortars in the 1950's. In keeping with their position as an industry leader, LATICRETE International is publishing this edition of the Industrial Tile and Paver Applications Technical Design Manual. This manual will make state-of-the-art information and technology available to architects, engineers, construction professionals, and manufacturers in the ceramic tile, paver and dairy brick industries. It is also the goal of this publication to encourage new ideas, research, and building regulations for the purpose of improving the future of this construction technology and the ceramic tile, paver and dairy brick industries.

1.2 Industrial Tile and Paver Applications Considerations

In the past, bulky conventional thick bed methods were employed for the installation of industrial ceramic tile, paver tile and dairy brick applications. Adhesive technology has opened up an entirely new world of aesthetic and technical possibilities for tiling in industrial applications. Industrial applications can present many challenges for the designer and the installer.

Many industrial installations place tremendous stress on the tile or paver application and create a challenging environment not only for the finish tile or paver, but also for the installation system materials.

This design manual has been created with the intent to assist the design professional in assessing and specifying the correct installation system for the specific application.

The building owner benefits from the more efficient and environmentally sensitive use of materials, resulting from reduced weight, lower cost of material, and more efficient use of natural resources.

The building construction process is made more efficient by utilizing modern technology and installation methods, which all reduce construction time, on-site labor costs, and provide better quality assurance.

However, all these advantages of using the systems outlined in this manual can only be realized with a new approach to the design and construction of the areas that will receive the finish materials. Design and construction techniques must be adapted to the specific requirements and behavior of construction adhesive technology, as well as the unique attributes of ceramic tile, pavers and dairy brick finishes.

1.3 History of Ceramic Tile and Thin Bed Adhesive Systems

Ceramic tile has been used for centuries as a decorative and functional building material for buildings. Ceramic tile development can be traced to 4000 B.C. in Egypt.

In the 1950's, Henry M. Rothberg, an engineer who later founded LATICRETE International, invented a product and new methodology that would make direct adhesive attachment of ceramic tile, stone, and thin brick applications physically and economically feasible. This development revolutionized both the ceramic tile and stone industries.

1.4 Summary of Manual Content

Ceramic tile, porcelain tile, pavers, quarry tile and dairy brick must be designed and constructed with careful consideration of the complex interactions that occur between the other components of an industrial tile assembly. This manual explores many of the issues that a design professional will encounter as specifications and details are prepared for these demanding, high performance applications.

Section 2 – Types of Floor Constructs

The selection and preparation of a substrate is one of the most critical steps in the design and construction of an industrial tile assembly. Suitability and compatibility of the most common substrates is covered in this manual, as well as comprehensive recommendations for preparation such as evaluation of level and plumb tolerances, surface defects, and the effect of climatic and site conditions on substrates. This section is a primer on the theory and terminology of floor construction. Types of floor structures and construction are presented, together with commentary on applicability to the installation of ceramic tile, paver and dairy brick finishes for industrial applications.

Section 3 – Types of Wall Constructs
A primer on the theory and terminology of walls and wall construction. Types of wall structures and construction are presented, together with commentary on applicability to the installation of ceramic tile, paver and dairy brick finishes for industrial applications.

Section 4 – Comparison of Alternate Industrial Flooring Systems
A comparison of other popular industrial flooring systems. Advantages and disadvantages of each type are discussed.

Section 5 – Types of Tile for Industrial Applications
Investigation and selection of the proper type of finish material is an important design decision. Detailed criteria for the assessment and selection of ceramic tile, porcelain tile, pavers, quarry tile and dairy brick are presented.

Section 6 – Types of Waterproofing Membranes
This section discusses the various types of waterproofing membranes that are available on the market, and their suitability for use in conjunction with tile applications. Criteria on selection and use are also discussed.

Section 7 – Types of Mortars/Adhesives and Grouts
This section covers the entire range of assessing and determining the selection criteria for mortars, adhesives and grouts as well as specific performance functions of installation materials for industrial applications.

Section 8 – Methods of Installation
This section covers the entire range of installation and construction issues, from the various types of installation procedures to the equipment required for the installation of industrial tile applications

Section 9 – Maintenance and Protection
Cleaning, protection, and preventative maintenance procedures are presented to ensure long term performance of a tiled industrial application.

Section 10 – Industry Standards, Building Regulations and Specifications
Detailed information on applicable industry standards and building codes for ceramic tile adhesives is provided.

Architectural details show typical industrial tile application assembly configurations and recommended design for such. Examples of these concepts are graphically depicted with various substrate/material combinations. Details include design recommendations for interface details such as penetrations, drain tie-ins, movement joint sealants, flashings, and waterproofing membranes.

Section 2: Types of Floor Constructs

2.1 Structural Considerations

TYPES OF STRUCTURAL MOVEMENT

It is essential that all industrial floor applications be designed to accommodate all types of structural movement. Structural movement can transmit through the adhesive connection and tile or flooring system, accumulate, and then exert stress on the floor, resulting in cracking, buckling, or loss of bond between the tile and adhesive or flooring system.

The different types of structural movement are individually quantifiable through mathematical calculations which, for industrial floors, will mainly be restricted to concrete substrates. Fortunately, the structural theory used in most building codes dictates the use of "worst case" conditions; the calculated movements are of the highest possible magnitude in order to provide a safety factor when exposed to most actual conditions.

Types of Structural Movement Include:

- Thermal Movement
- Creep
- Differential Settlement
- Seismic

Thermal Movement

Thermal movement is a term that refers to the expansion or contraction of a substance in response to changes in temperature. All materials react to changes in temperature. While all materials move in response to temperature, all materials can exhibit differences in both the speed of the reaction and the degree of movement when subjected to similar temperature changes. When two dissimilar materials react dramatically different in the same environment, then the ability of a tile adhesive to maintain strong bond through such challenges can be tested. In situations where dissimilar materials meet and flooring spans both materials, cracking or complete loss of bond may be the likely consequence. Allowing for movement within the substrate layer and the flooring installation is critical to assure long-term, problem-free installations.

There are two factors to consider in analyzing thermal movement:

1. The rates of expansion of different materials (i.e. linear coefficient of thermal expansion)
2. The anticipated temperature range exposure

Some building materials respond rapidly when exposed to temperature changes while concrete can respond more slowly. Some tile products and flooring systems have a higher tensile strength than concrete and may also respond to temperature changes at a different rate. Stresses applied to the finishes and concrete, as a result of the rapid or continuous movement of dissimilar materials, can be that the concrete cracks horizontally just below the bond line and the flooring system can fail at that point.

Thermal movement can be rapid and reoccurring. Rapid changes can be explained when normal conditions are introduced to extremely high temperatures (i.e. steam or ovens) or extreme cold (e.g. dry ice or liquid nitrogen). Temperature changes do not have to be

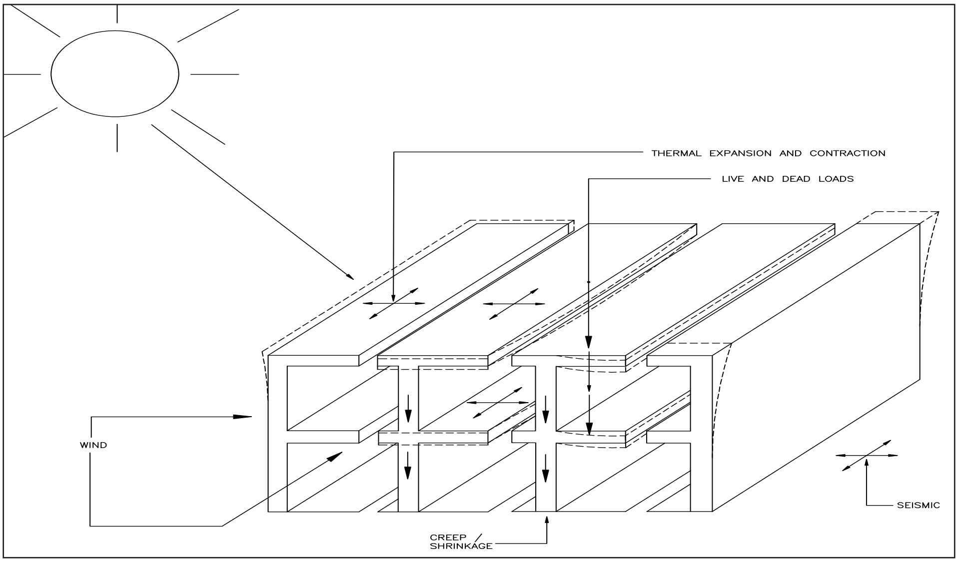

Figure 2.1 – Types of Structural Movement.

dramatic for movement to occur. Slower more repetitive temperature changes can be equally destructive. In these situations, there can be continuous stress at the bond line caused by such things as daily recurring temperature changes. These temperature changes, in conjunction with time, can fatigue the weaker material at the bond line. Over time the weaker material (i.e. concrete), may cause the same failure as if it were exposed to rapid temperature changes (e.g. steam cleaning). The conditions that might cause loss of bond are not always obvious.

Some conditions to be aware of are:

- Direct Application of Steam
- Areas Under Hot Ovens, Fryers or Commercial Dishwashers
- Direct Application of Water at or Above 180°F (82°C)
- Rapid or Wide Changes in Ambient Temperature
- Application of Cold Water to Hot Surfaces

When selecting materials for a tile floor or an industrial flooring system, be aware of the above conditions. Additionally, cleaning and disinfecting protocols requiring hot water or steam need to be considered, especially if the area being cleaned is normally kept cool, as in the case of controlled manufacturing facilities (i.e. food plants).

In applications of extreme temperature change, it may be necessary to use a coarser aggregate than that used in typical concrete. Thinner systems react well to thermal stresses because they are often too thin to exhibit destructive energy at the bond line. Tile installation materials are more at the mercy of the concrete properties than the other way around. However, if the application receives heavy vehicular traffic or extremely heavy loads, make sure the tile installation materials fit the service requirement of "Extra Heavy" when tested in accord with ASTM C627 (Standard Test Method for Evaluating Ceramic Floor Tile Installation Systems Using the Robinson-Type Floor Tester).

The primary goal in analyzing thermal movement is to determine both the cumulative and individual differential movement that occurs within and between components of the floor assembly.

Because the thermal expansion of the tile is greater, this figure is used. The general rule for determining the width of a movement joint is 2 – 3 times the anticipated movement, or 3 x 21 mm (.82") = 63 mm (2.5"). The minimum recommended width of any individual joint is 10mm (3/8"), therefore, a minimum of 6 joints across a 50 m (154 ft) floor, each 10 mm (3/8") in width is required just to control thermal movement under the most extreme conditions.

For example, a porcelain tile has an average coefficient of linear expansion of between (4–8 x 10^{-6} mm/°C/mm) of length. Concrete has an average expansion rate of 9–10 x 10^{-6} mm/°C/mm. The surface temperature of a porcelain tile in an application where steam is often used may reach as high as 140°F (60°C); an ambient temperature in a moderately cold climate may be 14°F (-10°C), or even cooler in freezer applications of -20°F (-29°C). The temperature variation within this tile installation can vary by as much as 160°F (71°C). The temperature range of the concrete, insulated from the temperature extremes by the tile and tile installation mortars, as well as length of exposure, may only be 85°F (30°C). For a building that is 50 m wide, the differential movement can be calculated as follows:

Concrete .000010 x 50 m x 1000 mm x 30°C = 15 mm.
Tile .000006 x 50 m x 1000 mm x 70°C = 21 mm.

Creep

Deformation movement in concrete structures, also known as creep, occurs more slowly and can increase initial deflection by 2–3 times. Creep is the time dependent increase in strain of a solid body under constant or controlled stresses. The placement of movement joints is critical in the success of the structure. Also the realistic prediction of both the magnitude and rate of creep strain is an important requirement of the design process. While there are laboratory tests that can determine the deformation properties of concrete, they

Linear Thermal Movement of Different Porcelain Ceramic Tile Sizes		
Tile Size	Thermal Coefficient x temp range x tile length	Linear Movement per Tile in mm
24 x 24 600 x 600	(8 x 10^{-6}) (60°C) (600 mm)	.288
16 x 16 400 x 400	(8 x 10^{-6}) (60°C) (400 mm)	.192
12 x 12 300 x 300	(8 x 10^{-6}) (60°C) (300 mm)	.144
8 x 8 200 x 200	(8 x 10^{-6}) (60°C) (200 mm)	.096
6 x 6 150 x 150	(8 x 10^{-6}) (60°C) (150 mm)	.072
4 x 4 100 x 100	(8 x 10^{-6}) (60°C) (100 mm)	.048

Figure 2.2 – Linear thermal movement of different porcelain ceramic tile sizes at normal maximum temperature range for temperate climate.

Thermal Coefficient of Expansion of Concrete Depending on Aggregate Type		
Aggregate Type (from one source)	Coefficient of expanion, millionths (10^{-6})	
	per degree Fahrenheit	per degree Celsius
Quartz	6.6	11.9
Sandstone	6.5	11.7
Gravel	6.0	10.8
Granite	5.3	9.5
Basalt	4.8	8.6
Limestone	3.87	6.8

Note: Coefficients of concretes made with aggregates from different sources may vary widely from these values, especially those for gravels, granites, and limestones. The coefficient for structural lightweight concrete varies from 3.9 to 6.1 millionths per degree Fahrenheit (7 to 11 millionths per degree Celsius) depending on the aggregate type and the amount of natural sand.

Figure 2.3 – Control of concrete thermal movement by type of aggregate.

are often skipped because of the time consuming nature and high cost of the test. In cases where only a rough estimate of the creep is required, an estimate can be made on the basis of only a few parameters such as relative humidity, age of concrete and member dimensions. Ideally a compromise has to be sought between an estimate of the prediction procedure and the laboratory testing and mathematical and computer analyses.

Differential Settlement

Buildings structures are typically designed to allow for a certain tolerance of movement in the foundation known as differential settlement. In most buildings the effect of normal differential settlement movement on the flooring system is considered insignificant because the allowable settlement has occurred before the flooring system has been installed. Differential settlement of a buildings foundation that occurs beyond the allowable tolerances is considered a structural defect, which can cause significant problems to any flooring system, including tile. At that point one would need to address the root cause of the problem and come to a solution before the flooring system can be properly repaired. Patching the visible problem areas in the flooring system will not provide an adequate solution, and one can expect repetition of the same issues in the floor.

Controlling Stresses With Movement (Expansion) Joints

One of the primary means of controlling the stresses induced by building movement, concrete shrinkage and typical concrete curing is with movement joints (also known as expansion, dilatation, or control joints). All buildings and materials move to varying degrees, and therefore the importance of movement joints cannot be understated. At some point in the life cycle of an interior floor, there will be a confluence of events or conditions that will rely on movement joints to maintain the integrity of the floor system. Maintaining integrity of the floor can be made as simple as preventing cracks in grout joints, to preventing complete adhesive bond failure of the tile. Proper design and construction of movement joints requires consideration of the following criteria:

- Location
- Frequency
- Size (Width/Depth Ratio)
- Type and Detailing of Sealant and Accessory Materials

Figure 2.4 – Result of stresses induced by concrete shrinkage and lack of movement joint control. As the concrete shrinks, expansion joints are required to relieve the stress. When expansion joints are omitted or are not sufficient, "tenting" of the tiles can occur, creating bond failure and cracking.

MOVEMENT JOINTS

Location of Movement Joints

The primary function of movement joints is to isolate the tile from other fixed components of the building, and to subdivide the substrate and tile into smaller areas thereby compensating for the cumulative effects of building movement (see section 10 for specifications and details). While each floor is unique, there are some universal rules for location of movement joints that apply to any floor installation. Many of the universal rules for movement joints can be found in the current edition of the TCNA Handbook for Ceramic Tile Installation, EJ-171.

Existing Structural Movement Joints

Movement joints may already be incorporated in the underlying structure to accommodate thermal, seismic or other load types. These movement joints must extend through to the surface of the tile or flooring systems, and equally important, the width of the underlying joint must be maintained to the surface of the tile or flooring finishes.

Changes of Plane

Movement joints should be placed at all locations where there is a change in plane, such as outside and inside corners.

Location – Dissimilar Materials

As stated earlier in this section, different materials have different rates and characteristics of movement. Movement joints must be located wherever the floor finishes and underlying adhesive and leveling mortars meet a dissimilar substrate, such as metal, penetrations, and a different type of floor finish.

Frequency of Movement Joints

Guidelines for movement joints in tile and paver applications are every 20' to 25' (6 m – 7.5 m) in every direction for interior applications, and 8' to 12' (2.4 m – 3.6 m) in every direction for exterior applications and any interior tile work exposed to direct sunlight or moisture. The placement of a movement joint needs to be incorporated where tile work abuts restraining surfaces such as perimeter walls, dissimilar floors, curbs, columns, pipes, ceilings, and where changes occur in backing materials, but not at drain strainers. All expansion, control, construction, cold, and seismic joints in the structure should continue through the tile work, including such joints at vertical surfaces. Joints through tile work directly over structural joints must never be narrower than the structural joint.[1]

Size of Movement Joints

The proper width of a movement joint is based on several criteria. Regardless of the width, as determined by mathematical calculations, the minimum functional width of a movement joint should be no less than 1/4" (6 mm); any joint narrower than this makes the proper placement of backer rods and sealant materials impractical and does not provide adequate movement allowance.

The width of a movement joint filled with sealant material must be 3 to 4 times wider than the anticipated movement in order to allow proper elongation and compression of the sealant. Similarly, the depth of the sealant material must not be greater than half the width of the joint to allow for proper functioning of the movement joint (width/depth ratio). For example, if 1/4" (6 mm) of cumulative movement is anticipated in the floor, the movement joint should be 1/2–3/4" (12 – 18 mm) wide and 1/4– 3/8" (6–9 mm) deep. A rounded backup rod is inserted in the joint to control depth, and to keep the sealant from bonding to the substrate. Sealants are products that should only be bonded to two parallel surfaces (the sides/flanks of two tiles). Sealant bonding to 3 surfaces (the sides/flanks of two tiles and the substrate) means that the sealant can lose 75% of its effectiveness. So the backer rod, which the sealant does not bond to, is very important to the success of the sealant.

Sealants

Sealants should be a neutral cure, high performance (also known as Class A, or have, a Shore-A hardness of 25 or greater), viscous liquid type capable of 12.5–25% movement. Silicone sealants can have the ability to compress to 50% of its original width and expand up to 100%. Floors exposed to heavy vehicular traffic (e.g. forklift or moving machinery) may require a sealant with a higher A-Shore hardness as specified.

Pre-fabricated movement joints, which typically consist of two L-shaped metal angles connected by a cured flexible material often may not meet the above movement capability required for an industrial application where extreme temperature changes occur (i.e. steam cleaning). Similarly, the selection of non-corroding metal, such as stainless steel, is required to prevent corrosion by alkaline content of cement adhesive or galvanic reactions with other metals.

Pre-fabricated movement joints are commonly installed in advance of the flooring finishes, so it is critical to prevent excessive mortar from protruding through the punched openings in the metal joint. The hardened mortar may subsequently prevent proper bedding of the tile or finished flooring onto the floor in these areas.

Mechanical Properties

Sealants should have good elongation and compression characteristics, as well as tear resistance to respond to dynamic loads, thermal shock, and other rapid movement variations which are not unusual for industrial floors. Many industrial floors are exposed to extreme vibrations from heavy machinery and are constantly under stress from these vibrations.

Compatibility

Some sealants may stain finishes, or curing by-products may be corrosive to concrete, metals, or waterproofing membranes. There are many types and formulations of sealant products, so it is important to verify compatibility and acceptability for the intended use. Compatibility varies by manufacturer's formulations, and not by sealant or polymer type. For example, acetoxy silicones cure by releasing acetic acid and can be corrosive; neutral cure silicones do not exhibit this characteristic.

Fluid migration and resultant staining is another compatibility issue to consider with sealants. There is no correlation with polymer type (i.e. silicone vs. polyurethane) and fluid migration is dependent solely on manufacturer's formulation. Dirt contamination is another common problem and can be associated with type of exposure, surface hardness, type and length of cure, and formulation, but not the sealant polymer type. Performing a test area to determine compatibility is recommended to make sure that problems are not encountered in the field during installation.

Adhesion

Sealants must have good tensile adhesion to non-porous or porous finish surfaces, ideally without special priming or surface preparation.

Subjective Criteria

Color selection, ease of application, toxicity, odor, maintenance, life expectancy and cost are some of the additional subjective criteria that do not affect performance, but do require consideration.

Types of Sealant

High performance sealants are synthetic, viscous liquid polymer compounds known as polymercaptans, polythioethers, polysulfides, polyurethanes, and silicones. Each type has advantages and disadvantages. As a general rule, polyurethane and silicone sealants are a good choice for ceramic tile, pavers, dairy brick and resinous flooring finishes.

Polyurethanes and silicones are available in either one-component cartridges, sausage packs, or pails; some polyurethanes come in two-component bulk packages, which require mixing and loading into a sealant applicator gun. Both types of sealants are typically available in a wide range of colors.

Installation of sealants and accessories into movement joints requires a skilled installer who is familiar with sealant industry practices. The installation must start with a clean, dry and dust free surface. Some products or materials require the use of a primer to improve adhesion or prevent fluid migration. If a primer is necessary, it should be installed before installation of the backer rod and it may be necessary to protect underlying flashing or waterproofing to avoid deterioration by primer solvents. Any excess mortar, spacers or other restraining materials must be removed to preserve freedom of movement. If necessary, protect the finish surface with masking tape to facilitate the cleaning process. The use of a suitable backer rod or bond breaking tape is typically used to prevent three-sided adhesion and to help regulate depth of the sealant. Once the sealant has been applied, it is necessary to tool or press the sealant to ensure contact with the tile or finish edges; the backer rod also aids this process by transmitting the tooling force to the tile / finish edges. Proper tooling of the sealant joint also gives the sealant a slightly concave surface profile consistent to the interior surface against the rounded backer rod. This allows even compression/ elongation, and prevents a visually significant bulge of the sealant under maximum compression.

2.2 Structural Considerations

LOADS

Forces that act on structures are called loads. Typically, dead loads are static in nature, which means they either do not change or change infrequently. Dead load is essentially the weight of the structure itself; anything permanently attached to the structure would be considered part of the dead load. This would include walls, flooring, roofing, columns, and so on.

Live loads are the weight of items in the building. Live loads are not static as they can change. Examples of live loads would be people, furniture and vehicular traffic (including forklifts). Live loads can have a profound effect on the success of a tile installation and on the long-term performance of the entire structure. Suitable allowance must be made for all anticipated live loads with enough allowance to meet any additional loads placed on the system in the future.

REQUIREMENTS OF BUILDING DESIGN

Buildings must be designed for the specific use that they will be utilized for. The architect or engineer has to know what the building is going to be used for in order to properly calculate the different live loads involved. If a second story floor were going to have forklifts driving on it, the design professional would have to calculate the total anticipated live load. Suitable allowance must be made for all anticipated live loads with enough allowance to meet any additional loads placed on the system in the future.

DEFLECTION

Floor systems over which the tile will be installed, shall be in conformance with the International Building Code (IBC) or applicable building codes for commercial applications[2]. Historically, for ceramic tile and paver applications, the maximum allowable deflection should not exceed L/360 under total anticipated load.

The ceramic tile industry abides by the following note on deflection: the owner should communicate in writing to the project design professional and general contractor the intended use of the tile installation, in order to enable the project design professional and general contractor to make necessary allowances for the expected live load, concentrated loads, impact loads, and dead loads including the weight of the tile and setting bed. The tile installer shall not be responsible for any floor framing or sub-floor installation not compliant with applicable building codes, unless the tile installer or tile contractor designs and installs the floor framing or sub-floor."[3]

(see section 10 Building Codes and Industry Standards for more information). These are also good 'rules of thumb' to follow for other resinous flooring finish types as this level of detail may be absent for other finish types.

2.3 Substrate Condition and Preparation

EVALUATION OF SUBSTRATE CONDITION

The first step in substrate preparation is the evaluation of the type of substrate and its surface condition. This includes the levelness (plane or flatness deviation), identification of general defects (e.g. structural cracks, shrinkage cracks, laitance, etc…), presence of curing compounds or surface hardeners, and contamination. Concrete should have a wood float or light steel trowel finish for proper adhesion of thin-sets, membranes or resinous flooring finishes. Over-finishing a concrete surface can close the pores and may inhibit proper adhesion of these materials.

The ability of a substrate to be wetted by an adhesive is essential to good adhesion and important in determining the performance of the adhesive in bonding to the substrate. This means that not only should the substrate possess a balance between porosity and texture, but also that the surface must be clean of any contamination such as dust or dirt that would prevent wetting and contact of an adhesive or coating. The levelness tolerance or smoothness of a substrate surface also plays an important role in allowing proper contact and wetting of an adhesive. Typically, the greater the surface area to which the adhesive is in contact, the better the adhesion.

ADHESIVE COMPATIBILITY

Compatibility plays an important role in determining adhesion between the substrate and the finishes being installed. The substrate material must be compatible not only with adhesive / coating attachment, but also with the type of adhesive coating under consideration. This means that the substrate material must have good cohesive qualities to resist tensile and sheer stress and not have an adverse reaction with the proposed adhesive / coating. Similarly, the finish being installed must also be compatible with the adhesive. A general consideration in determining compatibility with adhesives / coating is as follows;

The installation of any finish material with an adhesive will only be as good as the setting materials and the substrate to which the finish material will be bonded. The highest strength adhesives / coatings and most careful application with the best quality tile / finish will not overcome a weak or dirty substrate.

This section provides information on the identification of common substrate characteristics and defects, and the preventative and corrective actions necessary for proper surface preparation.

SITE VISIT AND CONFERENCE

Prior to commencing work, the contractor shall inspect surfaces to receive finishes and accessories, and shall notify the architect, general contractor, or other designated authority in writing of any visually obvious defects or conditions that will prevent a satisfactory installation. Installation work shall not proceed until satisfactory conditions are provided. Commencing installation of work typically means acceptance of substrate conditions.[4]

JOB SITE CONDITIONS

The following items are examples of potential issues that may need to be addressed prior to commencing the installation:

Contamination

Any surface to receive tile or coatings will always be exposed to varying degrees of contamination, especially normal construction dust and debris. The installation of finish flooring is often the last phase of the construction of a building. Imagine all other trades have been in and finished their certain part of the construction, (i.e. sheet rock, plumbing, painting, and many other trades). There is often paint, drywall compound, oil and other materials on the concrete from prior trades that need to be removed. One of the most difficult jobs for any installer is the preparation of the surface before the installation of the tile commences. But, it is one of the most important steps, if not the most important step, in providing for a successful, long lasting installation. Cleaning the surface is mandatory before finishes are placed, and sometimes multiple washings will have to take place before the finish work commences. Just sweeping the floor is not good enough!

With most adhesives or cement leveling mortars/renders, such as latex cement mortars or moisture insensitive adhesives, the substrate can be damp during installation; however, it cannot be saturated. The objective is not to saturate the floor, but to make sure all the dust and debris is removed before tiling.

MOISTURE CONTENT OF CONCRETE

Materials used in industrial applications can be affected by moisture during the installation and curing phase. For example, the strength of cementitious adhesives can be reduced from constant exposure to wet or damp substrates. Some materials, such as waterproofing membranes, may not cure properly or may delaminate from a continually wet substrate. A damp substrate may also contribute to the formation of efflorescence.

There are generally three tests that are used to determine moisture content in concrete. The three tests are ASTM F1869 (Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloors Using Anhydrous Calcium Chloride), ASTM F2170 (Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes) and ASTM D4263 (Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method). The Calcium Chloride test involves placing a petri dish of calcium chloride (covered by a plastic dome adhered to the concrete) on the concrete and allowing the petri dish to remain in place for between 60–72 hours. The calcium chloride absorbs any moisture vapor that transmits through the concrete within the plastic dome. The results of a calcium chloride test measures the amount of moisture absorbed and results are stated in pounds per 1,000 ft^2 (92.9 m^2) in a 24-hour period. The Relative Humidity Test involves placing probes in the concrete and taking readings with a hygrometer. A relative humidity reading of 75% or below is acceptable for most tile or coating applications. The Plastic Sheet Method involves taping a 24" x 24" (600 mm x 600 mm) piece of plastic on the concrete and allowing the plastic to remain in place for 18 – 24 hours to determine if any moisture has accumulated under the plastic when it is removed. Both ASTM F1869 and ASTM F2170 are quantitative tests (stating approximately how much moisture is present) while ASTM D4263 is a qualitative test (stating that moisture is present but not how much), and all are a "snapshot" of moisture vapor emission during the testing period. Please refer to Section 2.5 for more information on moisture content in concrete.

Figure 2.5 – ASTM F1869 Calcium Chloride Test Kit and ASTM F2170 Relative Humidity Meter.

Surface and Ambient Temperatures

During the placement of concrete and installation of other types of substrates, extreme cold or hot temperatures may cause numerous surface or internal defects, including shrinkage cracking, a weak surface layer of hardened concrete caused by premature evaporation, or frost damage. Once the concrete is cured, extreme temperatures of both the ambient air and surface of the substrate can also affect the normal properties of tile adhesives, membranes and coatings.

Elevated ambient air and surface temperatures (>90°F [32°C]) will accelerate the setting of cement, latex cement, epoxy adhesives and resinous flooring products. Washing and dampening floors will serve to lower surface temperatures for latex cement mortars and epoxy adhesives. Shading the substrate, if exposed to sunlight, is also effective in lowering surface temperatures, but if ambient temperatures exceed 100°F (35°C), it is advisable to defer work with adhesives and coatings to a more suitable time. Humidity may also have an effect on the curing of membranes and portland cement-based adhesives and grouts. Higher humidity will work to slow down cure rates while low humidity will accelerate the curing process.

Flatness and levelness

A flat, plane substrate is an important concern for any tile or floor coating installation requiring a direct bond adhesive application. Acceptable tolerance is 1/4" in 10' (6 mm in 3 m) and 1/16" (1.5 mm in 300 mm) from the required plane to conform with the ANSI specifications for ceramic tile installations. Greater deviations prevent the proper installation of tile into the adhesive, which may result in numerous problems, including loss of bond or lippage.

If levelness tolerance is exceeded, then it may be necessary to employ remedial work, such as re-construction, patching, grinding, or installation of a self-leveling underlayment (e.g. NXT® Level Plus or SUPERCAP® SC500) or a mortar bed (e.g. 3701 Fortified Mortar Bed; or, 226 Thick Bed Mortar mixed with 3701 Mortar Admix).

If the tolerance is within specifications, then the use of a large and heavy tile (LHT) adhesive mortar and a larger size notch trowel can alleviate any minor defects in the substrate. Please note that while a LHT mortar may be used to correct minor substrate defects, it is important to stay within the product manufacturer's guidelines for thickness of the setting material. For the preparation of substrates for LATICRETE resinous flooring systems, please reference the specific requirements in each of the respective LATICRETE® product data sheets for additional information.

CONCRETE CURING – AGE OF CONCRETE

The age of a concrete substrate is important due to the fact that as concrete cures and loses moisture, it shrinks. Under normal conditions, 28 days is the time that it typically takes for concrete to reach its full design strength. Thicker sections of concrete may take a longer time to reach full design strength. At that point, concrete will have maximum tensile strength and can better resist the effects of shrinkage and stress concentration.

Depending upon the curing techniques and exposure to humidity or moisture, there may be very little shrinkage in the first 28 days. Flexible adhesives, certain latex or polymer-fortified thin-set mortars or (e.g.257 TITANIUM™ or MULTIMAX™ Lite), can accommodate the shrinkage movement and stress that may occur in concrete less than 28 days old. In some cases it may be recommended to wait a minimum of 30–45 days to reduce the probability of concentrated stress on the adhesive interface. Some building regulations or codes may require longer waiting periods of up to 6 months. After this period, resistance to concentrated stress is provided by the tensile strength gain of the concrete, and its ability to shrink as a composite assembly. The effect of the remaining shrinkage is significantly reduced by its distribution over time and accommodated by the use of flexible adhesives.

CRACKING

Freshly placed concrete undergoes a temperature rise from the heat generated by cement hydration, resulting in an increase in volume. As the concrete cools to the surrounding temperature, it contracts and is susceptible to what is termed "plastic shrinkage" cracking due to the low tensile strength within the first several hours after the pour.

Concrete also undergoes shrinkage as it dries out, and can crack from buildup of tensile stress. Rapid evaporation of moisture results in shrinkage at an early stage where the concrete does not have adequate tensile strength to resist even contraction. Concrete is most susceptible to drying shrinkage cracking within the first 28 days of placement during which it develops adequate tensile strength to resist a more evenly distributed and less rapid rate of shrinkage. It is for this reason that it is recommended to wait 30–45 days before direct application of adhesive mortars.

Plastic shrinkage occurs before concrete reaches its initial set, while drying shrinkage occurs after the concrete sets. These types of shrinkage cracks generally do not produce cracks larger than 1/8" (3 mm) in width.

Treating Shrinkage Cracks

There are two different ways to treat shrinkage cracks for ceramic tile and paver installations. The first way is detailed in the LATICRETE Architectural Guidebook – ES-F125 (available at www.laticrete.com/ag) or TCNA Handbook for Ceramic Tile Installation – F125. This method only treats the individual crack and not the entire floor. Be sure to follow the LATICRETE Execution Statement and detail ES-F125 or TCNA Handbook for Ceramic Tile Installation – F125 for proper installation recommendations.

The second method of treating the shrinkage crack would be detailed in the LATICRETE Architectural Guidebook – ES-F125A (available at www.laticrete.com/ag) or TCNA Handbook for Ceramic Tile Installation – F125A. This method uses the anti-fracture membrane over the entire floor. Following this method will help to protect the finished installation from cracks currently in the concrete substrate and any cracks which may develop over time. For the treatment of concrete shrinkage cracks when coating with LATICRETE resinous flooring systems, please reference the specific requirements in each of the respective LATICRETE product data sheets for additional information.

Structural Cracks

There is no tile or coatings installation practice or method for treating any crack over 1/8" (3 mm) wide or structural cracks that experience differential vertical movement. These cracks are considered structural in nature and would require determination of the cause of the crack. Once the cause of the structural movement is determined, it must be remedied prior to repairing the flooring installation. Repair techniques can vary and a structural engineer should be consulted prior to any remediation or installation of a flooring system.

Excessive foundation settlement and movement can be caused by building on expansive clay, compressible or improperly compacted fill soils, or improper maintenance around foundations. Whatever the cause, settlement can destroy the value of a structure and even render it unsafe. In any case, water is the basic culprit in the vast majority of expansive soil problems. Specific components of certain soils tend to swell or shrink with variations in moisture. The extent of this movement varies from soil type to soil type.

When unstable soils are used as a base for a foundation, the tendency for movement is transmitted to the foundation. Since soil movement is rarely uniform, the foundation is subject to a vertical differential movement or upheaval. If all the soil beneath a foundation swells uniformly, there usually is no problem. Problems occur, however, when only part of the slab settles. Then, differential movement causes cracks or other damages. Once again this condition must be corrected before any flooring installation can occur.

Potential Bond Breaking Materials

A flooring installation is only as good as its adhesion to the substrate. An adhesive or coating, in any form, will bond to the first thing it comes in contact with. If that material is dirt, dust, paint, or any other impediment that is lying on a surface, then the adhesion to that substrate can be compromised. The importance of a good, clean surface cannot be over-emphasized, regardless of the substrate or flooring type.

Laitance

Laitance is a surface defect in concrete where a thin layer of weakened portland cement fines have migrated to the surface with excess "bleed" water or air from unconsolidated air pockets. Once the excess water evaporates, it leaves behind a thin layer of what appears to be a hard concrete surface, but in reality is weakened due to the high water to cement ratio at the surface. Laitance has a very low tensile strength, and therefore the adhesion of flooring systems will be limited by the low strength of the laitance.

Mechanical methods, including the use of chipping hammers or scarifying machines, are recommended. Concrete should be removed until sound, clean concrete is encountered. Measurement of surface tensile strength and the absence of loose material are good indicators of sound concrete.

Abrasive blasting by means of dry, wet or bead/shot-blast methods are preferred for the removal of laitance on new and fully cured concrete. Compressed air used in these methods must be oil free. Since wet abrasive blasting reintroduces moisture into the concrete, sufficient drying time must be allowed.

Curing Compounds and Sealers

Liquid curing compounds and sealers are topically applied materials, which are designed to keep moisture in the slab. The constant amount of water kept in the concrete by the curing compounds helps accelerate the curing time and improve the performance of the concrete. Curing compounds and concrete sealers are frequently used in all types of construction, especially in fast track jobs. Unfortunately, all types of curing compounds, concrete sealers and surface hardeners must be completely removed from the slab prior to the flooring installation. The best method to remove these curing compounds from the surface would be to bead-blast or shot-blast the concrete surface.

There is a very simple and effective test to identify the presence of curing compounds, sealers or other bond breaking conditions. Simply sprinkle a few drops of water onto the substrate and see what happens. If water absorbs into the slab then it is usually suitable for the direct adhesion of tile or coatings. On the other hand, if the water beads up on the concrete surface (like water on a freshly waxed car) then there is something present on the concrete surface that can inhibit proper adhesion.

Tile and Paver Installations over Existing Coatings

Seamless epoxy floors are used in many applications. It is important to note that these epoxy floor coverings are much different than epoxy painted surfaces. For example, warehouses, labs, automobile shops and dealerships, loading docks, and many more applications use epoxy coatings. Many renovation projects or new ownership in buildings desire to install new tile over the epoxy coatings. There are two options for installing tile over an epoxy floor coating. The first option would be to remove the epoxy coating by shot-blasting, bead-blasting or mechanical scarification. Once all the epoxy is removed, installation of the tile can commence directly over the concrete.

The second option would be to install the tile with LATAPOXY® 300 Adhesive. The only type of product that will bond to an epoxy coated floor is an epoxy adhesive. The existing epoxy floor must be well bonded with no loose peeling epoxy or chips in the epoxy coating. The coating needs to be very clean and free from all dust, oils, waxes, or any other possible bond breakers. If there are loose peeling spots or chips in the coating, it is a good indication that the coating may need to be completely removed prior to installing tile.

SUBSTRATE PREPARATION EQUIPMENT AND PROCEDURES

To determine if bond inhibiting contamination such as oil or curing compounds are present on concrete, conduct the following test: taking proper safety precautions, mix a 1:1 solution of aqueous hydrochloric (muriatic) acid and water, and place a few drops in various locations. If the solution causes foaming action, then the acid is allowed to react freely with the alkaline concrete, indicating that there is no likely contamination. If there is little or no reaction, chances are the surface is contaminated with oil or curing compounds. Acids do not affect or remove oily or waxy residue, so mechanical removal may be necessary.

CONTAMINATION REMOVAL

If contamination removal is required, or if surface damage or defects exist, bulk surface removal may be necessary to prepare the substrate to the required concrete surface profile (CSP) of the specific flooring system that is being installed.. There are several methods of removal, but it is important to select a method that is appropriate to the substrate material and will not cause damage to the sound material below the surface. The following methods are recommended:

METHODS OF REMOVAL

Mechanical Chipping, Scarifying and Grinding

Mechanical chipping, scarifying or grinding methods are recommended only when substrate defects and/or contamination exist in isolated areas and require bulk surface removal greater than 1/4" (6 mm) in depth. Chipping with a pneumatic square tip chisel or grinding with an angle grinder are common mechanical removal techniques.

Figure 2.6 – Dustless Grinding.

Shot-blasting

This is a surface preparation method which uses proprietary equipment to pummel the surface of concrete with steel pellets at high velocity. The pellets of varying diameters, are circulated in a closed, self-contained chamber, where the pellets and debris are separated. The debris is collected in one container and the pellets are re-circulated for continued use. This is the preferred method of substrate preparation when removal of a thin layer of concrete surface is required, especially the removal of surface films (e.g. curing compounds or sealers) or paint.

Figure 2.7 – Blastrac® Inc. Shot-Blasting Machinery.

Water-Blasting

High pressure water blasting using pressures over 3,000–10,000 psi (21–69 MPa) will remove the surface layer of concrete and expose aggregate to provide a clean, rough surface. Thorough rinsing of the surface with water after water-blasting is necessary to remove any laitance. Water-blasting is only recommended on concrete because of the high pressure. Proper allowance must be made to allow for the excess water in the slab to dry. This method is commonly used on vertical surfaces.

Acid Etching

Acid etching or cleaning is never recommended to clean a surface prior to receiving flooring finishes. If an acid is not neutralized or cleaned properly after the cleaning takes place, it can continue to weaken the flooring installation materials when in the presence of moisture. Acid must be neutralized with Tri-Sodium Phosphate or baking soda mixed with water and then completely rinsed to ensure all the acid is removed from the surface. Again, acid is not recommended for cleaning concrete, since it has an adverse affect on portland cement. A chemical reaction occurs when portland cement and acid are introduced to each other that can destroy the cement matrix. The interaction between the acid and the portland cement exposes the concrete aggregates and weakens the concrete. Acid can also leave a white powdery substance on the surface which can act as a bond breaker for any tile installation material. To avoid any potential problems it is best to avoid the use of acids as a substrate preparation method.

FINAL SURFACE (RESIDUE) CLEANING

The final and most important step of substrate preparation is the final cleaning, not only of the residue from contamination and bulk removal processes described above, but also cleaning of loose particles and dust from airborne contamination.

The final cleaning is considered minimum preparation for all substrates. Final cleaning can be accomplished by pressurized water as mentioned above, but can also be accomplished with standard pressure water and some agitation to eliminate the bond-breaking effect of dust films. In some cases, airborne contamination is constant, requiring frequent washing just prior to installation of cement leveling plaster/renders, adhesive mortars, membranes or coatings.

There is no exception from this general rule and the only variation is the drying time of the substrate prior to the application of the adhesive or coating. Drying time is dependent on the type of adhesive being used. With most adhesives, the substrate can be damp, with no standing water. A surface film of water will inhibit grab and bond of even water insensitive cement and epoxy-based adhesives. The use of a damp sponge just prior to installation of tile is an industry accepted method to ensure that the substrate is cleaned of any dirt and construction dust on the properly prepared substrate.

Contaminated Slab Alternative

On contaminated concrete slabs where it is not feasible to remove the top surface by a suitable method, an unbonded (wire-reinforced) mortar bed would be the best alternative. Please refer to the LATICRETE ES-F111 available at www.laticrete.com/ag or to Section 10 for more information.

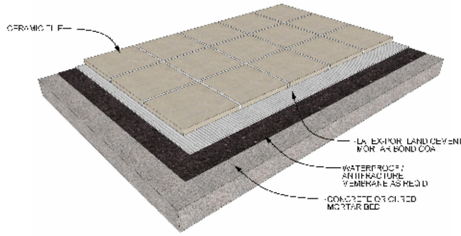

Figure 2.8 – Installation of an unbonded mortar bed. Diagram courtesy of International Masonry Institute[18]

2.4 Uncommon Substrates

ASPHALTIC WATERPROOFING MEMBRANES

Asphaltic (petroleum-based) waterproofing placed over substrate surfaces are generally not compatible with tile installation adhesives. The presence of this type of waterproofing would dictate the method of installation that would have to be used. An unbonded wire reinforced mortar bed (ES-F111), available at www.laticrete.com/ag, would be the best option for installing over this type of waterproofing product. (See Section 10 for executions statement on this method).

STEEL AND METAL (see section 2.7 for more information)

Steel and metal substrates require an epoxy adhesive or the mechanical fastening of diamond metal lath to the steel and the installation of a mortar bed due to the high density and very low porosity of this type of material. Portland cement or latex portland cement adhesives, by themselves, do not develop adequate bond to metals without expensive preparation or special adhesive formulations (See Section 10 for an execution statement on this method). Please refer to LATICRETE ES-S313 and ES-314 at www.laticrete.com/ag or to Section 10 for more information.

EXTERIOR GLUE PLYWOOD

Plywood and other wood-based products generally have high water absorption rates, and undergo rates of volumetric swelling and subsequent shrinkage that make these materials unsuitable as a substrate in industrial applications. The Tile Council of North America (TCNA) classifies most plywood floor substrates as residential and light commercial use. This classification would negate using plywood in any type of industrial application.

2.5 Concrete – Slab-On-Grade

PLACEMENT OF CONCRETE SLAB

The vast majority of all commercial tile and flooring systems installations are adhered directly to concrete. The most important factor for good, hard concrete is the water-to-cement ratio. Concrete needs water to hydrate and harden, but too much water can have a detrimental effect on concrete. Too little water will also affect the final performance of the concrete product. Understanding water and its effect on concrete is critical to achieving the desired results from a concrete slab. Water escapes from concrete via evaporation and also transpires through concrete from other sources and passes through as moisture vapor.

The water used to mix concrete must be clean (potable) and free of acids, alkalis, oils, or sulfates. This is necessary for proper hydration and curing of the concrete. There is a direct relationship between the strength characteristic of portland cement-based concrete and the amount of water used per weight of cement. This is known as Abram's Law (Duff Abrams, 1918). Essentially, the lower the water-to-cement ratio the higher the resultant physical properties of the concrete will be. Rule of thumb; LESS WATER = BETTER CONCRETE. [5]

Figure 2.9 – Placement of Concrete Slab (Photo courtesy of California State DOT).

A properly designed concrete mixture will possess the desired workability for the fresh concrete and the required durability and strength for the hardened concrete. Typically, a mix is about 10–15% cement, 60–75% aggregate (fine and coarse combined), 15–20% water and 5–8% entrained air.[6] The project engineer or design professional is responsible for specifying the actual concrete properties as required for each individual project.

Concrete will very often have an excess amount of water added to make the concrete easily workable. However, because portland cement only requires a certain percentage of its weight to hydrate, the excess water (water of convenience) will eventually escape. Much of the excess water will escape through capillary action (bleeding) while the concrete is in its plastic state during consolidation and finishing operations. Proper cure of concrete to attain the desired physical properties requires that moisture in concrete be maintained for a minimum of 3 to 7 days depending on temperature, humidity, type of cement, and type of admixtures used.

Typically, the first thing that a concrete contractor will do on a job site is perform a slump test to make sure that the concrete meets the slump criteria for that particular concrete. Unfortunately, many concrete contractors do not like the workability of concrete that passes the slump test. If this is the case, then the next words heard on the job site are "ADD MORE WATER". The concrete contractor may, without their knowledge, be affecting the final performance of the concrete. The fact is, if one extra gallon (3.8 L) of water is added to a cubic yard (1 m^3) of 3,000psi (21 MPa) concrete then one or more of the following problems may occur:

1. Finished concrete can develop 5% less than its intended design strength
2. Slump may increase by 1" (25 mm)
3. Compressive strength can be lowered by 150psi (1 MPa) or more
4. The effect of 1/4 sack of concrete can be wasted
5. Shrinkage potential increases
6. Resistance to attack by de-icing salts is decreased
7. Freeze/thaw resistance can be decreased by 20%[7]

IMPORTANCE OF VAPOR RETARDERS

Vapor retarders are necessary because concrete is a moisture-and vapor-permeable material. In fact, concrete can be thought of as being a very hard, dense sponge. Moisture vapor easily passes through concrete and can lead to problems with certain types of impervious tile, membranes, setting materials, and other types of flooring materials. In many cases, the vapor retarder is typically a 10 mil (.25 mm) thick polyethylene sheet placed directly under the concrete slab. Choosing the proper vapor retarder can be important since many polyethylene sheet materials are made with some recycled organic content. This organic content can decay over time leaving voids or holes through the sheeting; rendering it as an ineffective barrier. For better long term performance, architects and engineers are recommending 100% virgin polyethylene or 15 mil reinforced polyolefin as the vapor retarder. Proper placement and installation of the vapor retarder should also be specified by a qualified architect or engineer and shown in project details. No matter what material is used as the vapor retarder, it should conform to ASTM E1745 (Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs).

Figure 2.10 – Typical 15 Mil Thick Sheet Type Vapor Retarder – Photo Courtesy of Insulation Solutions. Inc.

A vapor retarder must have a maximum perm rating of 0.3 perms (0.2 metric perms) when tested by ASTM E96 (Standard Test Method for Water Vapor Transmission of Materials)[8].To give you an example of what a perm is, 7003 perms translates to 1 lb/1,000 ft^2 (.45 kg/92.3 m^3)/24 hours of moisture vapor as determined using the calcium chloride test ASTM F1869 (Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride). This means that moisture vapor can transpire through the vapor retarder but at an extremely low rate. A properly specified and placed vapor retarder will not allow any passage of moisture vapor through penetrations in the slab or at the perimeter. Good detailing, seaming and sealing of the vapor retarder is necessary to ensure that the required performance is attained. A good, properly placed and installed vapor retarder can also help to limit radon infiltration through a slab and into the structure.

PLACEMENT OF VAPOR RETARDERS

ACI Committee 302, "Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials" (ACI 302.2R-06) states in section 7.2 that some specifiers require concrete to be placed on the vapor retarder, and others require placement of a granular blotter layer between the concrete and the vapor retarder. As with many engineering decisions, the location of a vapor retarder is often a compromise between minimizing water vapor movement through the slab and providing the desired short- and long-term concrete properties.

There are benefits and drawbacks to each method. Therefore, proper detailing is very important not only to the performance of a flooring system but also to the potential health and safety of building occupants.

The original method places the vapor retarder directly onto the compacted soil. Next a 4" (100 mm) granular base blotter layer is placed on the vapor retarder with concrete poured on top. Based on the review of problem installations incorporating this method, it became clear that the fill course above the vapor retarder can take on water from rain, wet curing, wet grinding or cutting, and cleaning. Unable to drain, the wet or saturated fill provides an additional source of water that contributes to moisture vapor emission from the slab. These moisture vapor emission rates can be well in excess of the 3 to 5 lb/1,000 ft^2/24hr (1.4 to 2.3 kilo/92.9 m^2/24 hr) recommendation by many of the floor covering manufacturers.

As a result of these experiences, and the difficulty in adequately protecting the fill course from water during the construction process, caution is advised as to the use of the granular fill layer when moisture-sensitive finishes are to be applied to the slab surface. The committees believe that when the use of a vapor retarder is required, the decision whether to locate the material in direct contact with the slab or beneath a layer of granular fill should be made on a case-by-case basis. Each proposed installation should be independently evaluated to consider the moisture sensitivity of subsequent floor finishes, anticipated project conditions and the potential effects of slab curling and cracking.[9] It is also very important to lap up the vapor retarder onto the vertical plane and to seal off any penetrations through the sheeting to ensure maximum protection against vapor and moisture intrusion.

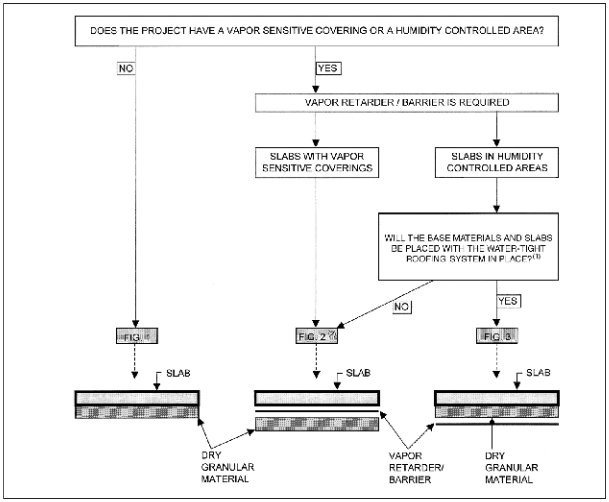

Figure 2.12 – Decision flow chart to determine if a vapor barrier is required and where it is to be placed. Chart courtesy of American Concrete Institute (ACI – 302.2R-06).

DRIVERS OF MOISTURE VAPOR

There are some very common reasons for having high moisture vapor emission problems in slabs. The most obvious would be a concrete slab without the placement of a vapor retarder. Without a vapor retarder there is nothing to prevent or limit any moisture underneath the slab from passing through the concrete. Soil capillarity can contribute as much as 12 gallons (45 L) per 1,000 ft^2 (92.9 m^2) per day to unprotected slabs from saturated shallow water tables. Broken pipes or leaking sewer lines can saturate the slab without obvious loss of water pressure. Some industrial applications have sump pumps underneath the slab to remove heavy chemicals and water used to clean machinery and floors. The pipes for these pumps can become corroded and eventually compromised by these chemicals and the soil underneath the slab can become saturated. Over-watered plant beds are another obvious contributor of water to building slabs as well.

When there is a vapor pressure differential, the higher pressure system will force moisture into the lower pressure system. Moisture vapor will consistently move from areas of high pressure to areas of low pressure. If sufficient moisture volume exists at the source and the concrete slab has low resistance to moisture, then the potential for floor covering or coating failure increases. Under the right conditions, there may also be sufficient moisture available to encourage the colonization of fungi. Indoor air quality and human health issues can be a far costlier outcome of excessive concrete moisture vapor emission than simply the loss of a floor.[10]

Figure 2.13 – Placement of vapor retarder over blotter layer / directly under the concrete pour.

TEMP. (F)	RELATIVE HUMIDITY %									
	100	90	80	70	60	50	40	30	20	10
100	0.948	0.854	0.758	0.663	0.569	0.474	0.379	0.284	0.189	0.095
90	0.639	0.621	0.551	0.482	0.414	0.344	0.275	0.209	0.138	0.069
80	0.506	0.455	0.405	0.357	0.303	0.253	0.202	0.152	0.101	0.051
75	0.429	0.386	0.343	0.3	0.258	0.214	0.172	0.129	0.086	0.043
70	0.362	0.326	0.29	0.253	0.217	0.181	0.145	0.108	0.072	0.036
65	0.305	0.274	0.244	0.213	0.183	0.152	0.122	0.091	0.061	0.03
60	0.256	0.23	0.205	0.179	0.153	0.128	0.102	0.077	0.051	0.026
55	0.214	0.192	0.171	0.149	0.128	0.107	0.085	0.064	0.042	0.021
50	0.178	0.16	0.142	0.124	0.107	0.089	0.071	0.053	0.036	0.018

Figure 2.14 – Chart Showing Static Pressures Based on Temperature and Relative Humidity (Moisture Vapor Intrusion into Building Envelopes From or Through Concrete Slabs).

The chart (Figure 2.14) above helps to explain how temperature and humidity work to draw moisture into a structure through walls and concrete slabs. If the temperature of the soil under a structure is 55°F (13°C) and the relative humidity is 100% then the static pressure equals 0.214; if the building interior is at 70°F (21°C) and the humidity is 30% then the static pressure equals 0.108. This means that the moisture is driven into the building through the slab moving from the area of high pressure to the area of low pressure. Proper placement of a suitable vapor retarder can help to minimize moisture vapor transmission.

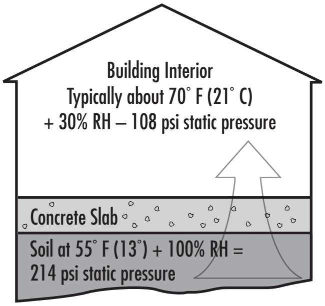

Figure 2.15 – Drawing showing movement of moisture vapor through a concrete slab.

Negative Hydrostatic Pressure

A common misconception points to negative hydrostatic pressure as the culprit in floor covering failures. Negative hydrostatic pressure can only occur when there is a physical water source higher than the slab. Therefore, it is very rare that a negative hydrostatic pressure condition exists on a project.

TESTING FOR MOISTURE IN CONCRETE

Many variables affect the results of moisture and pH tests commonly used to determine the moisture-related acceptability of concrete floors. Failure to run the test correctly can produce erroneous and misleading results. Owners and contractors must understand that accurate floor tests must be conducted after the HVAC system is operating and the building has been at service conditions for 48 hours or longer. Most floors will not even begin to dry until the building has been enclosed and the HVAC system is running.

The building owner or general contractor should hire an independent testing agent to conduct floor moisture testing. Testers should be trained and certified. The test results should be reviewed by the design professional or a knowledgeable consultant to determine whether the floor is ready to receive an applied finish.

Most moisture tests, whether for moisture vapor emissions, relative humidity, or moisture content, measure a property that changes after the tile or other floor covering is installed. Concrete at the bottom of the slab in contact with the vapor retarder contains more moisture than the concrete at the surface. The moisture condition at the interface between the concrete and finish flooring changes because evaporation at the surface is hindered after the flooring is installed. This is true even if the vapor retarder is properly installed, the water-to-cement ratio is less than 0.50, and the floor is protected to prevent re-wetting. Water moves from the bottom of the slab toward the top driven by differences in vapor pressure between the high relative humidity at the bottom and the lower relative humidity at the top (as noted in Figure 2.14). Changes in temperature and relative humidity above and below the slab affect the static pressure and, in turn, the drive of moisture vapor.

Current practice (if required) is for the flooring installer to measure the moisture and pH of the floor and submit the results to the general contractor or construction manager. Too often these results are not transmitted to the design team, nor are the tests performed as the design team might have preferred. Moisture vapor emission rates are critical to the long term performance of a tile installation that incorporates a waterproofing or crack isolation membrane. Typical liquid applied waterproofing/anti-fracture membranes (e.g. HYDRO BAN® or 9235 Waterproofing Membrane or many LATICRETE floor coatings) require that the maximum amount of moisture in the concrete substrate not exceed 5 lbs/1,000 ft^2/24 hours (2.26 kg/92.9 m^2/24 hours) per ASTM F1869 (Standard Test Method for Measuring Moisture Vapor Emission Rate of concrete subfloor using anhydrous calcium chloride) or 75% relative humidity as measured with moisture probes as per ASTM F2170 (Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring).

High alkalinity in conjunction with a high moisture vapor emission rate may affect the long-term performance of certain types of adhesives and "peel n' stick" asphaltic-type membranes. These adhesives and membranes may soften and deteriorate when subjected to high alkalinity. Alkalinity can be measured by performing a standard concrete surface pH test in compliance with ASTM F710 (Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring).

The design team should not leave the testing to the flooring installer. Specifications should require the owner's testing agency conduct these tests and report the test results to the tile installer, general contractor or construction manager, and the design team. The specifications also should require that each test be conducted in accordance with ASTM standard test methods, or that any deviations from these methods be approved by the design team [11]. If high moisture vapor emissions are present on the project, the use of vapor reduction membrane (e.g. VAPOR BAN or NXT® VAPOR REDUCTION MEMBRANE) is recommended.

COMMONLY USED MOISTURE TEST PROCEDURES

Calcium Chloride Test ASTM F1869 (Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride)

A calcium chloride test measures Moisture Vapor Emission Rates (MVER) passing through or from concrete and gives results measured in pounds of moisture per 1,000 ft^2 (98.3 m^2) in a 24 hour period. Three calcium chloride tests should be conducted for the first 1,000 ft^2 (98.3 m^2) and one additional test per 1,000 ft^2 (98.3 m^2) within a 60 – 72 hour time frame or as required by design team. These tests are a "snapshot" for the specific time/date when the testing takes place and results can vary when calcium chloride tests are performed on different dates. Calcium chloride tests should only be performed after a building has been completely enclosed and the HVAC system has been operating for a prescribed length of time. Check with the manufacturer of the moisture test kit for complete instructions and recommendations.

Figure 2.16 – Calcium Chloride Test in place (Photo Courtesy of Vaprecision).

Relative Humidity Testing ASTM F2170 (Standard Test for Determining Relative Humidity in Concrete Floor Slabs Using In-Situ Probes)

Relative humidity testing (also referred to as in situ testing) involves drilling a hole into the concrete and inserting a plastic sleeve. The sleeve is sealed and pressure is allowed to equalize for a prescribed length of time. A hygrometer probe is inserted into the sleeve and the reading is taken. Instructions for frequency and location of testing should be followed as recommended by design professional or engineer. Relative humidity testing can measure at selected depths of the concrete depending on the depth of the hole that is measured by the probe.

Figure 2.17 – In Situ Moisture Testing.

The results of relative humidity testing are measured in percentages. A reading of 75% roughly translates into 3 lbs/1,000 ft^2 (1.4 kg/98.3 m^2)/24 hours as measured by a ASTM F1869 calcium chloride test (see 2.4.4.1). A reading of 80–85% roughly translates into 5 lbs/1,000 ft^2 (2.2 kg/98.3 m^2)/24 hours).

Plastic Sheet Test ASTM D4263 (Standard Test for Determining Moisture in Concrete by the Plastic Sheet Method)

This test method is qualitative and only provides static results at the moment that the test is completed. This test method will not provide quantitative moisture level results and is strictly used to determine if moisture is present. This is generally considered an outdated method to measure moisture transmissions.

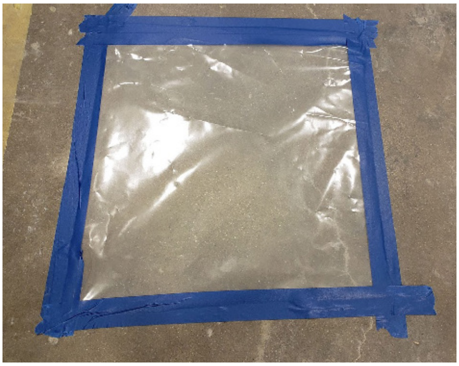

Figure 2.18 – ASTM D4263 – Plastic Sheet Method – 18" x 18" (45 cm x 45 cm) sheet of plastic is tightly taped to the substrate and allowed to sit undisturbed for 24 hours. If water or condensation is observed, then a measure of moisture vapor transmissions is present. This test will not provide a quantitative moisture vapor emission rate.

EFFLORESCENCE

Efflorescence is a white crystalline deposit that forms on or near the surface of concrete, masonry, grout and other cement-based materials. It is the most common post-installation condition in tile, stone and brick masonry installations.

Efflorescence can range from a cosmetic annoyance that is easily removed, to a serious problem that could cause adhesive bond failure or require extensive corrective construction and aggressive removal procedures.

Figure 2.19 – Presence of Efflorescence on surface of concrete slab. Moisture migration through the slab can carry destructive salts to the surface of the concrete slab.

Efflorescence starts as salts, present in portland cement products, which are put into solution by the addition of water. The salt is then transported by capillary action (or gravity on walls) to a surface exposed to the air. The solution evaporates, the salts react with carbon dioxide and a white crystalline deposit remains. Efflorescence can also occur beneath the surface or within ceramic tile or brick.Efflorescence occurs when the three conditions listed below occur. While theoretically, efflorescence cannot occur if one condition does not exist, it is impractical to completely eliminate the confluence of these conditions.

Causes of Efflorescence

- Presence of Soluble Salts
- Presence of Water (for Extended Period)
- Transporting Force (Gravity, Capillary Action, Hydrostatic Pressure, Evaporation, etc…)

Presence of Soluble Salts

There are numerous sources of soluble salts listed in Table 2.20. There is always the potential for efflorescence when concrete and cement mortars, adhesives and grouts are exposed to the weather. Other sources of soluble salts can be monitored, controlled or completely eliminated.

COMMON SOURCES OF EFFLORESCENCE	
Principal Efflorescing Salt	**Most Probaby Source**
Calcium sulfate $CaSO{\cdot}2H_2O$	Brick
Sodium sulfate $Na_2SO_4{\cdot}10H_2O$	Cement-brick reactions
Potassium sulfate K_2SO_4	Cement-brick reactions
Calcium carbonate $CaCO_3$	Mortar or concrete backing
Sodium carbonate Na_2CO_3	Mortar
Potassium carbonate K_2CO_3	Mortar
Potassium chloride KCl	Acid cleaning
Sodium chloride NaCl	Sea water
Vanadyl sulfate $VOSO_4$	Brick
Vanadyl chloride $VOCl_2$	Acid cleaning
Manganese oxide Mn_3O_4	Brick
Iron oxide Fe_2O_3 or Fe $(OH)_3$	Iron in contact or brick with black core
Calcium hydroxide $Ca(OH)_2$	Cement

Figure 2.20 – Common Sources of soluble salts.

Efflorescence – Sources of Soluble Salts

- Hydration of Cementitious Materials (Calcium Hydroxide)
- Calcium Chloride Contamination Sea Salt (Airborne, Sand)
- Mixing Water (Calcium Sulfate or Calcium Chloride Water Softeners)
- Cement Accelerator orAnti-Freeze Admixtures (Calcium Chloride)
- Acid Etching and Cleaning Residue (Chlorides)

Cement Hydration – The most common source of efflorescence is from portland cement-based materials (e.g. concrete, cement plasters/renders, concrete masonry units, cement backer board units, and cement-based mortars, including latex cement adhesive mortars). One of the natural byproducts from cement hydration (the chemical process of hardening) is calcium hydroxide, which is soluble in water. If portland cement-based products are exposed to water for prolonged periods and evaporate slowly, the calcium hydroxide solution evaporates on the surface, combines with carbon dioxide and forms calcium carbonate, one of the many forms of efflorescence. Once the calcium hydroxide is transformed to calcium carbonate efflorescence, then it becomes insoluble in water, making stain removal difficult.

Calcium Carbonate Contamination – A common source of soluble salts is either direct or airborne salt-water contamination of mixing sand and the surface of the substrate. Mixing water can also be contaminated with high levels of soluble salts. Typically, water with less than 2,000 ppm of total dissolved solids will not have any significant effect on the hydration of portland cement, although lower concentrations can still cause some efflorescence.

Presence of Water

While it is difficult to control naturally occurring soluble salts in cementitious materials, proper design, construction and maintenance of a concrete floor and its finish materials can minimize water penetration. Without sufficient quantities of water, salts do not have adequate time to dissolve and precipitate to the surface of a concrete slab or tile installation, and efflorescence simply cannot occur. Using less "water of convenience" can also help to minimize the occurrence of efflorescence.

For exterior installations, rain and snow are the primary sources of water. For interior installations, the primary source is cleaning water. Broken pipes, poor soil drainage and inadequate rainwater evacuation can also contribute to high moisture levels within a building.

Sealers and Coatings

Water repellent coatings are commonly specified as a temporary and somewhat ineffective solution to fundamentally poor slab design and construction. In some cases, water repellents may actually contribute to, rather than prevent the formation of efflorescence. Water repellents cannot stop water from penetrating cracks or movement joints in the slab. As any infiltrated water travels to the surface by capillary action to evaporate, it is stopped by the repellent, where it evaporates through the coating (most sealers have some vapor permeability) and leaves behind the soluble salts to crystallize just below the surface of the water repellent. The collection of efflorescence under the repellent coating may cause spalling of the concrete.

Effects of Efflorescence

The initial occurrence of efflorescence is primarily considered an aesthetic nuisance. However, if the fundamental cause (typically water infiltration) is left uncorrected, continued efflorescence can become a functional defect and affect the integrity and safety of a flooring installation.

The primary concern is the potential for bond failure resulting from continued depletion of calcium and subsequent loss of strength of cementitious adhesives and underlying cement-based components. The crystallization of soluble salts can exert more pressure on a flooring system than the volume expansion forces of ice formation.

Efflorescence Removal Methods and Materials

Prior to removal of efflorescence, it is highly recommended to analyze the cause of efflorescence and take corrective action to prevent recurrence. Analysis of the cause will also provide clues as to the type of efflorescence and recommended cleaning method without resorting to expensive chemical analysis.

Determine the age of the installation at the time the efflorescence appeared. In buildings less than one year old, the source of salts are usually from cementitious mortars and grouts, and the water source is commonly residual construction moisture. The appearance of efflorescence in an older building indicates a new water leak or new source of salts, such as from acid cleaning residue. Do not overlook condensation or leaking pipes as a water source. Location of the efflorescence will offer clues as to the entry source of water.

Chemical analysis of efflorescence can be conducted by a commercial testing laboratory using several techniques to accurately identify the types of minerals present. This procedure is recommended for buildings with an extensive problem, or where previous attempts to clean with minimally intrusive methods have failed.

Removal methods vary according to the type of efflorescence. Therefore, it is of critical importance to evaluate the cause and chemical composition of efflorescence prior to selecting a removal method.

Many efflorescence salts are water soluble and will disappear with normal weathering or dry brushing. Washing is only recommended when temperatures are warm so that wash water can evaporate quickly and not have the opportunity to dissolve more salts.

Efflorescence that cannot be removed with water and scrubbing requires chemical removal. The use of muriatic acid is a conventional cleaning method for stubborn efflorescence, however, even with careful preparation, acid etching can occur. There are less aggressive alternatives to muriatic acid, including a less aggressive sulfamic acid, available in powdered form. This acid dissolved in water between a 5–10% concentration should be strong enough to remove stubborn efflorescence without damage to the cementitious material.

Regardless of the cleaning method selected, the cleaning agent should not contribute additional soluble salts. For example, acid cleaning can deposit potassium chloride residue (a soluble salt) if not applied, neutralized and rinsed properly.

Acids should not be used on polished stone or glazed tile, because the acid solution can etch and dull the glaze or polished surface. Acids can react with compounds in the tile glaze and deposit brown stains on the tile surface which are insoluble and impossible to remove without ruining the tile.

Before applying any acid or cleaning solution, always test a small, inconspicuous area to determine if any adverse effects may occur. Just prior to application, saturate the surfaces with water to prevent acid residue from absorbing below the surface. While most acids quickly lose strength upon contact with a cementitious material and do not dissolve cement below the surface, saturating the surface is more important to prevent absorption of soluble salts residue (potassium chloride) which then cannot be surface neutralized and rinsed with water. This condition in itself can be a source of soluble salts and allow recurrence of the efflorescence problem intended to be corrected by the acid cleaning.

Application of acid solutions should be made to small areas less than 10 ft^2 (1 m^2) and left to dwell for no more than 5 minutes before brushing with a stiff acid-resistant brush and immediately rinsing with water. Always follow the acid manufacturer's directions for diluting, mixing, application, initial rinsing, neutralization, and final rinsing techniques.

2.6 Suspended Concrete Slabs

With advancements in concrete and concrete placement technology, the number of suspended (elevated) concrete slabs being placed is increasing around the world. There are numerous types of cast-in-place and pre-cast concrete floor systems available that can satisfy any structural, span or loading conditions. Since the cost of a floor system is a major part of the structure and the building cost, then selecting the most effective floor system is important to achieving overall performance of the building.

The ability to customize load capacity to suit the usage requirements, deflection, inherent fire-resistance, ease of installation, and the ability to create long spans makes concrete the material of choice for industrial applications. The ability to finish the floor with a wide variety of finish materials (including tile), permanently mount heavy machinery and the capability to stand up to extreme conditions are added benefits of concrete.

Defining the proper suspended slab type, reinforcement method, thickness, span, load bearing capacity, and all other performance requirements is the responsibility of a qualified design professional and/or structural engineer and is based on expected loads, usage, environment and much more.

We will take a look at several different types of suspended concrete slabs.

CAST-IN-PLACE CONCRETE SLABS

The main components and expenses of cast-in-place concrete slabs are the concrete, reinforcement (either mild or post-tensioned) and formwork. A major emphasis of the need for reinforcement in suspended concrete slabs is the fact that concrete, while strong in compression, is weak in tensile and flexural strengths. Steel is strong under forces of tension, so combining concrete and steel together makes for an extremely strong and versatile building material. By combining the properties of reinforcing steel with concrete, you achieve a building material that can easily resist both compressive and tensile forces.

Benefits can also be achieved by using the reinforcing materials to place additional forces on the concrete to place it in compression. By compressing the concrete, additional tensile strength can be realized. This additional tensile strength (stiffness) can provide an architect with the ability to achieve longer spans with a thinner concrete slab. Another benefit of tensioning concrete raises the capability of the slab to resist the development of shrinkage cracks. In theory, the more the concrete is squeezed together, the less likely it is that concrete slab shrinkage cracks will develop.[12]

Mild reinforced concrete slabs are poured in place, over framework, and around a steel reinforcement (rebar) grid. These rebar grids are most often assembled on site as defined by installation drawings with concrete poured around the reinforcing. This type of reinforcement is most often used in steel frame (deck) concrete slabs.

POST TENSIONED CONCRETE SLABS

Post-tensioning is a method of stressing concrete in which tendons have tension applied after the concrete has hardened and the pre-stressing force is primarily applied through the end plates or anchorages. Unlike pre-tensioning, which can only be done at a pre-cast manufacturing facility, post-tensioning is performed in-situ on the job site.

Concrete slabs usually utilize ultra high-strength steel strands to provide post-tension forces to the slab. Typically, these steel strands have a tensile strength of 270,000 psi (1,860 MPa), are about 1/2" (12 mm) in diameter and are stressed to approximately 33,000 pounds (15,000 kg).

Fig. 2.21 – Post Tensioned Concrete Slab – Photo Courtesy of Suncoast Post Tensioning Company.

Figure 2.23 – Post-Tensioned Concrete Slab Tendon Anchor – Anchor secures post-tensioning cables running through the concrete slab. Photo Courtesy of Precision-Hayes International. [13]

Reinforcing wire tendons are usually pre-manufactured at a plant, based on specific requirements, and delivered to the job site, ready to install. These tendons are laid out in forms in accordance with installation drawings that indicate how they are spaced, what their profile height should be, and where they will be stressed. After the concrete is poured and has reached required strength (up to 5,000 psi [34.5 MPa]) the tendons are stressed and anchored. These tendons, like rubber bands, want to return to their original length but are prevented from doing so by the anchorages.

The fact that the tendons are kept in a permanently stressed state causes a force in compression to act on the concrete. The compression that results from the post-tensioning counteracts the tensile forces created by subsequent loading (machinery, people, equipment, flooring, etc…).[14]

PRE-TENSIONED (PRE-CAST) CONCRETE SLABS

While pre-tensioning is similar to post-tensioning in the fact that steel tendons are exerting stresses onto concrete to increase tensile strength, the method of placement is different. In post-tensioning, the steel tendons are stressed after the concrete hardens; in pre-tensioning, the steel tendons are stressed to 70–80% of their ultimate strength prior to the concrete being placed or poured into the molds (in the case of pre-cast concrete) around the tendons. Once the concrete reaches the required strength, the stretching forces are released. As the steel reacts to return to its original length, the tensile stresses are translated into a compressive stress in the concrete.[15]

Pre-tension concrete members must be poured at a production facility and shipped to the job site individually. Each member is then installed as required and supported by columns, beams or other structural member.

Pre-cast concrete planking is another form of pre-tensioned concrete. The pre-cast concrete planks are tensioned prior to the concrete being poured. The concrete planks are then slipped together and mortared in place. Typically, a 2" (50 mm) thick concrete topping slab is required to create a monolithic concrete slab that is suitable to receive a ceramic tile, paver or other suitable flooring finish.

Advantages of pre-stressed concrete slabs is shallower depth for the same deflection rating as a thicker slab and greater shear strengths than plain reinforced slabs of the same depth.

Figure 2.24 – Pre-Cast Concrete Planks. Planks rest and are supported by a flange attached to the steel girders. The planks are hoisted into place by a crane and mortared to the beams and to each other. Photo courtesy of Country Materials Corporation.[16]

STEEL FRAME (DECK) CONCRETE SLABS

To achieve desired tensile strength in pre-tension and post-tension slabs, tendons are required that have stresses applied to them. In steel frame (deck) construction, the steel deck and additional mild steel reinforcing will provide the tensile strength required for the concrete slab. Post-tensioning is typically not necessary.
Modern profiled steel pan sheeting, specifically designed for the purpose, acts as both permanent formwork during concreting and tension reinforcement after the concrete has hardened. Shear connections are mechanical fasteners used to develop composite action between the steel beams and the concrete and maintain solid structural integrity. At this final stage the composite slab consists of a profiled steel sheet and an upper concrete topping which are interconnected in such a manner that horizontal shear forces can be resisted at the steel-concrete interface.[17]

Composite floor construction has certain advantages over typical concrete construction:

1. It is used in very tall buildings
2. It is lightweight and strong
3. It is prefabricated, so it assembles quickly

Figure 2.25 – Showing placement of shear connections and edge detail.

Figure 2.26 – Concrete pour over suspended composite steel pan floor construction.

TILE INSTALLATION OVER SUSPENDED CONCRETE SLABS

The TCNA handbook for ceramic tile installations recommends method F-111 for installation over a suspended concrete slab, or, for installations where an unbonded mud bed is impractical, follow TCNA handbook for ceramic tile installations method F-122 which requires an anti-fracture or waterproofing/anti-fracture membrane. Please reference www.laticrete.com/ag for further information on the LATICRETE recommended installation methods (ES-F111 and ES-F122) for the above mentioned TCNA handbook for ceramic tile installations guidelines.

2.7 Steel Coolers and Freezers

It is common to find steel coolers and freezers in industrial applications. There are some important guidelines to follow when steel or metal substrates are scheduled to receive tile finishes.

TEMPERATURES

Temperature is one of the biggest factors to consider when installing tile in a cooler or freezer. Installation materials have working temperatures that must be adhered to for proper curing of the setting materials and grouts. Installing tile over a steel substrate that is colder than the recommended temperatures will prevent the setting materials and grouts from curing, or, cure over a lengthy period of time. This can dramatically affect the overall hardness, bond strength, compressive strength, and long-term performance of the mortar and grout. The best alternative is to make sure that the cooler or freezer is turned off and allowed to warm to ambient temperatures. The surface that is to receive tile should be between 60°F (16°C) and 90°F (32°C) for epoxy adhesives (e.g. LATAPOXY® 300 Adhesive) and epoxy grout (e.g. SPECTRALOCK® 2000 IG), and between 40°F (4°C) and 90° (32°C) for cement-based setting materials (e.g. 3701 Fortified Mortar Bed; or, 226 Thick Bed Mortar gauged with 3701 Mortar Admix, or 257 TITANIUM™ or MULTIMAX™ Lite and grouts (PERMACOLOR™ Select Grout^). For installations requiring a waterproofing (e.g. 9235 Waterproofing Membrane or HYDRO BAN®) or anti-fracture membrane (e.g. Blue 92 Anti-Fracture Membrane) the temperature should be between 45°F (7°C) and 90°F (32°C).

The temperature depending on the product that it used must remain within the prescribed range for a minimum of 24 hours after installation. Rapid setting materials will speed up the curing process before grouting. Once the floor is grouted, allow for a 24 hour or longer cure period.

CONCRETE OR MORTAR BED SUBSTRATES

Once the mortar bed (e.g. 3701 Fortified Mortar Bed; or, 226 Thick Bed Mortar mixed with 3701 Mortar Admix) hardens and is cured properly, most waterproofing membranes can be installed directly over the mortar bed. Follow the membrane (e.g. 9235 Waterproofing Membrane or HYDRO BAN) installation instructions for proper cure time of the mortar bed prior to application of the membrane. When using an epoxy setting material or other epoxy membrane, full cure of the mortar bed is required.

The metal or steel substrate must be rigid enough to withstand the weight of the mortar bed, any membranes, setting materials, tile and grout. A 2" (50 mm) thick mortar bed weighs roughly 24 lbs per ft^2 (95 kg per m^2).

STEEL OR METAL SUBSTRATES

There are two methods for the installation of tile over steel or metal substrates. The preferred method would be to tack weld or mechanically fasten 3.4# diamond metal lath complying with the current revision of ANSI A108.1 (3.3 Requirements for lathing and portland cement plastering), ANSI A108.02 (3.6 Metal lath), and A108.1A (1.0-1.2, 1.4 and 5.1).

Next, apply 3701 Fortified Mortar Bed; or, 226 Thick Bed Mortar gauged with 3701 Mortar Admix to float and fill in the wire lath. Float surface of scratch/leveling coat plumb, true and allow mortar to set until firm. Once the mortar bed is firm and dry the installation of the membrane (e.g. 9235 Waterproofing Membrane, HYDRO BAN or Blue 92 Anti-Fracture Membrane), if specified can commence. Tile can be installed directly to the membrane using 257 TITANIUM™ or MULTIMAX™ Lite. Grout using SPECTRALOCK 2000 IG, and use LATICRETE Latasil™ for any movement or isolation joints.

An alternative method to set tile over a steel or metal substrate is as follows:

1. Make sure the steel or metal substrate is cleaned thoroughly, meets deflection ratings and can support the weight of the installation. Wash steel or metal with a strong detergent to ensure that all manufacturing oils are removed. Rinse completely and allow the steel or metal to air dry.

   If possible scuff up the surface to receive tile with sand paper or emery cloth and then re-wash the surface, rinse completely and allow to air dry.

   Once the surface is dry you may set the tile using an epoxy adhesive (LATAPOXY® 300 Epoxy Adhesive).

   Grout using SPECTRALOCK 2000 IG. Use Latasil™ for movement and isolation joints.

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Section 3: Types of Wall Construction

3.1 Structural Considerations

As in Section 2 with floor applications, the same criteria for surface and structural considerations applies to wall applications. Basically, the wall must be structurally sound, dimensionally stable, meet the maximum allowable standard for deflection of L/360 for finishes under total anticipated loads and be free from any bond-breaking or bond-inhibiting substances. (Please refer to Section 2.2 for more information on structural considerations and live and dead loads.)

3.2 Wall Types

CONCRETE WALL TYPES

One of the most common substrate types that will be found in industrial applications is concrete. This section will examine the various concrete construction types that can be encountered and their common characteristics.

Tilt-Up Concrete

Tilt-up and tilt-wall are two terms used to describe the same process. For a tilt-up concrete building, the walls are created by assembling forms and pouring large slabs of concrete called panels directly at the job site. The concrete panels are then tilted up into position around the building's slab to form the walls. Because the concrete tilt-wall forms are assembled and poured directly at the job site, no transportation of panels is required. A major benefit of this technique is that the size of the panels is only limited by the needs of the building and the strength of the concrete panels themselves.

Tilt-up construction panels can sometimes be extremely wide and/or tall. Tilt-up concrete panels have been as large as 69' (21 m) across and almost 96' (30 m) high. Thus, architects and tilt-up concrete contractors have a great deal of flexibility in planning and creating their buildings.

A tilt-up construction project begins with job site preparation and pouring the slab(s). During this phase of the project, workers install footings around the slab in preparation for the panels. The crew then assembles the panel forms on the slab. Normally, the form is created with wooden pieces that are joined together. The forms act like a mold for the cement panels. They provide the panel's exact shape and size, doorways and window openings, and ensure the panels meet design specifications and fit together properly. Next, workers tie in the steel grid of reinforcing bars into the form. Inserts and lift hooks are embedded for lifting the panels and then attaching them to the footings, the roof, and to each other.

Once the concrete panels have hardened and the forms have been removed, the crew connects the first panel to a crane with cables that hook into the inserts. Workers help to guide the concrete panel into position and the crane sets it into place. An experienced crew can erect as many as 30 panels in a single day.

Figure 3.1 – Tilt-Up Concrete Panels erected into place.

Pre-Cast Concrete

The pre-cast concrete building process is similar to tilt-up construction, but it addresses the challenges presented by weather. For pre-cast concrete buildings, work crews do not set up forms at the job site to create the panels. Instead, workers cast concrete panels at a large manufacturing facility. Because the pre-cast concrete forms are poured indoors, this activity can take place regardless of the weather conditions. After curing, the pre-cast concrete panels are trucked to the job site. From this point, pre-cast concrete buildings are assembled in much the same manner as tilt-wall buildings.

The fact that pre-cast concrete walls are formed at a manufacturing facility resolves the weather issue, but presents a different limitation not found in tilt-up construction. Because the panels must be transported, sometimes over long distances, this places a substantial limitation on how wide or tall each panel can be. It would be impossible to load pre-cast panels that were 60' (20 m) wide or 90' (30 m) long onto trucks and transport them any distance. For a pre-cast construction project, the panels must be smaller and more manageable to allow trucks to haul them over the road to their final destination. This places certain design restrictions on architects and limits the applications where pre-cast construction can be used.

Cast-in-Place Concrete

Cast-in-place concrete is a common substrate for the direct adhesion of tile. Cast-in-place concrete is poured into forms (sprayed with form release agents) where steel reinforcing has previously been placed. The condition of vertically formed concrete is extremely variable, due to the numerous potential defects that can occur with mix design, additives, forming, placement and curing. There may be concerns with poured-in-place concrete in relation to the long-term performance of a industrial finishes.

Some of these concerns include:

Laitance

As noted in Section 2.3, laitance is a thin layer of weakened portland cement fines that have migrated to the surface of the concrete. This condition is especially prevalent in vertically formed concrete, where excess water migrates by gravity, aided by the vibration of concrete and pressure to the surface against the wall form. The excess water gets trapped by the form where it stays until the form is removed. Once the forms are removed and the water has had a chance to evaporate, it leaves behind a thin layer of what appears to be a hard concrete surface, but in reality is weakened due to the high water to cement ratio at the surface. Laitance has a very low tensile strength, and therefore the adhesion of tile will be limited by the low strength of the laitance. Laitance should be removed from the concrete surface prior to the installation of finishes.

Honeycombing

Honeycombing is a condition where concrete is not properly packed or consolidated by vibration during the pour, where steel reinforcement is too close to the form, where there is internal interference with the flow of concrete during the consolidation procedure, or where there is poor mix design. These conditions can result in voids in the surface or core of the concrete. Surface honeycombing defects must be properly prepared and patched using a bonding agent to ensure proper adhesion to the concrete prior to installation of the finish material.

Unintended Cold Joints

In vertical walls, cold joints are usually unintended, and can result in a weakened plane. This weakened plane is subject to random shrinkage cracking which could transfer to the surface of the finishes. These conditions usually result from delays or equipment breakdowns and can be prevented by proper coordination of concrete delivery and proper maintenance and use of installation equipment.

Concrete Forms

Smooth formwork for concrete walls can result in a surface that is too smooth for direct adhesion of industrial finishes. A smooth surface provides little or no mechanical key for the initial grab required when applying wet adhesives or coatings. These surfaces do not typically facilitate absorption of cement paste and subsequent mechanical locking provided by the growth of cement crystals into the pores of the substrate. Mechanically grinding or vertical scarification can be used to achieve a better concrete surface to accept a direct adhered industrial finish installation. Epoxy-based tile installation materials (e.g. LATAPOXY® 300 Adhesive or LATAPOXY 210 Adhesive) do not rely on open pore structure to achieve exceptional bond and may be a better choice for this concrete finish.

Form Release Agents

There are a wide variety of form release agents on the market today. These products range from used motor oil or diesel fuel to sophisticated water-based products. Any type of oil-based or other potential bond breaking contaminant must be removed prior to the direct adhesion of tile and coatings.

Curing Compounds

The variety of materials and the unique characteristics of proprietary formulations require that you follow the same recommendations above for form release agents.

Concrete Additives

There are numerous concrete additives, which, depending on the properties they impart to the concrete, could be detrimental to the adhesion of finishes to the concrete wall. For example, super plasticizers are a type of concrete additive that allows extremely low water-to-cement ratios and resultant high strength, without sacrificing workability of the concrete. This type of additive can induce bleed water, and facilitate the formation of laitance. Similarly, additives that react with free minerals in the concrete produce an extremely dense and water-resistant pore structure and may be detrimental to good adhesive bond. It is therefore imperative to communicate to the concrete subcontractor, and to write into the concrete specification, which areas of the concrete are scheduled to industrial finishes or coatings. This communication can also help ensure that the concrete is fully compatible with the direct bond method of ceramic tile installation using a latex-fortified portland cement-based or epoxy adhesive.

3.3 Concrete Curing

The installation of ceramic tile and industrial coatings over concrete can only begin once the concrete reaches satisfactory cure. As concrete cures, it loses moisture and shrinks. A common misconception is that concrete cures completely and all concrete shrinkage takes places within 28 days of placement. This is simply not true. Thick sections of concrete could take over 2 years to reach the point of ultimate cure. 28 days at 70°F (21°C) is the period of time it takes for concrete to reach its full design strength. At that point, concrete will have reached its designed tensile strength, and can better resist the effects of shrinkage and stress concentration.

Depending on the humidity and exposure to moisture in the first 28 days, there may be very little shrinkage that occurs within that period. So while more flexible adhesives, like latex portland cement adhesive mortars can accommodate the shrinkage and stress that may occur in concrete less than 28 days old, it is recommended to wait a minimum of 30–45 days to reduce the probability of concentrated stress on the adhesive interface or coating. Some building regulations may require longer waiting periods (up to 6 months). After this period, resistance to concentrated stress is provided by the tensile strength gain of the concrete, and its ability to shrink as a composite assembly. The effect of remaining shrinkage is significantly reduced by its distribution over time and accommodated by the use of low modulus of elasticity or flexible adhesives.

3.4 Concrete Masonry Unit (CMU)

Concrete masonry units (CMU) are suitable as a substrate for an industrial tile application. When standard aggregate and density CMU is built to plumb and levelness tolerances (including the mortar joints), no further preparation is needed except for final water cleaning, unless there is a specific need or specification for an anti-fracture (e.g. Blue 92 Anti-Fracture Membrane) or waterproofing membrane (e.g. HYDRO BAN®) which typically are installed directly to the CMU (following the manufacturer's installation instructions).

Both standard and lightweight aggregate concrete masonry units present several other material specific concerns. Typically, CMU walls are fairly porous. Therefore, care must be taken to prevent possible pre-mature absorption of moisture (required for proper hydration of latex portland cement adhesive mortars) into the CMU. The CMU walls should be wiped down with a damp sponge prior to the application of any membrane or adhesive mortar. This will increase the working time of the membrane or adhesive mortar and also provide a final cleaning of the wall.

In some cases, where test panels may indicate poor adhesion at the CMU/adhesive interface, it is recommended to skim coat the CMU (1/8" {3mm} maximum thickness) with a latex portland cement mortar (e.g.257 TITANIUM™ or MULTIMAX™ Lite) to seal the rough surface texture of the CMU. With the proper latex portland cement mortar, the thin skim coat will harden quickly without risk of moisture suction. Another concern is the cohesion or tensile strength of the CMU material which may be less than the tensile bond strength of the adhesives; this is more of a concern with lightweight aggregate or cellular CMU.

Cellular or gas beton CMU (also commonly known as ytong or Aerated Autoclaved Concrete [AAC]) is manufactured with materials that react with portland cement to create and entrain air spaces and reduce weight and density. This type of block typically does not have good tensile and shear strength (< 7 kg/cm^2). Due to the low shear strength, slight shrinkage of conventional cement mortars may tear the surface and result in delamination. Similarly, the low density (40–50 lbs/ft^3 [500–600 kg/m^3]) of this material results in a coefficient of thermal expansion which is significantly different from typical cladding materials which may cause concern about differential movement. The porous structure of this material also requires careful consideration to compensate for suction of hydration moisture from cement-based adhesives. Most of the cellular or gas beton CMU block manufacturers require the use of a latex portland cement-based skim coat prior to the installation of the tile adhesive mortar, cement-based render or membrane.

3.5 Framed Wall Substrates

CEMENTITIOUS BACKER UNITS (CBU) OVER FRAMING[2]

There are a wide variety of product formulations in this category of substrates, such as pure portland cement, cement-fiber, and calcium silicate boards. This board type is designed for use on floors, walls and ceilings in wet or dry areas and is applied directly to wood or metal framing. Ceramic tile and industrial coatings can be bonded to it with dry-set, latex/polymer modified portland cement mortar, or epoxy adhesive by following the backer board manufacturer's instructions.

It is important to note that many of the other board types, including coated glass mat water-resistant gypsum backer board, fiber cement underlayments, fiber-reinforced water-resistant gypsum backer board and cementitious coated foam boards follow many of the same industry recognized installation instructions. However, the specific board manufacturer's installation instructions will take precedence over the general installation instructions. The ceramic tile industry supplies the following installation instructions for CBU applications.

1. Systems, including the framing system and panels, over which tile will be installed shall be in conformance with the International Building Code (IBC) for commercial and industrial applications, or applicable building codes. The project design should include the intended use and necessary allowances for the expected live load, concentrated load, impact load and dead load including the weight of the finish and installation materials

2. All CBU must comply with American National Standards Institute Inc. (ANSI) ANSI A118.9 (Standards for Test Methods and Specifications for Cementitious Backer Units) and ASTM C1325 (Standard Specification for Non-Asbestos Fiber-Mat Reinforced Cement Interior Substrate Sheets). CBU installation must comply with ANSI A108.11 (Interior Installation of Cementitious Backer Units).

3. Provide expansion movement/expansion joints for ceramic tile, stone and thin brick installations as per the current TCNA Handbook for Ceramic Tile Installation – EJ171.

4. Fasten the CBU with 7/8" (22 mm) minimum length, non-rusting, self-imbedded screws for wood studs. Fasten the boards every 6" (150 mm) at the edges and every 8" (200 mm) in the field. Tape all the board joints with the alkali-resistant 2" (50 mm) wide reinforcing mesh (provided by the CBU manufacturer) embedded in the same mortar used to install the ceramic tile, stone or thin brick.

5. To prevent water leakage through the walls, especially in high water exposure areas, apply a waterproofing membrane (e.g. HYDRO BAN®) directly on the CBU. Please refer to membrane manufacturer's written installation instructions. Some applications may require an additional vapor barrier installed behind the CBU.

6. Before applying the tile it is essential that the CBU be wiped down with a damp sponge to remove dust and to increase working/adjustability time over hot, dry surfaces. This will ensure that the thin-set or large and heavy tile adhesive mortar (e.g.257 TITANIUM™ or MULTIMAX™ Lite) has an opportunity to hydrate properly without the CBU absorbing the water. Apply the mortar or adhesive, using the flat side of the trowel to work the material into good contact with the CBU. Then comb on additional material with the notched side of the trowel. Spread only as much material as can be tiled in 15–20 minutes. Use the correct size notched trowel and "back butter" the tiles, if necessary, to achieve the correct coverage. It is recommended to pull tiles occasionally to ensure proper coverage is being achieved. Once the thin-set mortar or epoxy adhesive has cured for the appropriate amount of time, grouting can take place.

COATED GLASS MAT WATER-RESISTANT GYPSUM BACKER BOARD

Coated glass mat water-resistant gypsum backer board should conform to ASTM C1178 (Standard Specification for Coated Glass Mat Water-Resistant Gypsum Backing Panel) and be suitable for use as a ceramic tile backer board. This type of board should only be recommended for use on walls and ceilings over wood or metal framing for industrial applications. Ceramic tile can be bonded to a coated glass mat water-resistant gypsum backer board with latex/polymer modified portland cement mortar or an epoxy adhesive by following the backer board manufacturer's instructions.

FIBER CEMENT UNDERLAYMENT

A dispersed fiber-reinforced cement backer and underlayment designed for use on walls and ceilings in industrial applications. This board is typically applied directly to wood or metal framing. Ceramic tile can be bonded to it with latex/polymer modified portland cement mortar or an epoxy adhesive by following the backer board manufacturer's installation instructions. General interior installation and material specifications are contained in ANSI A108.11 (Interior Installation of Cementitious Backer Units) and ASTM C1288 (Standard Specification for Discrete Non-Asbestos Fiber-Cement Interior Substrate Sheets).

FIBER-REINFORCED WATER-RESISTANT GYPSUM BACKER BOARD

Fiber-Reinforced Water-Resistant Gypsum Backer Board should conform to ASTM C1278 (Standard Specification for Fiber-Reinforced Gypsum Panel). This board is typically used on walls and ceilings, and is applied directly to wood or metal framing in industrial applications. Ceramic tile is adhered to this board with latex/polymer modified portland cement mortar or an epoxy adhesive by following the backer board manufacturer's recommendations.

CEMENTITIOUS-COATED FOAM BOARD

Cementitious-coated foam board is a waterproof backer board constructed from extruded polystyrene and coated with a cementitious coating which is designed as a substrate for ceramic tile walls in wet and dry areas and is applied directly to wood or metal framing. Ceramic tile can be adhered with a latex/polymer modified portland cement mortar or an epoxy adhesive. Follow the manufacturer's recommendations for installation instructions.

WATERPROOF COATED LIGHTWEIGHT FOAM BACKER BOARD

Waterproof coated lightweight foam backer board (e.g. HYDRO BAN® BOARD) is a waterproof backer board constructed from extruded polystyrene and coated with waterproofing membrane which is designed as a substrate for ceramic tile walls in wet and dry areas and is applied directly to wood or metal framing. Ceramic tile can be adhered with a latex/polymer modified portland cement mortar or an epoxy adhesive. Follow the manufacturer's recommendations for installation instructions.

3.6 Substrate Condition and Preparation

EVALUATION OF SUBSTRATE CONDITION

As previously mentioned in Section 2.3, the first step in any installation is the evaluation of job site conditions. The extent of substrate preparation will not be known until the surface is examined for compliance with industry standards for substrate tolerances, plumbness, surface defects and substrate contaminates.

In relation to the overall cost of the installation, preparation of the substrate is neither costly nor time-consuming. However, proper preparation is one of the most important steps that leads to a successful, long term installation and helps prevent “call backs”.

ADHESIVE COMPATIBILITY

As mentioned in Section 2.3, adhesive and coating compatibility plays an important role in determining adhesion between the substrate and the finishes being installed. Both the substrate and the finishes must be compatible with the type of adhesive or coating being used and recommended for use in the environment in which it will be installed. The ability of a substrate to be ‘wetted out’ by an adhesive or coating is essential to good adhesion and important in determining the performance of the adhesive or coating in bonding to the substrate. The highest strength adhesives and the most careful application to the best wall will not overcome a dirty or contaminated substrate.

SITE VISIT AND CONFERENCE

Prior to commencing any work, the contractor shall inspect surfaces to receive finsihes, and shall notify the architect, general contractor, or other designated authority in writing of any visually obvious defects or conditions that will prevent a satisfactory installation. Installation work shall not proceed until satisfactory conditions are provided. Commencing installation of work deems acceptance of substrate conditions.

SUBSTRATE PREPARATION

Wall substrates to receive finishes will always be exposed to varying degrees of airborne contamination, exposure to other trades and site-applied products. This can include, but is not limited to, form release agents, sealers, or any other potential bond-inhibiting materials.

Therefore, any type of oily or other potential bond-breaking contaminant must be removed prior to the installation of tile or coatings on concrete walls. These types of contaminants may require mechanical scarification, grinding, shot-blasting or other methods of mechanical removal.

At times, a high pressure water wash can be used to clean concrete and concrete masonry unit walls. The high pressure water wash (approximately 3,000 psi {20.7 MPa}) can very easily remove a thin layer of contaminated concrete or masonry. Once the walls have been thoroughly cleaned, further evaluation is necessary.

Figure 3.2 – High Pressure Water Washing.

CRACKS

Plastic and Shrinkage Cracks

Freshly placed concrete undergoes a temperature rise from the heat generated by cement hydration, resulting in an increase in volume. As the concrete cools to the surrounding temperature, it contracts and is susceptible to what is termed “plastic shrinkage” cracking due to the low tensile strength within the first several hours or days after the concrete is placed. Plastic shrinkage can be controlled by reduction of aggregate temperature, cement content, size of pours/members, deferring concreting to cooler temperatures, damp curing, and the early removal of forms.

Concrete also undergoes shrinkage as it dries out, and can crack from build-up of tensile stresses. Rapid evaporation of moisture results in shrinkage at an early stage where the concrete does not have adequate tensile strength to resist contraction. Concrete is most susceptible to drying shrinkage cracks within the first 28 days of placement. After 28 days concrete typically develops adequate tensile strength to resist a more evenly distributed and less rapid rate of shrinkage. It is for this reason that it is recommended to wait 30–45 days before application of adhesive mortars or coatings. Just like floors prior to the installation of ceramic tile, treat any shrinkage cracks with an anti-fracture membrane (e.g. Blue 92 Anti-Fracture Membrane) to prevent the transmission of cracks through the finish surface. For the installation of other coatings over cracked substrates, consult the respective product data sheet on how to properly treat or repair cracks prior to their installation.

Structural Cracks

Cracks that are greater than an 1/8" (3 mm) in width, are displaced or not in plane, and occur throughout the cross section of a concrete wall or structural member, are an indication of a structural defect and must be corrected before the tile or coating is adhered to the wall. Structural cracking on vertical applications can be repaired using low viscosity epoxy or methacrylate pressure injection methods. Once the cracks are stabilized and properly repaired, the installation process can commence.

Cracks that are an 1/8" or less (3 mm) in width are typically non-structural shrinkage cracks. While these types of cracks do not require structural correction prior to the installation of ceramic tile or paver finishes, they require isolation by means of a crack isolation membrane (e.g. Blue 92 Anti-Fracture Membrane). The crack isolation membrane is applied to the crack with a 6" (150 mm) wide treatment (3" {75 mm} applied on either side of the crack). Next, another layer of the crack isolation membrane treatment that is at least three times the width of the tile, is applied over the previous layer (For more information on this method, please refer to LATICRETE ES-125 at www.laticrete.com/ag). This treatment ensures that the tile will sit directly on the membrane and will provide the full capabilities of the crack isolation membrane. An alternative method treats the entire vertical substrate with the crack isolation membrane to help prevent existing cracks and any future non-structural cracks from telegraphing through to the tile surface.

PLUMB AND LEVEL

It is imperative to evaluate how plumb a wall is before applying tile. The TCNA Handbook for ceramic tile installations stipulates maximum variation in the substrate shall not exceed 1/4" in 10' (6 mm in 3 m) or 1/16" in 1' (1.5 mm in 300 mm) from the required plane for most tile installations. At times, the design professional may specify a more stringent tolerance of 1/8" in 10' (3 mm in 3 m). This is especially true when installing large format tile or gauged porcelain tile, panels or slabs. If this variation is not achieved, a leveling coat or mortar bed may be necessary. For industrial applications, concrete, concrete masonry units and cement backer units over steel framing are generally the vertical substrates most frequently used. At times, the substrate may require a minor skim coating of latex/polymer-fortified patching or skimming mortar (e.g. NXT® Patch or Skim) to fix any minor irregularities, all the way up to a full render application that includes a scratch and brown coat (e.g. 3701 Fortified Mortar Bed); in order to make the walls plumb and true.

Although some walls may be plumb, they may not necessarily be level. Tile installations can overcome a wall that is not perfectly level, however, there could be consequences to setting tile on a wall that is not flat, the most serious being inadequate bond.

Tiles also have certain tolerances when it comes to their manufacturing process. For example, the greater the tolerance for tile thickness, the greater the chances are that the tile wall will appear wavy and irregular in profile. The quality of the tile can also play an important role in the final appearance of the finish.

After the walls have been brought into compliance with industry substrate tolerance standards, the installation of tile can commence. Prior to installing tile on walls, it is important to clean the wall surface just prior to installing tile so that dust and debris will not affect the bond of the tile installation.

Specialty and large and heavy tile adhesive mortars (e.g. MULTIMAX™ Lite) can alleviate small variations in the wall and tile tolerances without the need of a leveling coat or thick mortar bed. Follow the manufacturer's recommendation of thickness with these special setting materials.

Industrial walls that employ the epoxy spot bonding method (e.g. LATAPOXY® 310 Stone Adhesive. See Details ES – W260 and ES W215 in section 10 for more information.) generally tolerate greater deviations from a flat plane. Maximum deviation is a function of the recommended thickness and working properties of the adhesives such as sag resistance. Follow the manufacturer's installation instructions when utilizing the epoxy spot bond method.

SURFACE AND AMBIENT TEMPERATURE

During the placement of concrete and installation of other substrate types, cold or hot temperatures may cause numerous surface or internal defects, including shrinkage cracking, a weak surface layer of hardened concrete caused by premature evaporation, or frost damage. Prior to curing, extreme temperatures of both the ambient air and surface of the substrate will also affect the normal properties of adhesive mortars and coatings.

Warmer ambient air and surface temperature will accelerate the setting of cement and epoxy adhesives and coatings. Cooler ambient air will require a longer curing period.

The two general rules are;

1. For every 18°F (10°C) below 70°F (21°C) cement-based and epoxy-based materials will take twice as long to cure
2. For every 18°F (10°C) above 70°F (21°C) cement-based and epoxy-based materials will take half as long to cure

Washing and dampening walls as described previously, will not only help to remove any loose contaminants off the wall, but will also serve to lower surface temperatures in warmer climates, and lower the absorption rate of the substrate. It is important to follow the manufacturer's recommendations for temperature ranges for all installation materials.

3.7 References

1 Construction Photograhs.com. Retrieved October 3, 2007 from www.tiltupnews.com

2 TCNA Handbook for Ceramic Tile Installation. Tile Council of North America, Inc. Anderson, SC.

Section 4: Comparison of Alternate Types of Industrial Flooring

This section will provide general information on alternate systems (e.g. epoxy coatings, terrazzo, stamped concrete, polished concrete, metal wall panel cladding and more) which can be used in industrial applications. It is important to note that although tile/stone flooring systems have their place in industrial installations, there are many locations within these institutions in which they may not be suitable. These locations are typically those areas that demand a seamless flooring that can offer less penetrations for bacteria to grow and ease of cleaning benefits. The Tile Council of North America (TCNA) has conducted an extensive life cycle cost analysis (Tile Is The Natural Choice: Environmental and Cost Evaluation) comparing ceramic tile to other finish flooring types. See Section 11 for design considerations when using ceramic tile/stone finishes in medical, educational and hospitality applications.

4.1 Seamless Resinous Flooring Systems

Generally speaking, resinous floors can be defined as "a floor which is finished with a resinous coating that is used as the wearing surface". These resinous flooring solutions offers a variety of unique designs and finishes for an increase aesthetic value while still offering increased chemical and abrasion resistance. Gone are the days in which epoxy is the only choice to complete a resinous flooring install. Due to advances in technology, and modern day science, there are many options that can be offered to the customer for their resinous flooring install. These options consist of epoxies, polyaspartics, cementitious urethanes, MMAs (Methyl Methacrylate's), and others. Each of these products bring unique qualities to the application and we will briefing discuss each below.

General Information on Epoxy Coatings

It is important to note that epoxy flooring installed within industrial installations are 'epoxy coatings' which are much different than epoxy painted surfaces. For example, warehouses, labs, hospitals, automobile shops, car dealerships, loading docks, and many more applications use epoxy coatings. One manufacturer can define an epoxy floor by saying, "Multiple layers of epoxy placed on a floor surface, regardless of the kind of epoxy resins applied, provided that the total thickness of all layers is a minimum of 2mm". This type of epoxy is considered an epoxy paint. Another manufacturer may call out for a specific epoxy material in a specific number of layers to a specific thickness. This is considered an epoxy coatings which carry their own definition. For the purposes of this Technical Design Manual and given they type of use these floors will be installed in, we will be discussing the latter option, Epoxy Coatings.

Each epoxy coating material has its own unique characteristics that help to define exactly how these materials can and should be used. A poor choice of epoxy coating, based on the needs of the application, can result in rapid degradation of the epoxy. An important note, however, is the fact that there can be a vast difference in performance properties with industrial epoxy coatings vs. 'watered down' epoxies that are less expensive and perform at decreased levels. These diluted epoxy coating materials do not perform as well as the more expensive industrial epoxy coating materials which are installed as recommended by the manufacturer. For example LATICRETE offers some 100% high solids epoxies that are formulated to have increased chemical resistance, resistance to yellowing and UV damage, and slip resistance to name a few. Please see the applicable product datasheet for additional information on LATICRETE® epoxy products.

General Information on Polyaspartic Coatings

Polyaspartics are relatively new in the world of decorative concrete coatings, only being introduced in the early 1990s, but have been around in different forms in the coating industry for many years. Polyaspartic coating evolved from a class of material called polyurea, a durable fast drying material that has been used in many industrial applications as a corrosion resistant coating and repair material. Polyureas have two primary problems: Very fast setting (5-10 sec); and poor resistance to UV. Polyaspartics, a specific class of polyureas, have overcome these difficulties while maintaining the same strength, flexibility and chemical resistant properties.

LATICRETE now offers a variety of polyaspartic products with the introduction of our SPARACOTE™ Line. These polyaspartic products include SPARTACOTE FLEX SB that is used in environment that can handle a strong solvent smell during installation and wants a rapid setting, fast drying system. For areas that requires low VOC and low odor the SPARTCOTE FLEX PURE and SPARTACOTE FLEX XPL can be used. These products with the CLINICAL PLUS™ designation offers built in anti-microbial protection and also are low VOC with little to no odor. All of these low VOC/ low odor materials allows for an application in existing areas that are occupied without having to shut down the entire business. For instance, in industrial installations, an installer could section off a room (be it an operating room, classroom or hotel room) to install the coating while the daily operation commence just outside the door. Furthermore, a complete 3 coat system can be installed in a single day and returned to full service the next day. This is because of the unique fast drying capabilities of polyaspartic coatings, typically 1-3 hours between coats. This is very different from the standard epoxy coatings that could take 8-16 hours for each coat to dry or the urethanes coatings that can take 6-8 hours between coats. Additional benefits of polyaspartics are UV stability, color/gloss retention, no hot-tire pickup, high chemical resistance, and high abrasion & impact resistance. Please see the applicable product datasheet for additional information on LATICRETE® polyaspartic products.

General Information on Urethane Cement Coatings

Urethane Cement is basically a combination of a urethane based polymer binder and a cement based filler, although there can be additional fillers added for performance and aesthetic reasons. It is commonly referred to as polymer concrete. There are many benefit of using urethane cement but it is important to remember that this type of flooring is geared to more industrial applications. Given this, aesthetics isn't typically the focus when choosing this coating. This flooring type is chosen based on it physical properties which sets it apart from the rest of the coatings. Urethane cement has exceptional thermal shock qualities. Areas that can experience drastic temperature changes in a short amount of time, like those common seen in commercial kitchen around fryers or in areas where hot water is poured on the floor to clean, tends to weaken other coatings and can lead them to crack or delaminate over time. LATICRETE Urethane Cement products doesn't have this issue

Additionally, urethane cement isn't as effected by moisture in the concrete like the other resinous products are. Polyaspartics and epoxies have concrete moisture restrictions limited to 3 to 5 pounds of moisture per 1000 square feet in a 24 hour period if testing in accordance to ASTM F1869 (calcium chloride test) -or- less than 75% of moisture when testing in accordance to ASTM F2170 (Concrete probe test). Having a moisture limit of 12lbs of moisture per 1000 square feet in a 24 hour period Urethane cement can be placed on the concrete without addition prep. Urethane cement also have additional qualities of high abrasion and impact resistance.

4.2 Polished Concrete Floors

Polished concrete is just as the name implies; concrete which is mechanically grinded, chemically hardened (densified), sealed, and then polished. This process produces a dense concrete which in most cases, inhibits water, oil and other contaminants from penetrating the surface. Polished concrete does have its advantages when used within industrial facilities. FGS PERMASHINE polished concrete system is a great option for a beautiful, aesthetically- pleasing floor that is durable and built to last. Regular maintenance of the flooring, when using this system, does not require the use of harsh abrasives, solvents or waxes. Areas that are suitable to receive this type of flooring would be the kitchen (if applicable), lobby, visiting rooms, and other areas in which the flooring doesn't have to be completely sealed.

Polished Concrete Limitations

As in the case of any floor finish, polished concrete is not suitable for all locations. Situations in which polished concrete will be exposed to acid based chemicals and aggressive cleaning regimens can cause the concrete to become pitted, start to powder or even crack. One difficulty with this happening with any industrial floor is the time required vs. time allotted to perform repairs. Concrete must be properly cured prior to be put back into service and in some locations time is very limited. It is also important to note that these floors, although abrasion resistant, also requires regular maintenance. Most sealers used for polished concrete are topical and are more likely to show wear in the high traffic areas causing the luster to dull. This mean that a recoat of the sealer or a regular maintenance coat of wax will be necessary more often. The process used to create a polished concrete floor eliminates the ability to directly bond a resinous coating or tiled flooring system to the concrete surface. If a different floor finish is sought in the future all sealers would have to be removed and the extremely hard, dense polished concrete surface would have to be profiled by grinding, shot-blasting, or beadblasting

4.3 Carpet

Carpet is a textile floor covering consisting of an upper layer of fibers attached to a backing. The fibers are generally made from wool or a man-made fiber such as polypropylene, and usually consist of twisted tufts which are often heat-treated to maintain their structure. Carpet is widely used in office areas, hallways and other areas typically not subjected to water or vehicular traffic. Carpet is available in many colors and configurations and is an ideal product for use in areas which require sound control.

Carpet Limitations

Of all the products used to finish floors (i.e. tile, stone, terrazzo, hardwood, laminates, etc…) carpet has the shortest life. While tile or stone are expected to last 50 years, carpet has an expected life of 6 years, after which the carpet is usually replaced. While carpet typically has the lowest cost to install of all of the finishes, it would have to be replaced approximately 8 times during the expected life of tile or stone. According to TCNA "TILE: The Natural Choice – Environmental and Cost Evaluation" carpet has a $1.08 cost per year to maintain, while tile ranges from $0.32 to $0.35 per year.

The comfort of carpet is what attracts owners to it. Most carpets offers a soft and cushioned surface when walking atop of it and, when compared to other flooring, is warmer without the addition of a radiant system. However, carpet should not be used in areas subjected to liquids, chemical exposure, vehicular traffic, manufacturing, or other areas which would be difficult to clean, maintain, or where environmental considerations prohibit the use of carpet.

According to the American Lung Association "carpet can also have an impact your health. They may trap pollutants like dust mites, pet dander, allergens, particle pollution, lead, mold spores, pesticides, dirt and dust. Some of the chemicals and glues used to make and install carpets are made with volatile organic compounds (VOCs), which emits odors and pollutants. New carper installation also has been associated with wheezing and coughing in babies in their first year of life" (https://www.lung.org/our-initiatives/healthy-air/indoor/indoor-air-pollutants/carpets.html).

Section 5: Types of Tile for Industrial Applications

5.1 Selection of Industrial Application Tile Types

An industrial floor application can be exposed to some of the harshest and most extreme conditions of any system in a building. In general, many types of quarry tile, pavers, klinker tile, dairy brick, packing house tile and porcelain pavers are suitable for these applications. However, there is no standard formula or recommendation for the selection of these tile types. Selection must be made by an assessment of the individual finish material's functional and aesthetic characteristics in relation to the performance requirements. A discussion of the aesthetic merits of different finish materials is highly subjective and beyond the technical focus of this manual. This section will focus primarily on the functional criteria necessary to determine whether a finish material's physical characteristics satisfy the performance requirements of an industrial application's design and location. While every application can be unique, the following are criteria that can be used to determine general functional suitability of the finish materials:

SELECTION CRITERIA FOR FINISH MATERIAL

- Thermal Movement Compatibility With Adhesive and Substrate
- Chemical Resistance
- Thermal Movement and Shock Resistance
- Adhesive Compatibility
- Dimensional Stability (Heat and Moisture Insensitivity, Moisture Expansion)
- Dimension and Surface Quality/Tolerance
- Characteristics of Ceramic Tile
- Low Water Absorption Rate
- Frost Resistance (Where Required)
- High Breaking Strength
- Slip Resistant

Thermal Movement Compatibility

The tile's rate of expansion and contraction due to temperature changes must be relatively compatible with the tile adhesive mortar. Significant differences could cause excessive stress in the adhesive interface and lead to delamination or bond failure (see Section 7). Minor differences in thermal compatibility are acceptable, and the selection of flexible adhesives plays a critical role in distributing minor differential movement. Accurate prediction of thermal behavior is extremely complex, considering among other things, the amount and rate of temperature changes and the thermal gradients and lag that exists. Figure 5.1 shows typical rates of thermal movement of materials commonly used.

Material	Coefficient of Linear Thermal Expansion (10^{-6} mm/mm/C°)
Ceramic Tile	4 – 8
Granite	8 – 10
Marble	4 – 7
Brick	5 – 8
Cement Mortar	10 – 13
Concrete	10 – 13
Lightweight Concrete	8 – 12
Gypsum	18 – 21
Concrete Block CMU	6 – 12
Cellular Concrete Block	8 – 12
Steel	10 – 18
Aluminum	24
Copper	17
Polystyrene Plastic	15 –45
Glass	5 – 8
Wood – Parallel Fiber	4 – 6
Wood – Perpendicular	30 – 70

Figure 5.1 – Coefficient of linear thermal expansion for various materials.

Chemical Resistance

The finish materials must have good chemical resistance to prevent deterioration from not only chemicals that may be used in cleaning and maintenance, but also alkali and acids associated with the manufacturing of products.

Thermal Shock Resistance

An industrial tile application can be exposed to a tremendous range and rate of change of temperatures. There is a difference between thermal shock and thermal movement. Thermal shock refers to the rate and range of temperature fluctuation within short periods of time. Thermal shock could be experienced by an industrial tile application during manufacturing processes (e.g. hot or cold liquids spilled onto a floor or areas where liquid nitrogen is used). The tile and adhesive for an industrial application must be able to withstand any thermal shock.

Figure 5.2 – Result of improper tile selection for the application. The use of a semi-vitreous tile – 7% in absorption did not stand up to the demands of this installation.

Tiles must be able to resist thermal shock, freeze-thaw, be chemical resistant, dimensionally stable and resist moisture expansion for most industrial applications.

Compatibility with Adhesive

The suitability of adhesives for the proposed application must be evaluated taking into consideration the criteria listed in Section 7 – Selection of Adhesives. Part of that process is evaluating an adhesive's compatibility with the material's composition, surface texture, and other physical characteristics. Polymers of some latex additives not intended for industrial applications could be soluble in water and cause staining problems. This additive could contribute soluble salts and result in efflorescence after repeated water infiltration to the adhesive layer. Depending on the texture and porosity of the material's bonding surface, certain adhesives may require more or less dwell time in order to allow absorption of adhesive, a process known as "wetting out" a surface.

Dimensional Stability (Moisture and Heat Sensitivity)

Generally, the dense and compact nature of a low absorption material will impart good dimensional stability to a material, thereby making the finish material suitable for an industrial application

Dimension and Surface Quality

Ceramic tile, quarry tile, klinker tile, dairy brick and porcelain pavers are manufactured materials, and therefore dimensional. Surface tolerances required for direct adhesion can be assured by selecting materials in compliance with established standards. For ceramic tile the applicable standards would be ISO 10545-2 (Standard for Dimension and Surface Quality) and ANSI A137.1 (American National Standard Specifications for Ceramic Tile), which incorporates ASTM C499 (Standard for Determining Facial Dimensions). For thin brick, ASTM C1088 Type TBX (Specification for Thin Brick Veneer Brick Units Made from Clay or Shale) governs dimension and surface quality. Stone is generally fabricated to specification for a variety of methods of installation. There are uniform standards for dimension and surface quality of stone tiles or slabs listed for individual varieties of stone. However, the use of stone is generally not acceptable for industrial applications

Characteristics of Ceramic Tile

In order to select the most suitable type of ceramic tile or pavers for an industrial application, and to understand the technical considerations for adhesive compatibility and installation, the specifier must have a general understanding of the classifications and physical properties of ceramic tile.

Classification of Ceramic Tile by Water Absorption				
ISO (International Standards Organization) CEN (European Norms)				
	Group I	Group II	Group IIb	Group III
Absorption	≤ 3%	3 - ≤6%	6 - ≤10%	> 10% shaping
Group A	Group A1	Group AIIa	Group AIIb	Group AIIII extrusion
Group B	Group B1	Group BIIa	Group BIIb	Group BIIII dustpressed

Figure 5.3 – Classification of ceramic tile by water absorption. (EN or ISO Standards).

Classification of Ceramic Tile by Water Absorption	
ANSI Standards	
Classification	**Water Absorption**
Non Vitreous	>7%
Semi-Vitreous	3 – 7%
Vitreous	0.5 – 3%
Impervious	<0.5%

Figure 5.4 – Classification of ceramic tile by water absorption (ANSI Standards).[1]

Water Absorption (Body of Tile)

The definition of water absorption is the measure of the amount of water that can be absorbed through pores of the ceramic tile. This characteristic is an indication of a ceramic tile's structure and overall performance. Water absorption is measured by ASTM C373 (Standard Test Method for Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Whiteware Products) and ISO 10545-3 (Determination of Water Absorption, Apparent Porosity, Apparent Relative Density, and Bulk Density) as a percentage difference between dry and wet weight of tile. The water absorption characteristics of ceramic tile have significant influence on many other physical characteristics that are important to proper performance in industrial applications. Water absorption of ceramic tile for industrial applications should be 3% or less. One important note on water absorption; today, porcelain ceramic tile is the most popular choice. However, precision manufacturing processes now allow porcelain tiles with under 0.05% (negligible) water absorption rates. While this creates an extremely durable product, it makes adhesion with traditional portland cement adhesives difficult, because these types of adhesives rely on absorption of cement paste to provide mechanical locking of crystals within the pore structure of the tile body. Porcelain tiles require the additional adhesive power of latex thin-set mortars or epoxy adhesives in order to develop the high bond strength and flexibility required for industrial applications

Thermal Shock

The definition of thermal shock is the resistance to internal stress when a tile undergoes rapid changes in temperature. The significance of this characteristic is that it provides an indication of good performance in industrial applications where there are constant cycles of thermal shock. Thermal shock is measured by ASTM C484 (Standard Test Method for Thermal Shock Resistance of Glazed Ceramic Tile) and ISO 10545-9 (Determination of Resistance to Thermal Shock) where there are no defects after 10 cycles of sudden temperature change to and from 60 to 220°F (15 to 105°C). Industrial applications experience sudden temperature changes on a repeated basis. Hot or cold liquid spills can subject the tile to thermal shock. Therefore, this consideration is critical in determining the suitability of the tile for this purpose.

Thermal Expansion/Contraction

The definition of thermal movement is the amount of expansion or contraction a tile undergoes from temperature changes. The significance of this characteristic is that tile expands with temperature increases and contract with temperature decreases. The measurement of a tile's thermal coefficient of expansion provides the designer with the information necessary to determine compatibility of the tile with the substrate and adhesive materials, to calculate movement differentials, and for the design of movement (expansion) joints. Thermal expansion is measured by ASTM C372 (Standard Test Method for Linear Thermal Expansion of Porcelain Enamel and Glaze Frit and Fired Ceramic Whiteware Products by the Dilatometer Method) and ISO 10545-8 (Determination of Linear Thermal Expansion) and expressed as the linear coefficient of thermal expansion in units of in/in/°F (mm/m/°C).

Frost Resistance

Frost resistance measures the ability of the ceramic tile to resist the expansive action of freezing water. This characteristic is dependent on the tile absorption rate and the shape and size of pores. It is measured by ASTM C1026 (Standard Test Method for Measuring the Resistance of Ceramic Tile to Freeze-Thaw Cycling) and ISO 10545-12 (Determination of Frost Resistance). In many cases, industrial applications where freeze/thaw may be an issue can include cooler and freezer areas.

Breaking Strength (Modulus of Rupture)

Breaking strength primarily determines resistance to the handling and installation process. This characteristic is a measure of the tile material and not the tile itself. For example, if you compared two tiles of the same material with one being twice as thick, both would have the same unit breaking strength, but the thinner tile would require 75% less load or force to break. Impact resistance in service (fully adhered) is approximately 10 times greater than the minimum standard. It is measured by ASTM C648 (Standard Test Method for Breaking Strength of Ceramic Tile) and ISO 10545-4 (Determination of Modulus of Rupture and Breaking Strength) which requires a minimum strength for all floor tile of 250 psi (1.75 Mpa).

Moisture Expansion

Moisture expansion is the dimensional change of ceramic tile as a result of changes in moisture. This is a significant characteristic for tile used in industrial applications because moisture expansion of clay is irreversible. It is measured by ASTM C370 (Standard Test Method for Moisture Expansion of Fired Whiteware Products) and ISO 10545-10 (Determination of Moisture Expansion). Moisture expansion is directly proportional to absorption; the lower the absorption, the greater the resistance to moisture expansion and vice versa. In order to accommodate moisture expansion, there must be properly placed expansion joints within the installation itself to prevent heaving or failure due to moisture expansion of the finish material.

Slip Resistance (Dynamic Coefficient of Friction)

Many tiles are manufactured for floor use in mostly dry applications. Tile used for industrial environments should be slip resistant and have a high coefficient of friction. Testing for determining the coefficient of friction should be performed to comply with ANSI A326.3, Test Method for Dynamic Coefficient of Friction of Hard Surface Flooring Materials.

Chemical and Stain Resistance

The definition of chemical resistance is the behavior of tile when it comes into contact with aggressive chemicals. Chemical resistance actually measures deterioration caused by two mechanisms;

1) Chemical reaction resulting in alteration of tile and;
2) Penetration of a chemical or stain below the tile surface along with the difficulty of removal resulting in long-term deterioration or effect on materials in contact with the surface. Chemical and stain resistance is measured by ISO 10545-13 (Determination of Chemical Resistance) by determining visual deterioration after exposure to standard chemical solutions (cleaning detergents, bleach, lactic and sulfuric acid, potassium hydroxide/alkali). The importance of this characteristic for industrial applications is the resistance to deterioration and staining caused by exposure to various acids and alkalis and the resistance to cleaning chemicals necessary for normal maintenance.

Figure 5.5 – Quarry Tile Floor – Photo courtesy of The Flooring Factory.

5.2. Quarry Tile/Klinker Tile

The durability and functional qualities of industrial use quarry tile make it one of the most suitable finishes for these applications. As you might expect, there are an extraordinary number of different types and sizes of tile, only some types of tile have the physical characteristics required to be used in industrial applications. Generally, these tiles can range in size from 4" x 8" (100 mm x 200 mm), to 6" x 6" (150 mm x 150 mm), to 8" x 8" (200 mm x 200 mm).

The raw materials for quarry tile are a mixture of clay (to give plasticity), quartz sand (to give structural strength and an economical filler), and carbonates or feldspars (to provide fluxing/fusing action). Glazes are formed from sand, kaolinitic clay, prepared glasses (frit), and oxide based pigments to provide color. The raw materials are ground together with water. The raw material for ceramic tiles are typically dried to a moisture content of 4–7% and shaped by the dust pressed method at pressures of 4,270 psi (29.5 MPa) or higher.

Some tiles used may be formed by the extrusion method, where clay with a moisture content of 15–20% is extruded through a die of desired shape. After forming, the raw tile or “bisque” is dried to remove excess water and fired in kilns operating at temperatures of 1750–2200°F (950–1200°C). This results in vitrification or fusing of the clay and fillers, producing a tile product that is dense and non-porous. As mentioned previously, low water absorption is a key physical characteristic of industrial materials and has significant influence on the other physical characteristics.

Klinker tiles are defined as red body tiles formed by either the extrusion process or dust pressing. Klinker tiles can also be referred to as red stoneware. This tile type can be glazed or unglazed and generally has a water absorption rate of less than 0.7%.

Figure 5.6 – Red and Black Klinker tiles.

5.3 Dairy Brick and Packing House Tile

Dairy brick and packing house tile are very similar to brick in appearance. Dairy brick and packing house tiles are usually physically larger in dimension and thicker than thin brick. The difference in thickness allows the dairy brick and packing house tile to withstand the physical punishment that an industrial application demands. There are varying thicknesses of dairy brick depending upon the conditions to which the brick will be exposed. Light duty applications may require a thinner brick and extra heavy duty applications may require the brick to be thicker.

Physical characteristics (i.e. size, shape, color, absorption rate) of dairy brick vary considerably, depending on the source and grade of brick. Therefore, dairy brick manufacturers should be consulted early in the design stage of a building to determine the suitability of a product for an industrial application.

Dairy brick is typically available in thicknesses ranging from 3/8" – 1 1/4" (10 mm – 31 mm) and can have various facial sizes, shapes and textures. Variations in brick color and surface defects can occur, so it is important to pre-blend brick prior to installation for uniform visual appearance.

Typically, the bonding side of dairy brick and quarry tile has a key-back or grooved configuration in order to develop better mechanical lock with the bonding adhesive. The adhesive bond between the bonding surface of the dairy brick or quarry tile and the substrate will vary depending on the absorption of the clay. Low absorption of finish materials, while imparting durability to the brick, will result in reduced mechanical bond of latex cement mortars.

5.4 Porcelain Tile and Pavers

Porcelain pavers generally have a very low absorption rate just like porcelain tile (less than 0.5%). Porcelain pavers are generally considered full body porcelain products which means the middle of the porcelain paver looks just like the outside of the porcelain paver. This works well in industrial applications due to the fact that if a tile is chipped or broken, it is more difficult to notice the defect. Due to its dense nature, porcelain tiles are able to resist abrasive environments which can be found in industrial applications.

Figure 5.7 – Porcelain tiles.

5.5 Abrasive Tile/Treatments

Abrasive tiles are used in areas to prevent slipping and where greater traction is required. Abrasive tiles are manufactured to have a high coefficient of friction or slip resistance built into the product. These types of tile are frequently installed in commercial and industrial kitchen applications, due to the amount of oil and water on the floor, to help prevent kitchen personnel from being injured by slipping on a slick surface. In addition, abrasive tile is used on ramp areas to increase traction and reduce the potential for slip/fall accidents. Generally, corundum or metallic shavings are mixed in with the clay prior to the firing or extrusion process. These shavings become an integral part of the tile body. Abrasive tile can be manufactured in the form of quarry tile, klinker tile, dairy brick and porcelain pavers. In extreme cases where extra slip resistance is required, double abrasive tile can be used.

There are also treatments that will help aid in slip resistance for tiles that do not have a high coefficient of friction. The treatments are spray applied to the tile. The treatment eventually becomes part of the tile itself. These treatments can last for years and can help to reduce the possibility of slip/fall accidents. Abrasive treatments usually require regular cleaning with non-abrasive cleaners. See Section 9.5 Protection and Sealing – Water repellant sealers and coatings for more information on applying surface sealers to tile surfaces.

5.6 Expansion and Contraction of Industrial Floor Tile Finishes

Quarry tile and dairy brick will permanently increase in volume as a result of absorption of atmospheric moisture after removal from the kiln after firing. The total recommended design coefficient for moisture expansion as recommended by the Brick Institute of America is 3–4 x 10 –4" per inch of length. Factors affecting moisture expansion are:

Time of Exposure – 40% of the total expansion will occur within three months of firing and 50% will occur within one year of firing.

Time of Installation – Moisture expansion will depend on the age of the brick and the remaining potential for expansion.

Temperature – The rate of expansion increases with increased temperature when moisture is present.

Humidity – The rate of expansion increases with the relative humidity. Brick exposed to a relative humidity of 70% will have moisture expansion rates two to four times as great.

In addition to permanent moisture expansion, brick will undergo reversible expansion and contraction due to changes in ambient air and surface temperatures.

A tile with an average coefficient of linear expansion of 7.3 x 10 -6"/°F could expand and contract up to 7/8" (20 mm) over a distance of 100' (30 m) in as little as 2 hours if it is cool and then subjected to steam cleaning or other source of heat! This is not only a graphic example on the importance of movement joints, but also the importance of using a flexible, low modulus adhesive that can absorb the differential movement between the finish material and the underlying substrate[2].

5.7 References

1. American National Standard Specifications for Ceramic Tile, ANSI A137.1, American National Standards Institute.

2. Brick Institute of America, “Thin Brick Veneer,” Technical Notes on Brick Construction # 28C, Feb. 1990

Section 6: Types of Membranes

6.1 Overview

Waterproofing protection is one of the most practical steps to ensure the longevity of an industrial tile installation. It not only protects the spaces below and adjacent to the tile and finish flooring installation, it also protects the setting bed, reinforcing wire (if used), concrete base and concrete reinforcing from potential damage and corrosion. Since damage to many flooring components can occur, it is no surprise that the majority of construction liability claims involve water damage that has resulted from the lack of, or an improperly installed, waterproofing membrane. Today's pressures of completing projects in a timely matter, often leads to installations being rushed and not installed correctly. The advanced technology that goes into waterproofing and anti-fracture membranes allows the end-user to take advantage of quicker curing times, which allows quicker flood testing and ultimately allows the installations to move forward in a timely fashion. Various types of waterproofing and anti-fracture membranes include; troweled applied types, liquid applied and sheet types. The traditional asphaltic/bitumen-based roofing type waterproofing membranes are omitted from this manual. However, it is important to note that if they were to be specified and used in an industrial flooring application, a full, wire-reinforced non-bonded thick bed mortar bed (following LATICRETE ES-F111 or TCNA Method F111) would be required for tile installations. Direct bonding to these membrane types is not possible.

The most important factor in all types of waterproofing membranes is to closely follow the setting material manufacturer's installation recommendations. This will significantly reduce the possibility of job site problems and potential failures. Adhering to industry standards is also paramount to the success of the installation. Consideration should be given to membranes that carry plumbing and building code approval as well as being environmentally friendly (e.g. HYDRO BAN®).

Many crack isolation and waterproofing membranes can be applied over concrete, mortar beds, exterior glue plywood and cement backer board. Some waterproofing membranes serve as both waterproofing and anti-fracture membranes in one (e.g. HYDRO BAN).

The installation of waterproofing is covered under ANSI A108.13 (Installation of Load Bearing, Bonded, Waterproofing Membranes for Thin-set Ceramic Tile and Stone), and crack isolation is covered under ANSI A108.17 (Installation of Crack Isolation Membranes). The product standards for waterproofing can be found under ANSI A118.10 (American National Standard Specifications for Load Bearing, Bonded, Waterproof Membranes for Thin-set Ceramic Tile and Dimension Stone Installation) and the product standards for crack isolation membranes can be found under ANSI A118.12 (American National Standard Specification for Thin-set Ceramic Tile and Dimension Stone Installation). Selection of membranes must take into account the conditions of an industrial application including exposure to high temperatures, chlorinated cleaners, and chemicals that will be used or exposed to the tile installation.

6.2 Sheet Membranes

Sheet membranes are typically made from chlorinated polyethylene, polyvinyl chloride, and other materials. Sheet membranes are made in a variety of lengths and widths to accommodate many different types of installations, with product performance that can vary depending on the manufacturer and product type. Generally, these sheet membranes have polyester or fiberglass mesh bonded to both sides of the membrane sheet which allows the membrane to be bonded to the substrate, and tile or pavers to bond directly to the sheet membrane.

Typically, a latex portland cement mortar meeting ANSI A118.4 or ANSI A118.15 (American National Standards Specifications for latex-portland cement mortar) is used to bond the membrane to the substrate and to bond tile to the membrane. If time is a limiting factor, some membrane manufacturers allow the use of a special quick-setting glue to adhere the membrane to the substrate, which in turn allows the installation of tile to take place immediately without the loss of bond from the membrane to adhesive.

It is very important to consider the moisture vapor emission rate (MVER) and the alkalinity of the concrete slab prior to the installation of these products. A high MVER rate and/or high alkalinity can create adhesion problems and can even be destructive to the membrane and the overall installation. The sheet membrane manufacturer can provide information on the MVER and alkalinity limits of their products.

Sheet type membranes are pressed into contact with the substrate in an effort to eliminate air bubbles and voids between the membrane and substrate. Generally this can be done using a 75- or 100- (34 or 45 kg) pound sheet vinyl roller. It is important to note that the substrate or setting bed surface must meet the same substrate smoothness criteria required for direct bond tile applications. If the surface is not smooth and flat enough for tile, then it is not smooth and flat enough for a membrane.

Precautions and concerns with sheet-type membranes are as follows:

1. Trapping air below the membrane can cause air pockets to form and radically diminish the compressive strength of the membrane.
2. Overlapping and sealing the seams. The seams can be treated with a suitable sealant or solvent. This process can be very involved and requires careful attention to detail.
3. Membrane thickness increases in the folds of inside and outside corners, seams and other transition areas. Additional flashing or skim coating treatment may be necessary to minimize the effects that this can have on the finish tile appearance.
4. High alkalinity can attack and adversely affect some sheet type membranes and the adhesive used to adhere the membrane to the substrate.
5. High MVER, generally in excess of 5 lbs/ 1000 ft^2 (11 kg/92.9 m^2) in 24 hours, can have a negative impact on the adhesion of sheet-type membranes (follow manufacturer's guidelines for MVER). In these instances, the use of a moisture vapor reduction membrane (e.g. VAPOR BAN™ or NXT® Vapor Reduction Membrane should be placed over he concrete slab prior to the installation of the membrane.

6.3 Peel and Stick Membranes

Peel and stick membranes are very similar to sheet type membranes in performance. The major difference between the two styles is that the peel-and-stick type does not rely on a separate adhesive to bond it to the substrate. These membranes are generally asphalt-based with a reinforcing fabric on the tile bonding side of the membrane and a removable Kraft paper type backing which exposes a tacky surface once it is peeled away. The installation of peel-and-stick membranes begins with priming the substrate with the appropriate primer for the application. Some primers are latex based types and others can be epoxy-based materials.

Once the primer is in place, the removable film is peeled from the back side of the membrane and rolled onto the primed floor.

Precautions and concerns with sheet type membranes are as follows:

1. Careful consideration must be taken where the seams overlap. Spreading the tile mortar over the seam can be tricky to avoid humps where the tile lays over the seam.
2. These types of membranes have a tendency to soften when exposed to sunlight. Windows that face the sun and let more sunlight in could pose problems for peel and stick membranes.
3. Cleaning regimens also play a factor in whether peel-and-stick membranes should be used or not. Solvents typically have an adverse effect on this type of membrane. Consult the manufacturer for specific applications.

6.4 Trowelable Membranes

Trowel applied membranes come in various forms, including latex-fortified cement-based types, epoxy resin types and urethane types. Some of the trowel-applied membranes include a reinforcing fabric used to reinforce corners, coves, and to tie into plumbing fixtures (including drains). After the typical pre-treatments are made to cracks and transition areas, the main application normally consists of keying the membrane into the substrate with the flat side of the trowel. This is immediately followed by combing the material in a singular direction, and then finally another pass with the flat side of trowel to smooth the surface. A key element are the notches in the trowel act as a gauging device for the membrane. Most membranes require a certain thickness of product to ensure complete waterproofing coverage. As with all waterproofing membranes, the products should be applied at the continuous required mil thickness to ensure waterproofing integrity. The use of a wet film gauge is recommended to assure acceptable uniform thickness.

LATEX CEMENT-BASED MEMBRANES

This membrane type is generally comprised of a liquid latex polymer blended into a portland cement-based powder. These products can be one component powders mixed with water (e.g. HYDRO BAN® Cementitious Waterproofing Membrane) or two component latex additive with cement powder products. These products are generally more economical in cost and easy to apply. However, the physical characteristics of these types of products generally restrict their use in demanding applications that require chemical and shock resistance.

EPOXY-BASED MEMBRANES

Epoxy membranes are normally three-component systems consisting of an epoxy hardener, epoxy resins, and a filler powder. These products are generally very chemical-resistant and suitable for industrial applications. Some other advantages to this type of waterproofing are as follows:

- Flood Testing Can be Performed Quickly, Sometimes in as Little as 24 Hours at 70°F (21°C)
- Adheres to Metal, Such as Stainless Steel, Aluminum Cooler Floor and Base Areas as Well as Metal Plumbing Fixtures
- Flexible and Able to Adhere to Most Substrates
- Can be Used as a Flashing Membrane to Tie Into Other Types of Membranes or Surfaces When Required

An example of this type of waterproofing membrane is LATAPOXY® Waterproof Flashing Mortar.

URETHANE BASED MEMBRANES

Urethane-based waterproofing membranes are soft, rubbery materials that are usually applied in a minimum thickness of 60 mils (1/16" [1.5 mm]) and may be as thick as 90 – 125 mils (1/8" [3 mm]). This material type generally cures very slowly and the ultimate finish remains relatively soft and tacky after placement

These membrane types are generally chemical-resistant and would hold up under typical chemical attack. However, the disadvantages of the membranes will usually outweigh the advantages. For example, this membrane type generally will not hold up well under the shock and impact loads that industrial applications experience. This membrane type can creep and deform under load. Therefore, ceramic tile and pavers would not have sufficient support. Consequently, under traffic and point loading or even normal service requirements, the installation could develop severe cracking of the joints and even cracked or broken tiles.

The ceramic tile industry recommends that a conventional, wire-reinforced, non-bonded thick mortar bed mortar be placed over soft urethane waterproof membranes and over soft built-up asphalt waterproof membranes.

6.5 Liquid Applied Membranes

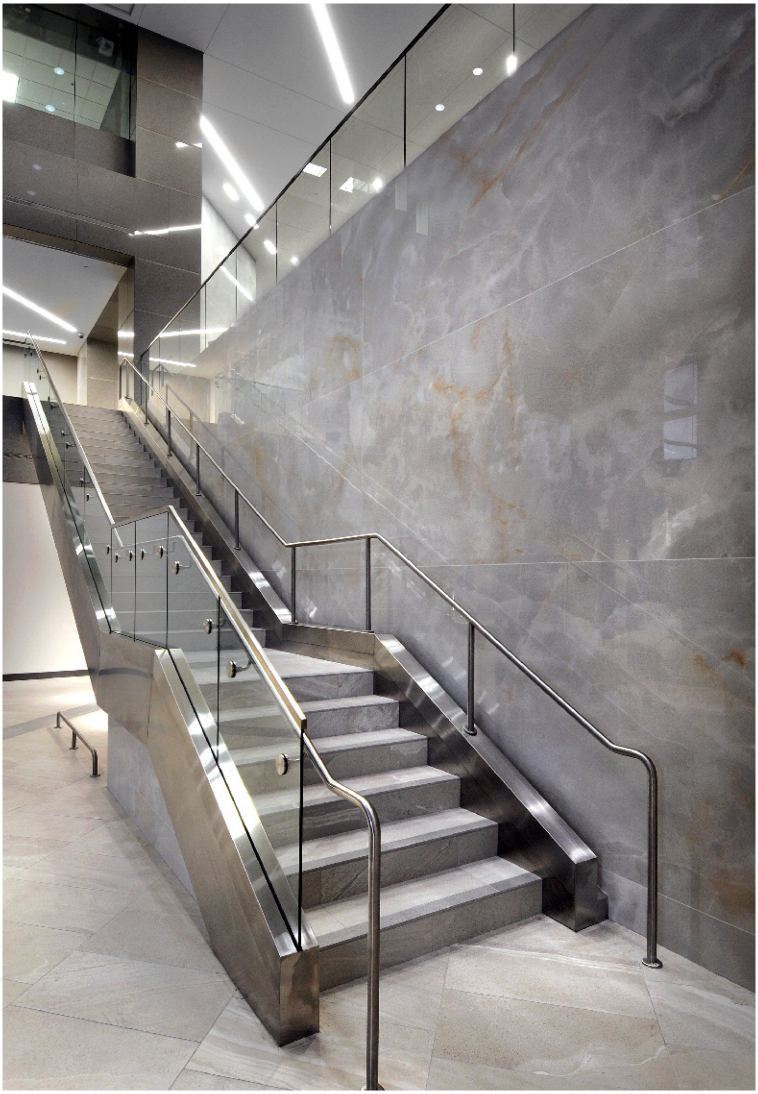
This category type offers an ideal solution to the demanding requirements of industrial applications. In addition to holding up under normal conditions in industrial applications, liquid applied waterproofing membrane types are the easiest to install and provide many features and benefits. These features and benefits include:

- Provide Both Waterproofing and Anti-Fracture Protection
- Meet ANSI A118.10 (American National Standard Specifications for Load Bearing, Bonded, Waterproof Membranes for Thin-set Ceramic Tile and Dimension Stone Installation)
- Meet ANSI A118.12 (American National Standard Specification for Crack Isolation Membranes for Thin-set Ceramic Tile and Dimension Stone Installation
- Plumbing Code Approved
- Green Building Approved for Low VOC Content
- Thin, Load Bearing and Shock Resistant
- Fully Compatible With the Entire Ceramic Tile or Paver Installation Materials
- Fully Formable to Fit Into Tight Areas
- Can be Shaped to Follow Any Substrate Contour
- Flood Testing Can Vary According to the Membrane Type and Generally Ranges From 24 Hours to 7 Days at 70°F (21°C)
- Some Liquid Applied Waterproofing Membranes (e.g. HYDRO BAN®) May be Spray-Applied With a Commercial, Airless Sprayer

Figure 6.1 – Liquid applied membrane applied to concrete substrate.

An example of this category type is HYDRO BAN. HYDRO BAN is a single component, thin, load-bearing, self-curing liquid rubber polymer membrane that does not require the use of fabric in the field, coves or corners.

Section 7: Types of Mortars/Adhesives/Grouts



7.1 Adhesive and Mortar Performance and Selection Criteria

The performance and use of ceramic tile adhesives are regulated by country or region according to prominent standards that govern the installation of ceramic tile. These standards are discussed in Section 10. Compliance may either be mandatory or voluntary in the respective countries, depending on whether the standard is incorporated into a building code (see Section 10).

CRITERIA FOR SELECTION OF ADHESIVES AND MORTARS

- High Adhesive Strength (Tensile and Shear Bond Strength)
- Water-Resistant
- Flexible (Differential Movement)
- Permanent
- Fire- and Temperature-Resistant
- Non-Toxic and User-Friendly
- Good Working Properties (Open Time, Pot Life, Sag Resistance)

High Adhesive Strength (Tensile and Shear Bond Strength)

Shear stress occurs when a force is applied parallel to the face of the material. The greater the resistance to shear stress, the higher the shear strength result.

Tensile stress occurs when a force is applied to pull a material to the point where it loses bond with the surface to which it is applied. The greater the resistance to tensile stress, the higher the tensile strength result.

Tile installations can experience both shear and tensile forces. It is important to note that shear bond testing is limited to laboratory testing. On the other hand, tensile bond testing can be performed in both laboratory conditions and in the field. Therefore, both tests are applicable and suitable to measure a material's bond strength.

The shearing force exerted by seismic activity is by far the most extreme force that an adhesive must be able to withstand. The shear stress exerted by an earthquake of a magnitude of 7 on the Richter Scale is approximately 215 psi (1.5 Mpa) so this value is considered the minimum safe shear bond strength of an adhesive to both the surface of the finish materials and the substrate (Figure 7.1).

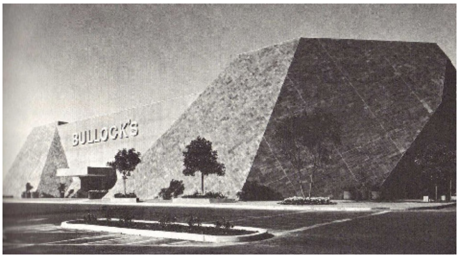


Figure 7.1 – High adhesive shear and tensile strength to resist seismic movement. Before photograph of building prior to the Northridge California earthquake in 1994. Tiles were installed on the exterior façade with LATICRETE® 4237 Latex Additive mixed with LATICRETE 211 Powder.

Figure 7.2 – High adhesive shear and tensile strength to resist seismic movement. Photograph of the Bullocks building after the Northridge California earthquake in 1994. Tiles remain adhered after severe shear stress from seismic activity and structural failure.

Water Resistance

For proper exterior and interior wet area performance, and in demanding industrial applications, an adhesive must not be soluble in water after cured. The adhesive should also develop water insensitivity within 24 hours so as not to require an unreasonable degree of protection against deterioration in the event of exposure to water.

Flexible (Differential Movement)

Adhesives must be flexible (low modulus of elasticity), to withstand differential movement between the finish material and the underlying substrate/structure. Differential movement can be caused by uneven or sudden temperature changes, moisture expansion or shrinkage of the finish material, substrate or the structure, or other loads such as wind or seismic activity (see Section 2 and 3).

Permanence

This criteria may seem obvious, but even if all other performance criteria are met, beware that some "old" technology urethane or epoxy adhesives can deteriorate over time, depending on how they are chemically modified, even if installed properly. Some epoxies can become brittle with age, and some urethanes can undergo a phenomena known as "reversion," where the adhesive may soften and revert back to its original viscous state. Certain polymeric modification of cement mortars work only to enhance the workability and curing process to improve the physical characteristics of cement, but do not contribute any significant lasting improvement to physical characteristics of the cement adhesive mortar.

Fire and Temperature Resistance

When cured, adhesives must meet building codes and standard engineering practice by not contributing any fuel or smoke in the event of a fire. In addition, the adhesive must maintain strength and physical properties during and after exposure to high temperatures of a fire, or from absorption of heat under normal service.

Non-Toxic and User-Friendly

The adhesive should be non-hazardous during storage, installation, and disposal. This includes other materials which may be necessary for preparation or final cleaning. The adhesive should be nontoxic, non-flammable, low odor, easy to use, user-friendly to the applicators, and environmentally (VOC) compliant. It is always best to look for a third party endorsement for the installation materials in this regard (e.g. GREENGUARD). For example, LATICRETE International, Inc. manufacturers a variety of setting materials that are low VOC as certified by GreenGuard. For more information, please visit our web site at www.laticrete.com/green.

Good Working Properties

The adhesive should have good working properties to insure cost-effective and problem-free installation. This means that adhesive must be easy to handle, mix, and apply without having to take extraordinary precautionary measures. Good initial adhesive grab to substrate and the finish material, long pot life, long open time (tacky, wet surface after spreading), vertical sag resistance (both the adhesive alone and with tile), and temperature insensitivity are all recommended working properties.

7.2 Types of Adhesives and Mortars

TYPES OF ADHESIVES

- Redispersible Polymer-Fortified Cement Mortar (Mixed With Water)
- Liquid Latex-Fortified Cement Mortar (Latex in Lieu of Water)
- Modified Emulsion Epoxy Adhesives (Cement, Water, Epoxy Resins)
- Epoxy Resin Adhesives (100% Solids Epoxy)

REDISPERSIBLE POLYMER-FORTIFIED CEMENT MORTAR

This type of cement-based adhesive mortar is available only as a manufactured proprietary product. There are a wide variety of these types of adhesive mortar products on the market. These materials typically are mixed with potable water; however, many redispersible polymer mortars can be mixed with liquid latex additive to improve performance (see latex-fortified cement mortar). For example, 220 Marble & Granite Mortar can be mixed with either water for good performance or with 3701 Mortar Admix for improved performance. These adhesive mortars differ mainly by the type and quantity of polymeric content. Performance characteristics may comply with either ANSI A118.1 (American National Standard Specifications for Dry-Set Portland Cement Mortar) or A118.4 (American National Standard Specifications for Latex-Portland Cement mortar). In addition, premium high strength redispersible polymer-fortified thin bed mortars are available and suitable for use in industrial applications. For example, 257 TITANIUM™ or MULTIMAX™ Lite are ideal for these areas. Performance characteristics of 257 TITANIUM and MULTIMAX Lite comply with both ANSI A118.4 (American National Standard Specifications for latex-portland cement mortar)and ANSI A118.11 (American National Standards Specifications for exterior glue plywood latex-portland cement mortar) standards. Please visit www.laticrete.com for more information on each LATICRETE product including mixing instructions.

Figure 7.3 – Mixing of liquid latex-fortified portland cement thin-set mortar.

Types of Redispersible (Polymeric) Powders

- Modified Cellulose
- Polyvinyl Acetate Powder (PVA)
- Ethylene Vinyl Acetate Copolymer Powder (EVA)
- Polyacrylate Powder

Many redispersible powder cement mortars available on the market are not recommended for industrial applications for a variety of reasons. Some of the polymers used, such as PVA's, are water soluble and can re-emulsify after prolonged contact with moisture, causing polymer migration and resulting in staining, loss of flexibility and strength. Most products that conform to ANSI 118.1 (American National Standard Specifications for Dry-Set-Portland Cement Mortar) adhesive standards contain only water-retentive additives such as cellulose, which provides water retention for prolonged open time and improvement of working properties, but ultimately provides minimal improvement of strength or flexibility when compared to traditional cement mortar.

EVA fortified mortars that conform to ANSI 118.4 (American National Standard Specifications for Latex-Portland Cement Mortar) standards may require special formulation and vary in quantity of the polymeric powder in order to have the characteristics and physical properties required for an industrial application. Some, but not all products which employ EVA polymers have poor resistance to prolonged moisture exposure and are not recommended for industrial applications. While dry redispersible polymer-fortified adhesives are economical and easy to use, it is recommended to verify suitability for use in industrial applications with the manufacturer, and to request or conduct independent testing to verify the manufacturer's specified performance.

EPOXY RESIN ADHESIVES

This type of adhesive is typically a three-component system, consisting of epoxy resin and hardener liquids, and some type filler material, such as silica sand. Epoxy adhesives which conform to ANSI A118.3 (American National Standard Specifications for Chemical-Resistant, Water Cleanable Tile-Setting and – Grouting Epoxy and Water Cleanable Tile-Setting Epoxy Adhesive) essentially contain 100% epoxy solids. LATAPOXY® 300 Adhesive is a high strength 100% solids epoxy that works well for industrial applications. It is important to note that while the grouting materials will take the brunt of any potential chemical attack, some chemicals and strong cleaners can work their way through the tile and even attack the adhesive over an extended period of time. Therefore, it is important to consider that this potential problem exists. The use of LATAPOXY 300 Adhesive can ensure the long-term performance of an industrial floor exposed to chemical attack. Chart 7.16 depicts the chemical resistance of LATAPOXY 300 Adhesive to common chemicals and cleaners. More economical versions of epoxy adhesives, known as modified epoxy emulsions, are also available in the market.

Modified epoxy emulsions which conform to ANSI A118.8 (American National Standard Specifications for Modified Epoxy Emulsion Mortar/Grout) consist of special epoxy resins and hardeners which are emulsified in water, and then mixed with cement mortar. This type of epoxy adhesive combines the economy of cement-based mortars and the high strength of epoxy adhesives. An example of this type of material is LATAPOXY 210 Adhesive. The advantages of epoxy adhesives are that they have exceptionally high adhesive strength (shear bond and tensile strength) to most any type of substrate material suitable for a tile installation, and more recent formulations have good flexibility to accommodate differential movement. While modified epoxy emulsions have lower strengths than 100% solid epoxy resin adhesives, they benefit from the higher temperature resistance and economy of portland cement adhesives. The primary disadvantages are that epoxy adhesives can be significantly more expensive, and the working qualities in cold or warm temperatures possible with many industrial application conditions during construction, can limit production and further escalate costs. Sag resistance and temperature resistance are secondary limitations, depending on the requirements for the installation. Epoxy adhesives can bond to virtually any suitable substrate which is structurally sound. They are often recommended as a supplementary adhesive to more economical cement-based systems when the tile or pavers must be adhered to unusual substrates (e.g. steel coolers, freezers, fiberglass or other metal substrates).

FURAN (FURNANE) ADHESIVES

This type of setting material is typically a two-part mortar system of furan resin and furan hardener used for bonding tile to back-up material where chemical resistance of floors is important. These adhesives meet ANSI 118.5 (American National Standard Specifications for Chemical-Resistant Furan Mortars and Grouts for Tile Installation) and are known for their strong chemical resistance. However, these materials generally are hard to use, caustic, hazardous to one's health, require the use of respirators, give off pungent odors and are high in VOC content.

Furan adhesives and mortars can be grouped with the following chemical categories:

- Vinyl Ester Resins
- Furan Resins
- Epoxy Novolac Resin
- Carbon-Filled Furan Resins
- Carbon-Filled Vinyl Ester Resins
- Phenolic Resins

BONDING AGENTS (SLURRY BOND COATS)

Bonding of conventional cement mortars can be achieved by bonding agents or slurry coats. There are three main types of bonding agents: cement-based slurries, latex emulsions (either latex alone or mixed with cement/cement-sand), and epoxies. These materials should meet the requirements of ASTM C1059 (Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete) for latex bonding agents and ASTM C881 (Standard Specification for Epoxy Resin Base Binding Systems for Concrete) for epoxies. Bonding agents are typically applied after substrate preparation and just prior to installation of leveling mortars or the tile and pavers. A thin coat, 1/8" [3 mm] maximum of slurry (a wet, creamy consistency) is vigorously brushed into the substrate surface (and/or onto the tile or paver) and installation is made while the slurry remains wet and tacky. Latex emulsions may be of the styrene butadiene or acrylic type (see types of liquid additives), but do not use soluble polyvinyl acetate (PVA) bonding agents. 257 TITANIUM™ slurry bond coats. Epoxy slurry bond coats should only be utilized in specialized or isolated conditions, as the epoxy can form a vapor barrier and cause delamination failure from entrapment of moisture vapor. It is a common misconception that bonding agents are a high-technology substitute for substrate preparation. This is not true; bonding agents or slurry bond coats are not designed to compensate for poor substrate preparation or conditions.

7.3 Methods of Installation

There are several methods generally used in the installation of tile and pavers in industrial applications.

APPLICATION METHODS FOR INDUSTRIAL INSTALLATIONS

- Thin Bed
- Large and Heavy Tile (LHT) Mortar Method
- Thick Bed (Unbonded Wire-Reinforced Cured Thick Bed Method, Unbonded Wire-Reinforced Wet-Set Method, Bonded Type Wet-Set Method, Bonded Type Cured Thick Bed)

Thin Bed Method

This method, also referred to as the adhesive method, is defined as an application of a layer of adhesive, ranging from a minimum of 1/8" (3 mm) to a maximum of approximately 3/8" (9 mm) thick that is in full contact with no less than 95% of the bonding surface of the tile or paver. The substrate is prepared to proper level and plumb in advance; adhesives are not intended for leveling or correcting level and plumb deviations. The adhesive can range from a pure or neat portland cement paste, to latex cement and epoxy adhesives. The thickness of the adhesive layer is dependent on the type and size of the tile or paver, the tile or paver and substrate bonding surface texture, configuration of the tile or paver (flat or ribbed back), and tolerance from consistent thickness. A “gauged” tile or paver is one with a consistent thickness and a specified tolerance for deviation; an ungauged finish material type is not consistent in thickness and typically requires thick bed methods of installation. Generally, most, redispersible powder polymer and latex cement mortars (assuming that the formulation is first evaluated for suitability as an adhesive for industrial applications) are suitable for use with the thin bed or adhesive method. Follow the manufacturer’s guidelines for limitations on thickness, which varies based on formulation.

Large and Heavy Tile (LHT) Mortar Method

Generally, thicknesses over 3/8" (9 mm) are not recommended for standard thin-bed or adhesive types of cement mortar mixes. Thicknesses over 3/8" (9 mm) typically require either a special formulation of powder containing a higher proportion of coarse sand, or modification of a site mix with the addition of extra coarse sand. These products are also known as Large and Heavy Tile (LHT) Mortar. They are typically used when the adhesive thickness ranges from 1/8" (3 mm) up to 3/4" (19 mm). An example of this type of mortar is MULTIMAX™ LITE.

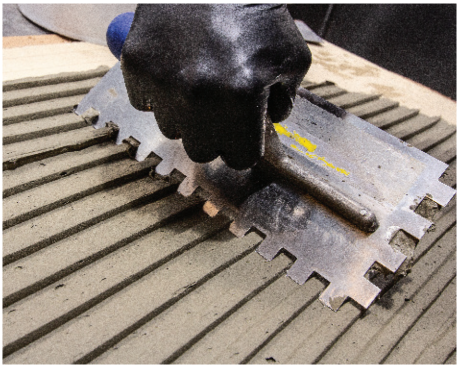


Figure 7.5 – Trowel-applied Large and Heavy Tile (LHT) Mortar with a 3/4" (19 mm) loop notch trowel.

Thick Bed Method

Also known as the "wet-set or "float and back-butter" method of installation, this method encompasses several different techniques. The most common thick bed technique is the "float and back butter" method. This method starts with the floating or screeding of the substrate with cement leveling mortar. The mortar bed can either be of the unbonded type or the bonded type.
(See Section 10 for detailing of both methods).

Bonded Type

In the bonded type, a slurry bond coat consisting of 257 TITANIUM is brush-applied to the concrete substrate. While the slurry bond coat remains wet and workable, the mortar bed is placed, compacted and then screeded, leveled, and pitched as required.

Unbonded Type

In the unbonded type, a cleavage membrane is placed over the substrate. The cleavage membrane can take the form of 15 lb builders felt, 6 mil thick polyethylene sheeting or a waterproofing membrane. Half of the mortar bed thickness is placed over the cleavage membrane. Next, 2" x 2" (50 mm x 50 mm), 16 gauge, galvanized, welded wire mesh complying with ANSI A108.02. 3.7 (Reinforcing wire fabric) is placed as close to the middle of the mortar bed as possible. This will allow the mortar bed to achieve maximum tensile strength resistance. Then, the rest of the mortar bed is placed. At this point, the mortar bed is compacted, screeded, leveled, and pitched as required.

Figure 7.6 – Example of a non-bonded, wire-reinforced mortar bed. Wire mesh is placed in the middle of the mortar bed and lapped together to ensure continuity.

Once this point is reached, the mortar bed can either be allowed to cure or the tiles/pavers can be installed into the fresh mortar bed.

If a waterproofing or anti-fracture membrane is required, the mortar bed should be allowed to harden for at least 72 hours at 70°F (21°C). Cooler temperatures require longer cure time prior to installation of the waterproofing or crack isolation membrane. Consult product data sheet for specific guidelines.

If the option to bond the tiles to the fresh mortar bed is desired, a second slurry bond coat is required. A trowel-applied slurry bond coat consisting of 257 TITANIUM™ or epoxy bonding slurry is preferred over the conventional dusting with dry portland cement and wetting with water method. The preferred method provides complete contact with the bonding slurry and reduces the chances of hollow and drummy sounding areas.

Figure 7.7 – Tile mechanic screeding a mortar bed.

The tile is then placed into the wet slurry bond coat and tapped into place and leveled with adjacent tile.

Once the tiles are installed, they can be grouted while the installation is fresh with conventional portland cement grouts or allowed to cure to receive the higher performing and recommended epoxy grouts (e.g. SPECTRALOCK® 2000 IG).

Self-Leveling Mortars

In order to achieve the desired height where concrete slabs may be recessed, an industrial grade portland cement-based self-leveling underlayment can be used. These products are highly polymerized and can be poured from feather edge up to 3" (75 mm) depending on the product formulation used. These products are installed very quickly and can be mixed and pumped into place with specialized equipment. It is important to specify a product that can withstand the usage and exposure to the environment in which it will be subjected (e.g. NXT® LEVEL Plus or SUPERCAP® SC500 Plus). Many traditional residential or commercial grade self-leveling underlayments are not suitable for use in industrial applications. LATICRETE manufactures several self-leveling underlayments (e.g. NXT LEVEL PLUS, SUPERCAP SC500 PLUS) that can be used in these applications. In most cases, a suitable primer must be used prior to the application of the self-leveling underlayment. The primer is designed to increase adhesion to the substrate. Once in place, strict adherence to cure times must be observed prior to the installation of membranes, epoxy adhesives and epoxy grouts.

Figure 7.8 – Application of self-leveling underlayment over a primed concrete substrate.

7.4 Types of Grout and Joint Fillers

MATERIALS FOR JOINT GROUTING AND SEALING

- Polymer-Fortified Cement Grout
- Latex Cement Grout
- Modified Epoxy Emulsion Grout
- Epoxy Grout (Commercial Grade)
- Furan Grouts
- Epoxy Grout (Industrial Grade)
- Silicone or Urethane Sealant

It is important to note that in many cases, renovations to existing tile floors are conducted in industrial applications, solely to the grout joints. Therefore, replacement of the grout joints can take place in areas where normal operations are being conducted. In applications where food and beverages are prepared or handled, it is critical that the grouting and/or installation products are suitable for the application (e.g. SPECTRALOCK 2000 IG in commercial or industrial kitchens) and will not result in adulteration of food products if used and applied as intended or indicated on the product directions. LATICRETE grouts contain no known carcinogens, mutagens and teratogens classified as hazardous substances, heavy metals or other toxic materials.

Polymer-Fortified Cement Grout

Redispersible powder polymer-fortified cement grouts mixed with water typically compensate for the reduced workability and premature evaporation of moisture inherent in conventional cement-sand-water grouts. While the proprietary formulations of these types of joint filler vary widely, they generally do not add any appreciable performance in flexibility or adhesion that is important to a joint filler in industrial applications. Similar to the same category of adhesives, some proprietary formulations are not recommended for use in wet areas due to the polymer sensitivity to prolonged water exposure. These types of materials do not offer any chemical resistance characteristics and are generally not recommended in demanding industrial applications.

Figure 7.9 – Effects of inappropriate grout used on an industrial application. Notice not only the erosion of the grout joints, but also the adhesive mortar under the tile. In most industrial floor applications, the use of an epoxy-based adhesive and an industrial epoxy grout are required in order to ensure long-term performance.

Latex Cement Grout

Similar to the same adhesive mortar category, latex grout is a combination of either a proprietary premixed sand-cement (and pigment) powder, or site mixed cement-sand grout powder with a ratio of approximately 1:2 by volume for joint widths to 1/2" (12 mm), gauged with a liquid latex or acrylic polymer additive. As with polymer modified grouts, the liquid latex or acrylic additive must be formulated for wet areas. Examples of this product type are PERMACOLOR™ or PERMACOLOR Select Grout^. These products also have very limited chemical resistance and are generally only used where no exposure to chemical attack occurs.

Modified Epoxy Emulsion

ANSI 118.8 (American National Standard Specifications for Modified Epoxy Emulsion Mortar/Grout) compliant grouts essentially include emulsified epoxy resins and hardeners, pre-blended portland cement, and silica sand. They typically can be used as a tile setting mortar or grout. Note that not all manufacturers recommend this material be used for grouting. An example of this type of product is LATAPOXY® 210 Adhesive.

Epoxy Grout – Commercial Grade

ANSI A118.3 (American National Standard Specifications for Chemical-Resistant, Water Cleanable Tile-Setting and –Grouting Epoxy and Water Cleanable Tile-Setting Epoxy Adhesive) compliant grouts are chemical-resistant, water cleanable tile-setting and grouting epoxies. An epoxy composition, essentially a 100% solids system that is supplied in two or more parts to be mixed immediately before use as a setting adhesive and joint filling grout for ceramic tile, and that is partially emulsified by water, after mixing, in order to expedite cleaning from tile surfaces during application before the epoxy hardens. SPECTRALOCK® PRO Premium Grout complies with this standard. These types of grouts can be used for industrial applications where they may experience limited chemical exposure. Typically this type of product is used for walls in industrial applications. They offer both lower water absorption rates and improved chemical resistance when compared to traditional cement-based grouts.

Epoxy Grout – Industrial Grade

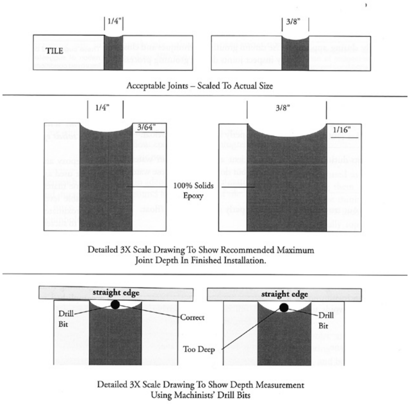
SPECTRALOCK 2000 IG is a highly chemical resistant industrial grade epoxy grout for ceramic tile pavers, floor brick, packing house tile and stone. SPECTRALOCK 2000 IG is supplied as factory proportioned kits consisting of epoxy resin, hardener and chemical resistant silica filler. This product is ideal for use in environments such as bakeries, breweries, dairies, cheese factories, clean-in-place (CIP) rooms, meat packing plants, soft drink plants, confectionaries, distilleries, pharmaceutical factories, canneries, veterinary clinics, hospitals, clinics, kennels, institutional kitchens, fast food restaurants, cafeterias, laboratories, supermarkets, and any other area exposed to harsh conditions. This material is water cleanable, fast curing and cures at low temperature. SPECTRALOCK 2000 IG exceeds ANSI A118.3 (American National Standard Specifications for Chemical-Resistant, Water Cleanable Tile-Setting and – Grouting Epoxy and Water Cleanable Tile-Setting Epoxy Adhesive) and also the much more stringent standard, ANSI A118.5 (American National Standard Specifications for Chemical-Resistant Furan Mortars and Grouts for Tile Installation) that applies to furan grouts. Ease of application, performance, (a water absorption rate of .16% and a compressive strength of 14,770 psi) makes this an excellent choice for use in demanding Industrial applications. There are no toxic fumes or huge learning curves that are generally associated with grouts that meet this standard. This product is ideal for use in active food and beverage environments. (Please see the chemical resistance chart for SPECTRALOCK 2000 IG – Figure 7.17)

Acceptable Epoxy Grout Appearance

Unlike portland cement-based grouts, epoxy grouts will have a tendency to slump slightly in the grout joints. Due to their viscous nature, epoxy grouts also tend to flow under the tile and fill any voids that may be present. This can be both a benefit and a problem. The benefit is that the grout can fill any voids left by the adhesive mortar to create a solid base under the tile. The drawback is that the grout joint can develop pinholes and voids in the finish surface. Careful attention must be given to bedding the tile properly to minimize the flow of the epoxy grout under the tile. This will alleviate the potential problems with sagging and pinholes.

In addition, the finished grout joint appearance will have a slightly concave appearance. The American National Standard Institute (ANSI) specifications for epoxy grouting of ceramic tile (ANSI A108.6 3.0.7) states, "Joints grouted with epoxy shall be filled to provide a contoured depression no deeper than 3/64" (1 mm) for a 1/4" (6 mm) wide joint, and 1/16" (2 mm) for a 3/8" (10 mm) wide joint. Reference Figure 7.11 for the acceptable grout joint appearance criteria as taken from the NTCA Reference Manual (latest edition).

Acceptable Joints when Grouting with 100% Solids Epoxy



This document compiled by the NTCA Technical Committee. Published by Tile Contractors Association, Inc. P.O. Box 13629, Jackson, MS 36236 USA.

Epoxy grouting systems employing resin and hardener portions and silica filler are especially formulated for industrial, commercial and residential installations where impervious chemical resistant grout joints are of paramount importance. High temperature, chemical resistant formulas are also available. The grouts also provide high bond strength and impact resistance. They impart structural qualities to the tile when used both as a mortar and grout, especially over wood subfloors. Their use involves extra costs and special installation skills when compared to portland cement grouts.

While perfectly flushed epoxy grout joints are desirable, they are not obtainable using normal grouting procedures. The slightly concave epoxy grout joint, however, is superior in performance in every way when tested against other grouting materials.

The American National Standard Institute Specifications (A-3.313) states, "Joints grouted with epoxy shall be filled flush with the edges. Provide a contoured depression no deeper than 3/64" (1 mm) for 1/4" (6 mm) wide joint, and 1/16" (2 mm) for a 3/8" (10 mm) wide joint. To measure a 100% solids epoxy grout joint, place a drill bit in the grout joint (a 3/64" bit for a 1/4" joint – a 1/16" bit for a 3/8" joint) and place a straight edge across the bit. If it touches or rocks on the respective drill bit, it meets or exceeds the ANSI specifications.

Figure 7.11 – Acceptable epoxy grout joint appearance.[1]

Figure 7.12 – Spreading of industrial epoxy grout.

Furan Grout

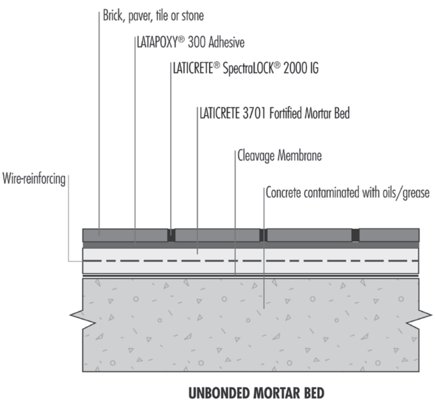
This category grout meets A118.5 (American National Standard Specifications for Chemical-Resistant Furan Mortars and Grouts for Tile Installation). Although highly chemical-resistant, the same precautions must be taken with furan grouts as with furan (furnane) adhesives. The use of furan grouts necessitates the use of pre-waxed brick or quarry tile. Furan grouts generally cannot be washed like traditional cement-based or epoxy grouts. A steam cleaner must be used to remove the furan and the wax from the dairy brick or quarry tile. This increases the cost of quarry tile/dairy brick. Since furan products are used in limited applications, most installers are not familiar with this category type product. There are very few furan mortar and grout manufacturers in existence. Typically, these products can be very caustic and require the use of full respirators. Therefore, these products may not be suitable for use in active environments where food and beverages are prepared or handled.

Silicone or Urethane Sealant

Silicone and urethane sealants are typically used as joint fillers only in movement joints and between dissimilar materials in an application (such as steel coolers and freezers and metal window frames) where a high degree of adhesion and resistance to differential movement and tensile or compressive stress is required. Movement joints are intended for relief of significant stress buildup that may be transmitted over a larger area, and have the characteristics to resist much greater elongation or compression than more rigid materials. These materials also adhere to dissimilar materials such as metal window frames to not only maintain a water barrier where a more rigid material may fail, but also to accommodate the significantly different thermal movement characteristics of dissimilar materials.

Silicone and urethanes may also be used as a filler for all joints in vertical cladding under certain conditions. In types of wall construction such as epoxy spot-bonding, rigid grouts would have no support or composite action with an underlying adhesive mortar, and may crack and fail. In designs where narrow joints are unavoidable, flexible joint fillers are the recommended joint filler. (See Sections 2.1 and Section 10.5 for more information on the use of flexible sealants in expansion joints).

7.5 Typical Renders and Details for Industrial Applications



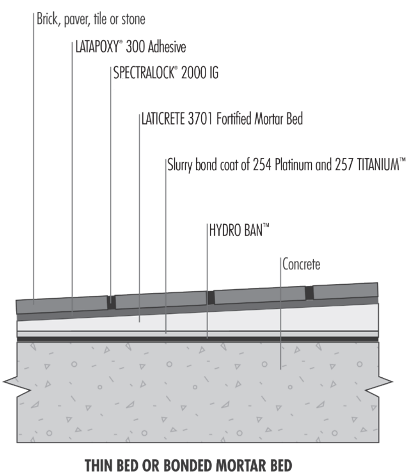
Thick Bed System

For areas requiring a conventional mortar bed to provide pitch, use LATICRETE® latex fortified mortar consisting of 3701 Fortified Mortar Bed. This bed provides superior strength and durability, and eliminates unsanitary high absorption of conventional morar beds. Brick, stone or tile are bedded directly into the mortar. Grouting is completed with SPECTRALOCK® 2000 IG.

Advantages

- Superior Load Performance
- Performs Over Contaminated or Unsound Substrates
- Provides Pitch to Drain
- Supports Extra Heavy Traffic

Figure 7.13 – LATICRETE International, Inc. Chemical-Resistant Unbonded Thick Bed System.



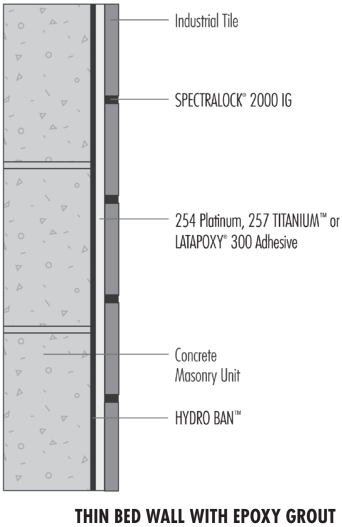
Thin Bed System

For areas the substrate is properly pitched, brick, paver and tile are economically installed using LATAPOXY® 300 Epoxy Adhesive and SPECTRALOCK® 2000 IG. Proper pitch and evenness are achieved using LATICRETE latex mortars. For wet areas and areas above occupied space, use HYDRO BAN™.

Advantages

- Provides for Thinnest/Lightest Provide Where Height/Thickness Restrictions are a Consideration
- Short Installation Time
- Supports Extra Heavy Traffic

Figure 7.14 – LATICRETE International, Inc. Chemical-Resistant Thin Bed or Bonded Thick System.



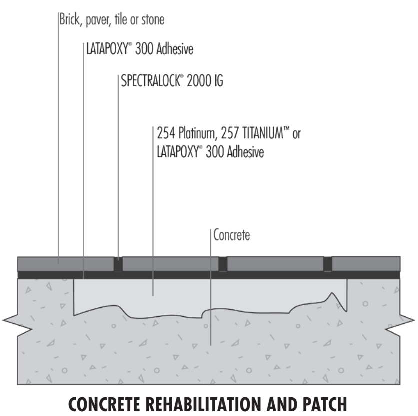
Wall Applications

Suitable for ceramic tile, structural glazed facing tile and glazed masonry units. Ceramic tiles are installed over CMU (Concrete Masonry Unit) or cement backer board with LATICRETE® latex thin-set mortar or LATAPOXY® epoxy adhesive. Grout with SPECTRALOCK®* PRO Grout or LATAPOXY epoxy grout. Structural glazed tile and masonry are tuck pointed with LATICRETE/LATAPOXY Epoxy Grout. LATICRETE/LATAPOXY epoxy grout is available in a range of colors including white.

Advantages

- Provides a Sanitary Joint
- Wide Range of Colors
- Chemical Resistant and Steam Cleanable
- Fast Installation
- Waterproof (With HYDRO BAN™)

Figure 7.15 – LATICRETE International, Inc. – Chemical-Resistant Wall Tile Installation.



Wall Applications

For restoration of floor and wall sections, use LATICRETE latex mortars to patch and fill deteriorated concrete. Install and grout brick/paver/tile with LATAPOXY epoxy adhesive and grout. Sound, existing bedded brick or tile can be regrouted using SPECTRALOCK® 2000 IG. SPECTRALOCK 2000 IG provides the quickest return to service time.

Advantages

- Fast Job Turnaround
- Low Temperature Installation
- Economical Regrout Instead of Replacing Entire Floor
- Chemical Resistant and Steam Cleanable

Figure 7.16 – LATICRETE International, Inc. – Chemical-Resistant Rehabilitation and Repair System.

LATAPOXY® 300 ADHESIVE			
CHEMICAL RESISTANCE			
Category Chemical Name	**Exposure time**		
	Splash	**Intermittent**	**Continuous**
Folic Acid			
Lactic Acid to 5%	R	R	R
Acetic Acid to 5%	R	R	R
Tannic Acid to 50%	R	R	R
Tartaric Acid to 50%	R	R	R
Phosphoric Acid to 80%	R	R	R
Mineral Acid			
Sulfuric Acid to 20%	R	R	R
Oxalic Acid to 10%	R	R	R
Sodium Hydroxide to 50%	R	R	R
Benzoic Acid 5%	R	R	R
Alkali			
Sodium Hydroxide (Saturated)	R	R	R
Solvents			
Methanol	R	NR	NR
MEK	R	NR	NR
Methylene Chloride	NR	NR	NR
Toluene	R	NR	NR
Xylene	R	NR	NR
Ethanol	R	NR	NR
Food/Miscellaneous			
Milk	R	R	R
Wine	R	R	R
Fruit Juice	R	R	R
Distilled Water	R	R	R
Mineral Water	R	R	R
Sea Water	R	R	R
Potassium Permanganate 1%	R	R	R

R = Recommended NR = Not Recommended

SPECTRALOCK® 2000 IG			
CHEMICAL RESISTANCE			
Category Chemical Name	**Exposure time**		
	Splash	**Intermittent**	**Continuous**
Folic Acid			
Lactic Acid to 10%	R	R	R
Acetic Acid to 15%	R	R	R
Formic Acid to 5%	R	R	R
Citric Acid to 50%	R	R	R
Tannic Acid to 50%	R	R	R
Tartaric Acid to 50%	R	R	R
Oleic Acid to 10%	R	R	R
Phosphoric Acid to 80%	R	R	R
Mineral Acid			
Hydrofluoric Acid to 1%	R	R	R
Sulfuric Acid to 50%	R	R	R
Nitric Acid to 30%	R	R	R
Hydrochloric Acid to 36.5%	R	R	R
Corrosive Cleaners			
Sodium Hypochlorite (Bleach) 3%	R	R	R
Alkali			
Sodium Hydroxide (Saturated)	R	R	R
Solvents			
Xylene	R	R	R
Ethyl Alchohol	R	R	R
Mineral Spirits	R	R	R
Toluene	R	R	R
Methylene Chloride	NR	NR	NR
Ethyl Acetate	R	R	R

R = Recommended NR = Not Recommended

Intermittent
Exposure where clean-up takes place several times a day, as in a commercial kitchen. Use the "continuous" exposure recommendations for intermittent exposure to reagents at temperatures above 90°F (32°C).

Fig 7.17 – Chemical-Resistance Charts for LATAPOXY® 300 Epoxy Adhesive and SPECTRALOCK® 2000 IG.

Expansion Joints

A critical element to the functionality of the total floor system.

- Mechanical Type – Pre-Formed Stainless Steel, With Impact, Chemical Resistant, Polyurethane Filler
- Field Applied Type – Pourable Polyurethane. Fast Curing With Excellent Chemical and Impact Resistance.

Advantages

- Protects Brick and Tile Edges from Chipping (Mechanical Type)
- Provides for Dynamic Movement in the Floor Assembly – Prevents Cracking and Delamination of Tile

Waterproofing Membranes

Required to isolate areas above occupied space, and to prevent seepage into concrete subfloor.

- Liquid Applied – Safe, Water-Based Liquid Rubber Applied With Roller or Squeegee, Bonds Directly to Concrete Subfloor

Advantages

- Safe, No Flammables or Solvents Required for Installation or Clean-Up
- Single Source Responsibility, Compatible With All Other Components
- Provides Anti-Fracture Protection (ANSI A118.12)
- Thin – Adds No Appreciable Thickness to Floors or Walls

Underlayments

Provide leveling and pitching capability over structural concrete slabs and masonry walls.

- Epoxy Type – a Three Component, Modified Epoxy Mortar for Areas of Extreme Chemical Exposure. Builds from 1/4" – 3/8" (6 mm – 10 mm)
- Latex Type – Portland Cement-Based Mortar That Produces a High Impact-Resistant Bed.Builds from 1/4" – 2" (6 mm – 50 mm)
- Self-Leveling Type – Fluid, Cement-Based Underlayment Designed to Level Low Areas. Builds from Feather Edge to 1-1/2" (38 mm)

Advantages

- Single Source Responsibility
- Provides All-Important Pitch to Drains in Critical Cleaning and Wash Areas

Fig 7.18 – LATICRETE International, Inc. Industrial Floor Systems Accessories and Components.

7.6 Rapid Installation Options

For fast return to service applications, LATICRETE offers rapid setting products that can enable installations to have a faster turn-around while still maintaining a high level of performance and extended LATICRETE Systems Warranties.

The following products are options that can be substituted for 'normal' setting products for their specific application.

SPARTACOTE™ FAST FIX™ – Is a fast set two-component hybrid urethane. Ultra-low viscosity properties allow for deep penetration into concrete and a thorough wetting of selected aggregate to form a high- strength permanent concrete repair. Material exotherms throughout repair and can be ground smooth in 15-20 minutes at 72°F (22°C). Ideal for use with SPARTACOTE coating systems. Can be combined with aggregate and used for patching spalls and repairing joints/large cracks in concrete. Fast Fix can be used for hairline cracks or nail holes. May also be employed as an anchoring mortar. Advantages to this product, is its ability to be used down to a feather-edge with minimal preparation and downtime. The product has excellent abrasion and high impact resistance.

VAPOR BAN™ Primer ER – is a single-coat, all-in-one moisture vapor coating and primer. It is a 100% solids, liquid applied, 2-part epoxy coating specifically designed for controlling the moisture vapor emission rate from new or existing concrete slabs. It will also perform as a primer prior to installing NXT® Level and SUPERCAP® self-leveling underlayments. VAPOR BAN Primer ER exceeds ASTM F3010 standard with a perm rating of 0.094 grains/h/ft2/in. Hg (5.4 ng/s • m2 • Pa) at only 16 mil thickness. The product ensures protection of moisture/pH sensitive floor coverings and reduces MVER ≤25 to below 3lbs/1000ft2/24hrs (170 µg/(s • m2). It can be used on concrete slabs with up to 100% RH / 14 pH. Ideal for slab-on-grade construction and elevated slabs and can be used with vinyl, rubber, VCT, carpet, wood, ceramic tile, stone and other moisture sensitive floor coverings and floor adhesives.

Quick Cure Mortar Bed – is a rapid setting, polymer fortified blend of carefully selected polymers, portland cement and graded aggregates. Quick Cure Mortar Bed does not require the use of latex admix, you only need to add water to produce a thick bed mortar. It allows for foot traffic and walkability in as soon as 60 minutes. Can be used in conjunction with HYDRO BAN® Quick Cure for faster shower system installation and is excellent for ramping and pitching down to a feather edge when used in a bonded mortar bed assembly with a slurry bond coat of 254 Platinum or 257 TITANIUM™.

HYDRO BAN Quick Cure - is a rapid, thin, liquid applied ready-to-use waterproofing membrane that is ANSI A118.10 compliant. Featuring wet-cure technology, this allows curing even in humid, cold and damp environments. HYDRO BAN Quick Cure allows for flood testing within 30 minutes (at 70°F [21°C]) or higher allowing contractors to install a shower system all in one day. Designed for both commercial and residential tile installations. Suited for interior substrates, HYDRO BAN Quick Cure creates a continuous waterproofing barrier with outstanding adhesion. It bonds directly to metal, PVC, stainless steel and ABS drain assemblies.

254R Platinum Rapid – The ultimate one-step, polymer fortified, multipurpose thin-set mortar for interior and exterior installation of ceramic tile, stone, quarry tile, pavers and brick. 254R Platinum Rapid is designed to mix with water and provide unsurpassed adhesion and workability with a superior bond to exterior glue plywood and concrete. 254R Platinum Rapid is the ultimate rapid setting adhesive for porcelain tiles. Contains antimicrobial protection to inhibit the growth of stain- causing mold and mildew in the substrate. Exceeds ANSI A118.4 Requirements & ANSI A118.11. 254R Platinum Rapid can be grouted in 2–4 hours.

LATAPOXY® 310 Rapid Stone Adhesive – A fast setting two component, high strength epoxy adhesive, which is formulated for the spot bonding of tile and stone installations on vertical surfaces. LATAPOXY 310 Rapid Stone Adhesive maintains its non- sag consistency (when applied up to 1" [25mm] thickness) at high temperatures up to 95°F (35°C) while achieving a fast permanent bond in 5 to 8 minutes. The adhesive is non-staining, making it ideal for white and light colored marble and other stones and tiles. It withstands shock and vibration. The product is ideal for spot bonding marble, granite, adhered masonry veneer and large format ceramic tile on walls and overheads, interior or exterior applications. Ideal for fireplace surrounds, elevators and stair risers. Approved by the TCNA for interior application methods W215 and W260.

PERMACOLOR® Select – is an advanced high performance cement grout that offers the industry's first dispensable dry pigment solution which exceeds ANSI A118.7 performance. PERMACOLOR Select is designed for virtually all types of residential and commercial installations and offers optimum performance on the most demanding exterior or interior applications. Easy to mix, grout and clean, PERMACOLOR Select is fast setting (ready for foot traffic in as little as 3 hours) and is suitable for joints 1⁄16" to 1⁄2" (1.5mm – 12mm) wide on floors or walls. This grout features vibrantly consistent color, minimizes efflorescence, is fiber reinforced and crack & shrink resistant. PERMACOLOR Select is GREENGUARD® certified – low VOC and is equipped with Anti-Microbial protection. PERMACOLOR Select grout is available in 40 LATICRETE colors and can be color matched to any color.

Consult the respective LATICRETE® product data sheet and / or LATICRETE Technical Services for any compatibility concerns, performance details, cure times, warranty information and return to service information.

7.7 References

Acceptable Epoxy Grout Joint Appearance Chart courtesy of the National Tile Contractor's Association (NTCA)

Section 8: Methods of Installation

8.1 Traditional Installation Equipment and Procedures

The construction equipment and installation procedures required for each project and region of the world are unique, and therefore it would not be possible to list all the types and combinations of tools, equipment and procedures involved in the installation of every industrial tile application. This section will present the most common tools, equipment and installation procedures required for each phase of construction. Tool and equipment requirements are determined by the phase of the installation shown below, and further defined by the type of construction, type of finish material, and the type of adhesive installation.

Installation Procedures, Tools and Equipment for Industrial Installations include:

- Substrate and Finish Material Surface Preparation (See Section 2)
- Access for Preparation and Installation (Rolling Scaffolds for Vertical Work)
- Mixing of Adhesives
- Installation of Adhesives
- Installation of Finish Material
- Installation of Joint Grout/Sealants
- Cleanup and Protection (See Section 9)

WEATHER AND SUBSTRATE PROTECTION

The optimum conditions for installation of ceramic tile and pavers are temperatures between 60° and 80°F (15° and 25°C), with 50% relative humidity. However, these conditions are atypical, so provisions must be made for variations in climate conditions. Protection applies to the substrate (see Section 5), the installation of adhesives and joint grouts, and also the storage and handling of the finish material.

Hot Temperatures

Protection or corrective action is required if either ambient air or surface temperatures of substrates/finishes go above certain thresholds during installation. Temperature thresholds vary with the types of adhesives, but generally, elevated ambient air (80–100° [25–35°C]) and surface temperatures will accelerate setting of cement, latex cement, epoxy and silicone adhesives. Washing and dampening floors and walls will not only remove contaminants, but also serve to lower surface temperatures by evaporative cooling. Shading surfaces that may be in direct sunlight is also effective in lowering surface temperature, but if ambient temperatures exceed 100°F (35°C), it is advisable to defer work to another time. If work cannot be deferred, it is also possible to cool additives (ice water, latex, epoxy liquids) in conjunction with the above techniques.

Cold Temperatures

Protection or corrective action is required if either ambient air or surface temperatures of substrates go below certain thresholds during installation. Temperature thresholds are different for various types of adhesives. Protection and corrective actions to elevate temperatures to optimum range typically involve enclosing or tenting of work areas, augmented by temporary heating. This condition typically occurs when ambient temperatures during installation are around 40°F (5°C). It only affects exposed surfaces. The length of exposure is a function of temperature. Cement hydration stops at 32°F (0°C) surface temperature, when water necessary for hydration freezes. Hydration of cement slows significantly starting at 40°F (5°C). Concentration of carbon dioxide can be elevated when temporary heating units are not properly vented outside of any protective enclosure during cold temperatures. Proper venting of temporarily heated areas is necessary to prevent exposure to toxic fumes and can reduce carbonation of cementitious materials. As a general rule, temperatures should be maintained above 50°F (10°C) during installation of cement, epoxy, and silicone-based products. Some cement adhesive product formulation may allow installation in temperatures close to 32°F (0°C) and rising, however, at this critical ambient air temperature threshold, it is likely that surface temperatures are below freezing due to thermal lag, and hydration or other chemical reaction may not occur at the adhesive interface.

As a rule of thumb, for every 18°F (10°C) above 70°F (21°C) cement-based and epoxy-based materials cure twice as fast. Conversely, for every 18°F (10°C) below 70°F (21°C) cement-based and epoxy-based materials take twice as long to cure.

Cold weather application.

Dry, Windy Conditions

This condition can cause premature evaporation of water necessary for hydration in cementitious materials, and result in loss of strength. Latex additives are formulated to significantly reduce this drying effect by coating water with a latex film. However, in extreme dry, windy conditions coupled with high temperatures >90°F (30°C), even latex additives do not provide adequate protection. It is recommended to provide temporary protection against rapid evaporation of moisture during hot, dry, windy conditions in the initial 36 hours after installation of cement mortars, screeds, plasters/renders and cement grouts, and to augment by damp curing with periodic daily water misting. Cement-based adhesives are only susceptible to premature drying between the time the adhesive is spread and the tile is installed, and requires only temporary protection from dry, high wind speeds during the open or exposed time of the adhesive.

Wet Conditions

Certain materials used in ceramic tile and paver assemblies can be moisture sensitive. For example, the strength of cementitious adhesives can be reduced from constant exposure to wet or damp substrates. Some materials, such as waterproofing membranes, may not cure properly or delaminate from a continually wet or damp substrate. A damp substrate may also contribute to the formation of efflorescence (see section 2.5 Efflorescence). This is a particular concern not only from normal rain exposure during construction, but also in areas of an installation, which may be exposed to rising dampness at ground level, or in areas where leaks from poor design or construction cause continual dampness in the substrate. When specifying liquid latex or dry redispersible polymer adhesive mortar, verify with the manufacturer that the polymer formulation is not water soluble. However, even formulations that are not soluble when dry are vulnerable to rain during the initial set period (typically 12–24 hours). Therefore, it is essential to provide protection from any significant rain or washing within this period to avoid loss of strength and prevent possible fluid or latex migration staining.

8.2 Finish Material Preparation

Cleaning of the tile back and substrate surface prevent contamination from inhibiting adhesive bond. Preparation and cleaning of substrates are covered in Section 2.3. While careful consideration is often given to the preparation of the substrate, preparation and cleaning of the finish material bonding surface is an often overlooked specification item or quality control checkpoint. Considerations are dependent on the type of finish material.

TYPES OF FINISH MATERIALS

Ceramic and Porcelain Tile

The bonding surface of the tiles may be contaminated with dirt or dust from normal manufacturing, storage and handling. Porcelain tile may have a coating of a release agent (known by terms such as bauxite, engobe) which prevents fusion of the tile to kiln surfaces during the firing process. The type, amount, and degree of removal of release agent prior to shipping will vary according to manufacturer or production batch. It is recommended to wipe each tile with a clean, damp towel or sponge during or just prior to installation to maximize adhesive bond. Cement, dry redispersible polymer cement and latex cement adhesive mortars can be applied to a damp, but not dripping wet surface (see Section 2.3 Moisture Content of Concrete).

Figure 8.1 – Example of kiln release present on tile back.

Dairy Brick and Quarry Tile

This type of finish typically has a rougher, more open pore structure and most have a ribbed back configuration manufactured specifically for demanding applications such as industrial floors. As a result, dairy brick and quarry tile are less susceptible to contamination due to the safety factor provided by both mechanical and adhesive bond. There are no specific cautions other than to remove normal dirt caused by storage and handling using normal cleaning techniques prior to installation.

8.3 Adhesive Mixing Equipment and Procedures

Equipment and tools required for mixing of adhesives are primarily dependent on the type of adhesive and construction site conditions such as the size of project.

TYPES OF ADHESIVES AND EQUIPMENT

Latex Cement-Based Adhesive Mortars

Manual mixing

- Bucket and Trowel

Mechanical mixing

- Low Speed Drill (< 300 rpm) and Non-Air Entraining Mixer Blade (Figure 8.2)
- Rotating Blade (Forced Action) Batch Mortar Mixer (Figure 8.3)

NOTE: Rotating drum type concrete mixers are not suitable for mixing adhesive mortars. In mixing cement adhesive mortars, always add the gauging liquid (water or latex additive) to the mixing container or batch mixer first. Begin mixing and add the dry cement-based powder gradually until all powder is wet, then continue mixing for approximately one minute or until mortar is wet and plastic. If using a site prepared powder mix of portland cement and sand, add the sand first until it is wet, and then add the cement powder. Take caution to prevent over-mixing by blending only until the mortar is wet and plastic in accordance with the manufacturer's instructions. Over-mixing can trap air in the wet mortar and result in reduced density (high absorption will reduce freeze thaw stability) and strength.

Epoxy Adhesive

Manual mixing

- Bucket and Trowel

Mechanical mixing

- Low Speed Drill (<300 rpm) and Non-Air Entraining Mixer Blade

The mixing instructions for epoxy adhesives vary according to the manufacturer's formulations. The most common epoxy adhesives are three-component products, which involve mixing two liquid components (resin and hardener), and a powder component (silica filler). The liquids are mixed together first and fully blended before adding filler powder. There are several important considerations in mixing epoxies. First, the chemical reaction begins immediately upon mixing the epoxy resin and hardener. Because the "pot" or useful life of the adhesive is relatively short (1 hour) and can be further reduced by ambient temperatures above 68°F (20°C), all preparation for mixing and installation of the epoxy adhesive should be made in advance. Mixing should also be made in quantities that can be installed within the prescribed useful life under installation conditions. Most epoxy adhesives cure by an exothermic or heat-generating chemical reaction beginning with the mixing of the liquid components. The useful life of the epoxy not only begins before adding the filler powder, but the heat-generated may accelerate the curing process in many formulations. Removal of the mixed epoxy from the mixing container is one technique used to dissipate heat generation and minimize set acceleration. Liquid components may also be cooled if anticipated ambient or surface temperatures will significantly exceed recommended use temperature range. Conversely, epoxy adhesive cure is retarded by cold temperatures, and the curing process can stop at temperatures below 40°F (5°C); the curing process will continue unaffected if temperatures are raised.

Figure 8.2 – Variety of mixing paddles used for drill type mixers.

Mortar Beds

- Aluminum Straight Edges and Screeds
- Concrete/Mortar Bed Finishing Trowel
- Wheelbarrows
- Square Edge Shovels
- Steel Rakes
- Walking Boards
- Mortar Bed/Tile Shoes
- Mortar Mixer

Figure 8.3 – Rotating blade type mixer.

8.4 Finish Material Installation Equipment and Procedures

The basic concept of installation of finishes using the direct adhered method is the same. The entire back surface of the finish material is adhered, and the basis for evaluating adhesion performance is by strength of a unit area; the size of the finish material is affected only by the logistics of construction and any legal/building code requirements. Adhesives are designed to bond at safety margins of about 250–400% greater than what is typically required by building codes. The reason for the high safety factor is, of course, to compensate for the unforeseen extreme forces such as earthquakes, and the difficulty in the quality control of labor. Until sophisticated diagnostic quality control test methods become more readily available and cost-effective, it is foolish to expect maximum specification strength over the entire adhesive interface hidden from visual inspection.

INSTALLATION OF CERAMIC TILE AND PAVER FINISHES

The following are the basic tools and equipment used for the installation of ceramic tile and paver finishes:

Equipment for Application and Bedding of Adhesives and Grout Joints

- Notched Steel Trowel
- Flat Steel Trowel
- Margin Trowel
- Hawk
- Metal Applicator Gun (Silicone Sealant)
- Rubber Mallet
- Wood Beating Block
- Spacer Shims and Wedges
- Grout Float (Cement or Epoxy)

Cutting/Fitting of Finish Materials

- Wet Saw (See Figure 8.4)
- Ceramic Tile Cutter and Accessories

Figure 8.4 – A commercial grade wet saw is ideal for cutting all types of tiles in industrial applications.

Measurement

- Carpenter's Level
- Laser Level
- Straight Edge (4'/1200 mm)

Cleanup

- Sponges, Towels
- Water Bucket
- Solvents (Epoxy or Silicones)

Safety Equipment

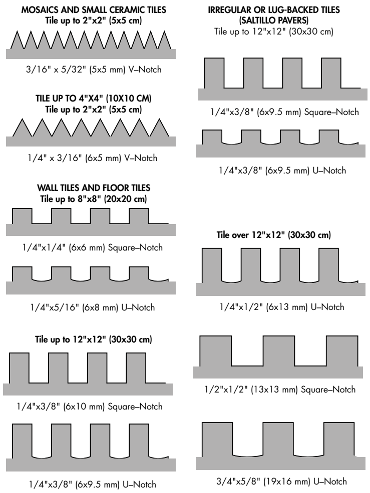
- Safety Glasses
- Rubber Gloves
- Dust Mask/Respirator
- Safety Belts and Harness

8.5 Installation Procedure for Finishes Using Thin Bed Adhesives

FUNCTIONS OF A NOTCHED TROWEL

- Gauges the Proper Thickness of Adhesive
- Provides Proper Configuration of Adhesive
- Aids in Efficient Application of Adhesive

Notched steel trowels are the primary and most fundamentally critical installation tool for the thin bed method of installation. The proper thickness of the adhesive layer is dependent on the type and size of finish, the cladding and substrate bonding surface texture, configuration and tolerance from consistent thickness. A "gauged" or "calibrated finish" is one with a consistent thickness and a specified tolerance for deviation; an "ungauged" cladding is not consistent in thickness. Even gauged dairy bricks and quarry tiles can experience thickness tolerances of up to 0.05" (1.3 mm). Notched steel trowels are available in several sizes and configurations to control thickness of applied adhesive mortar. The configuration of adhesive application is critical to performance of the tile or paver installation. In addition to controlling final thickness of adhesive, the notched configuration results in "ribbons" or "ribs" of adhesive separated by spaces that control bedding or setting of the finish into the adhesive. The spaces allow the ribs of adhesive to fold into one another to decrease the resistance to pressure required for proper contact, and provide a controlled method of filling all air voids and allowing escape of air parallel to the ribs. This function is critical in assuring full contact and coverage of adhesive, not only to ensure maximum bond strength, but also to eliminate air voids or channels, which can harbor or transport water.



Notch Chart

Figure 8.5 – Notched trowel sizes for installation of adhesive mortars. [2]

It is important to maintain the specified notch depth and configuration of notched steel trowels throughout the project. The angle of application can have a significant effect on the height of adhesive ribs, which in turn can affect the height-to-width ratio necessary for control of thickness and elimination of air voids. Therefore, it is recommended to prohibit the common use of severely worn trowels and to require frequent cleaning of the trowel. Recommendation of the notched trowel application angle should also be a part of the specification and quality control inspection program. A flat steel trowel is a tool used in applying an initial thin layer of adhesive in positive contact with both the bonding surface of the tile, also known as back buttering, and the surface of the substrate. The opposite side of a notched trowel typically has a flat edge for this purpose. A rubber mallet (or wood beating block, or hard rubber grout float for smaller tiles) can be used to beat in the tiles after they are placed to assure full contact with the adhesive, and help eliminate any voids in the adhesive layer (Figure 8.6).

Figure 8.6 – Example of incomplete bedding due to lack of sufficient mortar and/or incorrect trowel size selection and beat-in.

THIN BED INSTALLATION PROCEDURE

The following is an abbreviated step-by-step process for the application of thin bed adhesive mortars. Follow the mortar manufacturer's installation instructions for detailed information. For full installation specifications for thin bed, thick bed and membrane instructions see section 10.

1. Apply a thin skim coat (1/16"/1.5 mm thick) of thin-set or epoxy adhesive to the properly prepared dampened substrate with the flat side of the trowel; ensure good contact by scratching the edge of the trowel against the surface.

2. Additional thin-set or epoxy adhesive is then applied with the notched side of the trowel. Comb the mortar on the wall or floor with the notched trowel holding it as close as possible to a 90° angle to the substrate. This will ensure the proper size of notches.

Figure 8.7 – A notched trowel has several important functions that contribute to a successful installation of ceramic tile and paver tiles.

3. The ribs of thin-set or epoxy adhesive should be troweled in one direction only, and not in a swirl pattern. If additional thickness of adhesive is needed, add to the back of the finish using the same procedure as on the substrate, making sure that the direction of the combed mortar is identical to the one on the substrate, otherwise, you will end up with notches in two directions that disturb each other and consequently will not allow full contact between the mortar and the back of the tile.

4. As a rule, tile sizes larger than 12" x 12" (300 mm x 300 mm) should be back-buttered. Back buttering not only improves the contact between the mortar and the back of the tile, but also helps to ensure complete coverage. Another important consideration for back buttering is that if the tile is not fully bedded by proper beat-in, the ribs of thin-set or epoxy adhesive, which are not flattened, are being sealed by the coat applied to the back of the tile.

5. The tile should be pressed into place, and either twisted and pressed into position, or for tile sizes 12" x 12" (300 mm x 300 mm) and greater, slide into position with a back and forth motion perpendicular to the direction of the thin-set or epoxy adhesive ribs.

6. The final step is to beat-in with a rubber mallet to ensure thin-set or epoxy adhesive contact and make surface level with adjacent tiles.

8.6 Grout and Sealant Materials Selection, Methods and Equipment

PURPOSE OF GROUT OR SEALANT JOINTS

The joints or spaces between pieces of tile serve several important purposes. Aesthetically, joints serve as a design element, primarily to lend a pleasing scale with any size tile module. Functionally, joints prevent water infiltration, and compensate for manufacturing dimensional tolerances of the tiles. More importantly, though, joints lock the tiles into place and provide protection against various delaminating forces. Depending on the joint material, a joint may also act to dissipate shear stress caused by movement.

Compensate for Tile Thickness Tolerances

The joints between tiles compensate for allowable manufacturing or fabrication tolerances, so that consistent dimensions (from center to center of joints or full panel dimensions) can be maintained. As a result, joints must be wide enough to allow variations in the joint width to accommodate manufacturing or fabrication tolerances in the tile without being evident.

Prevent Water Infiltration

Filled joints between tiles allow most surface water to be shed. This helps prevent infiltration of water, which can lead to saturation of the setting bed and substrate, freezing, strength loss and efflorescence. Depending on the grout or sealant material used, and the quality of installation, no grout or tile will be 100% effective against water penetration, so there may always be a small amount of water infiltration by capillary absorption. Therefore, the use of a waterproofing membrane is strongly recommended in most industrial applications.

Dissipate Movement Stress

Probably the most important function of grout or sealant joints is to provide stress resistance and stress relief. The composite locking action with the adhesive layer allows the tile finish to better resist shear and tensile stress. Joints serve to provide stress relief of thermal and moisture movement that could cause delamination or bond failure if the edges of the tiles were butted tightly. Further isolation of movement is handled by separating sections of tile with movement joints (see Section 2.1 Movement Joints and Section 10 Movement Joint Specifications and Details). This ensures that the grout or sealant joint will always fail first by relieving unusual compressive stress from expansion before it can overstress the tile finish or adhesive interface. The dissipation of stress provides additional safety factor against dangerous delamination or bond failure.

GROUT INSTALLATION PROCEDURE

The following is an abbreviated step by step process for the installation of grout. Follow the grout manufacturer installation instructions for detailed information. For full grout installation specifications – see section 10.

1. Prior to grouting, it is essential to conduct a test panel (preferably as part of the pre-construction quality assurance procedures) to test the grouting installation cleanup procedures and final color under actual climatic conditions. During this test, you may determine the need to apply a grout release or sealer to the tile prior to grouting in order to aid in cleanup and prevent pigment stain and absorption of cement paste (especially latex cement or epoxy liquids) into the pores of the tile. This test may also determine if additional adjustments are necessary, such as saturation of the finish with water to reduce temperature, lower absorption, and aid in installation and cleaning.

2. Wait a minimum of 24 hours after installation of tile before grouting.

3. Before commencing with grouting, remove all temporary spacers or wedges; rake any loose excess adhesive mortar from joints. Remove any hardened thin-set or epoxy adhesive which is above half the depth of the tile. Insert a temporary filler (rope, foam rod) in movement joints to protect from filling with hard grout material. Wipe the tile surface with a sponge or towel dampened with water to remove dirt and to aid in cleanup.

4. Apply the grout joint material with a rubber grout float, making sure to pack the joints fully.

Figure 8.8 – Grout joint installation equipment – floats.

5. Remove excess grout by squeegee action with the edge of the rubber grout float diagonal to the joints to prevent pulling of grout from the joints.

6. Allow grout to take an initial set, then follow the appropriate clean up process for the specific grout type used as stated in the manufacturer installation instructions.

7. Any remaining weakened grout haze or film should be removed within 24 hours using a damp sponge or towel.

Silicone or Urethane Sealant Joint Fillers

Installation procedures for sealant joint fillers are the same as for movement joints (see Section 2.1 Movement Joints and Section 10 Expansion Joint Specification and Details).

Make sure that there is no mortar or grout materials in any joints that will be receiving silicone or urethane sealant.

8.7 Post-Installation Cleaning

Most cleanup should occur during the progress of the installation while the material is still fresh. Hardened adhesive and grout joint residue may require more aggressive mechanical or chemical removal methods than required while still relatively fresh. Water-based cement and latex cement adhesives clean easily with water while fresh or may require minor scrubbing or careful scraping together with water within the first day. Epoxy and silicone adhesives and joint sealants may require more aggressive scrubbing and solvents if residue is greater than 24 hours in age.

8.8 Mechanical Means and Methods

As an alternative to the common traditional means and methods of installation, industrial applications lend themselves to the use of mechanized means and methods due to the size and uniqueness of the application. In many cases, mechanized equipment can greatly improve productivity and lower labor and installation costs. Generally, the setup and cleanup time of the equipment factors into the decision whether to use the mechanized equipment. The following sections provide an alternative to the traditional means that are typically used in most ceramic tile installations.

Power Screeds

Power screeds are used as an alternative to the conventional wood or aluminum straight edge methods of leveling and "pulling" of mortar beds. The power screeds run on small electric-powered or gas-powered engines. The vibration that is caused helps to facilitate the screeding. The power screed sits on aluminum ribbons which are set to the desired height. The power screed is pulled over the ribbons to compact the and level the mortar faster and more efficiently than manual methods.

Figure 8.9 – Raimondi USA – Power Screed and Accessories.

Power Grouting

Power grouting is accomplished by using a mechanized grout spreading machine. The grout is spread by using rubber blades mounted on a powered rotating machine. This equipment will spread both latex portland cement-based and epoxy grouts in an effective manner. These machines pack the joints and strike the excess grout from the face of the tiles. The rubber blades can be changed when excessive wear is noticed. The mechanized power grouting machine has interchangeable pads to easily convert to the cleanup process. Traditional methods and equipment will still need to be used in small areas where the use of the mechanized equipment becomes impractical. Grout can then be cleaned using a rotating, self-wringing, drum-type sponge (figure 8.11).

Figure 8.10 – Raimondi USA – Power grouting

Figure 8.11 – Raimondi USA – Power grouting machine.

Figure 8.12 – Raimondi USA – Low-speed power mixer.

Mortar Mixers and Pumps

Mortar mixers and pumps are used as an alternative to conventional mortar mixers. The pump and mixer apparatus effectively mixes and pumps the mortar through a 3" (75 mm) hose to the desired location. The strength and style of these machines varies greatly depending on the amount of mortar to be mixed, the distance to place the mortar, and the amount of mortar to be placed.

Fig. 8.13 – Mortar mixer and pump.

8.9 Vibrated Floor System

The vibrated floor system uses many of the mechanized forms of equipment to accomplish an industrial floor installation. The vibrated floor system is generally used on large open industrial applications. It employs the use of mortar mixers and pumps/power screeds/power grouters/tile beat-in vibration apparatus. The vibrated floor system is installed with traditional latex-fortified bonded mortar beds placed over a latex-fortified slurry bond coat. The tiles are then placed into another slurry bond coat of latex portland cement or a special epoxy resin slurry bond coat over the fresh mortar bed while it is still plastic. Porcelain klinker tiles with self-spacing edge lugs are then stacked together onto the fresh slurry coat and mortar bed. Walking boards or "screed shoes" (wide plastic walking shoes for this purpose that will not "dig" into the fresh screed) are used during the tile installation process. Then, vibrating beat-in equipment is passed over the tiles. This equipment employs the use of vibrating rolling pins that gradually vibrate and set the tiles into place. The machine is passed over the fresh tiles in alternating directions to ensure that the tiles are evenly placed.

Next, while the tile and floor is still fresh, a special vibrated floor epoxy grout is squeegeed into the narrow grout joints (> 3/16" [4 mm]). Several passes of the squeegee and the very fluid epoxy grout is used over the tile and grout joints. Once the joints have been filled, the vibrating machine is passed over the floor again to effectively bind the entire floor together.
It is important to note that the grout is never cleaned with water.

This method uses the dry grouting process, whereby fine sand is cast over the freshly grouted floor to compact the grout joints and to dry clean the tiles. Aesthetically, the tiles can show a measure of grout residue and haze. However, these applications are more designed for performance and production than aesthetic appeal. See Figures 8.16 a-f for a step-by-step visual process.

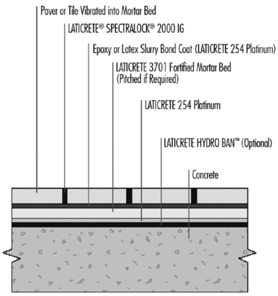


Figure 8.15 – Vibrated floor detail.

Figure 8.16a – Vibrated floor process – Mortar is mixed and pumped to area in a combination mortar mixer/pump combination.

Figure 8.16b – Vibrated floor process – screed mortar is discharged onto floor area from the mortar pump.

Figure 8.16c – Vibrated floor process – mortar is screeded with a vibrating screed to the desired height and pitched.

Figure 8.16d – Vibrated floor process – floor is squared and prepared to receive quarry tile floor.

Figure 8.16e – Vibrated floor process – epoxy slurry bond coat is troweled onto fresh screed. Porcelain pavers are installed into the fresh epoxy slurry bond coat.

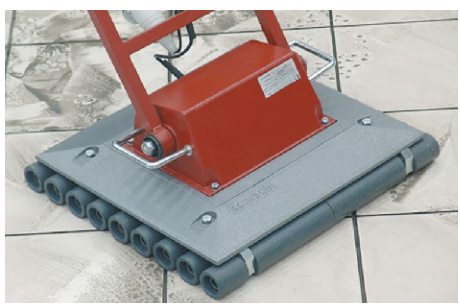


Figure 8.16f – Vibrated floor process – tiles are vibrated into place with t
he vibrated machinery.

LATICRETE® VIBRATED FLOOR SYSTEMS VS. CONVENTIONAL INSTALLATIONS				
		Conventional Mortar Bed	**LATICRETE® Latex System**	**LATICRETE Epoxy System**
GROUT JOINTS	Type	Portland Cement/Water	Latex Fortified Portland Cement	Epoxy
	Width	1mm +/-	1mm +/-	1-6mm
BOND COAT MATERIAL	Type	Portland Cement, Dry Dusted	Latex Slurry Bond	Epoxy Slurry Bond
	Shear Bond Strength	0.8 MPa (116 psi)	2.2 MPa (320 psi)	4.2 MPa (580 psi)
MORTAR BED	Semi Dry	w/Water	w/LATICRETE® Latex Admix	w/LATICRETE Latex Admix
	Compressive Strength	<10 MPa (1,450 psi)	31 MPa (4,496 psi)	31 MPa (4,496 psi)
	Water Absorption	>12%	<5%	<5%

Figure 8.17 – Comparative analysis of the vibrated industrial floor process versus conventional installation methods.

Section 9: Maintenance and Protection

9.1 Quality Assurance

The success of a tile installation in an industrial installation (like any other tile installation) depends entirely on a good quality assurance program implemented at all levels of the project. Unfortunately, comprehensive quality assurance programs remain the most overlooked and ignored process in the design and construction of both the facility and the tile installation.

There is an important distinction between the terms “quality assurance” and “quality control.” The distinction is that quality assurance is preventative in nature and encompasses all of the procedures necessary to ensure a quality job. Quality control is typically corrective in nature, implemented during or after a procedure, and is only one component of a more comprehensive and planned quality assurance program.

A quality assurance program should include quality checks during the design, specification and bidding phases as well as during and after construction. One factor of tile used in industrial facilities is that the quality of the installation is only as good as each component, and its installation, within the system. Therefore, choosing the proper products and installing them correctly is critical to the long-term performance of the installation.

A comprehensive quality program for the design and construction of tile installations in industrial applications should involve, but not be limited to the following:

Owner

- Define Scope of Work
- Organizational Requirements
- Quality Objectives

Design Professional

- Tile Installation System Product Component Design, Specification, Installation, and Inspection Procedure Training
- Pre-Installation Conference on Materials and Methods
- Identification of Construction Progress and Post-Installation Inspection, Testing and Evaluation Requirements; Identify Resolution Methods for Non-Compliant Conditions
- Develop and Specify Post-Installation Preventative Maintenance Programs

Construction Professional

- Substrate Preparation
- Control of materials (Evaluation of Contract Document Performance Requirements, Material Suppliers, Delivery, Handling, and Records)
- Product Use Monitoring and Documentation (Pot Life, Curing, Protection and Batch Mixing)
- Setting or Fixing All Tile – Adhesion Monitoring (Spreading, Thickness, Open Time, Tackiness, Beat-In, and Coverage)

9.2 Preventative and Corrective Maintenance

A systematic maintenance plan is a critical required final step, which is often overlooked. Industrial installations are demanding environments that are often exposed to harsh chemical cleaners, sanitizers, heavy foot traffic, forklift traffic, extreme temperature variances and much more. Without regular maintenance, any normal deterioration or degradation of a standard grout would be accelerated. The end result would be a loss of performance and shortening of the expected service life.

Facility maintenance is categorized according to how and when maintenance actions are taken. Preventative maintenance is planned and proactive action taken, which maintains specified performance and prevents potential defects or failures. Preventative maintenance includes both anticipated routine actions and repairs, such as application of protective sealers or deteriorated sealant replacement, as well as unexpected repairs such as replacement of cracked tile or fixing water leaks that may manifest into structural problems later.

The benefits of preventative maintenance are well documented; prevention has been proven to increase expected service life and cost a fraction of any extensive remedial action typically required once a problem occurs.

Corrective maintenance is remedial action, which repairs a defect after occurrence. Corrective maintenance is necessary to prevent further deterioration or total failure of a tile installation. Corrective action typically involves evaluation with either a non-destructive or destructive test procedure.

9.3 Typical Industrial Application Cleaning Regimens

Typical industrial application cleaning regimens include the use of steam cleaning with intermittent temperatures reaching up to 185 – 200°F (80–93°C). In addition, the use of harsh chemicals are routinely used in these applications. These cleaners include bleach, chlorinated cleaners, phosphoric acid, caustic soda, and iodine or chlorinated sanitizers.

The use of SPECTRALOCK® 2000 IG aids in the performance and maintenance of the installation. SPECTRALOCK 2000 IG reduces the amount of time to clean and provide general upkeep of the system and eliminates the requirement for sealing the grout. Make sure that the SPECTRALOCK 2000 IG is protected from traffic, chemicals, cleaners, other trades, and anything else that may affect the grout until it has hardened sufficiently to support exposure. For more information, please refer to the product data sheet for SPECTRALOCK 2000 IG (634.0) at www.laticrete.com. For floors and base as well as repair work, SPECTRALOCK 2000 IG is the grout of choice for these applications.

SPECTRALOCK PRO Premium Grout (for wall applications) and SPECTRALOCK 2000 IG are extremely low in absorption (<.5%). Liquids will not penetrate the surface of these grouts due to the low absorption rate. Dirty grout can always be cleaned down to the original color which may not be true with portland cement-based grouts, latex modified portland cement grouts or modified epoxy grouts. Stains may well become part of portland cement-based grouts.

Protect grouted areas from traffic and other trades for at least 24 hours after installation or until the grout is hard and no longer tacky. For areas that must have traffic during curing time, cover installation with plastic sheeting and plywood or other temporary load-bearing course. Protect grout from dirt and dust for 72 hours at 70°F (21°C). Please note that temperatures lower than 70°F (21°C) will require protection from traffic for a longer period of time.

SPECTRALOCK PRO Premium Grout reaches maximum hardness in 14 days and maximum stain resistance in 7 days at 70°F (21°C).

SPECTRALOCK PRO Premium Grout and SPECTRALOCK 2000 IG are both stain resistant when properly installed and allowed to cure fully. It is, unfortunately, not self-cleaning. Routine maintenance can be done with STONETECH® Stone & Tile Cleaner and a sponge or mop. For tough or difficult to remove soil, a bleaching cleaner (e.g. Soft Scrub®, Comet®, Ajax®, etc. or electric dish washing detergent) on a nylon scrubbing pad or a long-handled stiff bristle brush can be used.

PLEASE NOTE: Prior to using any cleaning material on a tile installation, test a discrete area or scrap piece of tile to insure desired results.

SPECTRALOCK 2000 IG can be steam cleaned when allowed to reach full cure. Mechanical cleaning can also be done with a floor cleaning machine such as a "Tennant" floor machine or power buffing machine with nylon pads and a commercial tile cleaner. A "Grout Hog" which is basically a motorized brush for fast aggressive cleaning may also be used.

Tennant Company Grout Hog Floor Cleaner
Windsor Industries

701 North Lilac Drive
1351 West Stanford Avenue
Minneapolis, MN 55440
Englewood, CO 80110
612.540.1200
303.762.1800

LATICRETE SPECTRALOCK 2000 IG exposed to grease, oil, and areas of potential bacteria accumulation (floor drains, equipment supports, etc.) should be cleaned daily using suitable degreasing materials, disinfecting cleaning agents, and a commercial floor washing machine, and then thoroughly rinsed. SPECTRALOCK 2000 IG is recommended for high abuse areas such as these.

Ongoing maintenance must take into account the types of cleaners that will be used in the facility. In many cases, the cleaners are harsher than the products produced or the chemicals used within the facility. It is always best to contact the manufacturer of the cleaners that will be used to ensure that use of the cleaning products will not result in long-term damage to the tile system.

SPECTRALOCK 2000 IG provides the best defense against aggressive cleaners. With the increase in use of "no-rinse" cleaners in commercial kitchen and industrial applications, attention needs to be given to the potential effect on the grout used in the tile applications. These cleaners rely on active enzymes to attack grease in commercial and industrial environments. Unfortunately, these active enzymes can have an adverse effect on the long-term performance of latex portland cement-based grouts and epoxy grouts. These grouts can potentially start to break down under continuous exposure to enzymatic/no-rinse cleaners.

Enzymatic/no-rinse cleaners are primarily used in areas of food preparation in commercial kitchens and industrial applications where traditional cleaning regimens have become impractical.

Therefore, in many cases epoxy grouts are not appropriate for conditions that exist on projects where the grout is exposed to enzymatic/no-rinse cleaners.

However, in most cases, a higher performing epoxy grout that meets the ANSI A118.5 (American National Standard Specifications for Chemical-Resistant Furan Mortars and Grouts for Tile Installation) requirements; such as SPECTRALOCK 2000 IG, which is specially formulated to be used in harsh environments, would be the appropriate grout for projects where chlonnated cleaners, aggressive cleaning regimens such as high pressure wash and steam cleaning will be used.

9.4 SPECTRALOCK® 2000 IG Regrouting Procedure

Degradation or deterioration of grouts can occur when the circumstances are right or when the wrong epoxy grout is used in areas subject to extreme conditions. Degradation or deterioration of portland cement-based grouts is a more common occurrence in harsh commercial and industrial areas or areas exposed to chemicals.

Deterioration can be caused by chemical erosion, extreme temperatures and even bacterial attack. The best defense against harsh chemicals, extreme conditions or areas exposed to bacterial attack is SPECTRALOCK 2000 IG

If an epoxy grout, with less performance quality, or a portland cement-based grout was installed and is deteriorating, follow these instructions to re-grout with SPECTRALOCK 2000 IG:

Removing Existing Deteriorating Grout

Option 1. Using a hot water, high pressure cleaning machine

Use a high-pressure water jet with hot water and a pump capable of producing a minimum of 1,000 psi (6.9 Mpa). The use of hot water in the pressure cleaning system will soften and remove all questionable and soft grout.

a. Direct the high-pressure jet at all the joints, moving continuously, to remove the existing grout. The existing grout should be removed to at least 1/2 the depth of the grout joint down to stable and sound existing grout or bedding mortar.

b. After removing the grout, soak the floor using hot water containing a degreaser detergent (follow the manufacturer's guidelines for mixing ratios).

c. Allow the joints to soak with this solution a minimum of 10 minutes.

d. Remove water using a wet vacuum.

e. Rinse the floor two times with clean water and use wet vacuum to remove water.

f. Blow the joints clean and dry with compressed air.

g. Ensure that joints are clean, free of grease and oil contaminants, and are fully dry before installing SPECTRALOCK 2000 IG (or call LATICRETE Technical Services for proper grout recommendations).

Option 2. Using hand scraping tools

a. Soak the floor and joints with a strong solution of bleach and water.

b. Allow the bleach to remain 30 – 60 minutes and wet vacuum excess solution off (this will soften all weak grout).

c. Use a scraping tool to remove the softened grout. The existing grout should be removed to at least 1/2 the depth of the grout joint down to stable and sound existing grout or bedding mortar. Be sure to scrape out all soft and loose grout and leave joints clean.

d. After removing the grout, soak the floor using hot water containing a degreaser detergent (follow the manufacturer's guidelines for mixing ratios).

e. Allow the joints to soak with this solution a minimum of 10 minutes.

f. Remove water using a wet vacuum.

h. Rinse the floor two times with clean water and use wet vacuum to remove water.

i. Blow the joints clean and dry with compressed air.

j. Ensure that joints are clean, free of grease and oil contaminants, and are fully dry before installing SPECTRALOCK 2000 IG (or call LATICRETE Technical Services for proper grout recommendations).

Re-Grouting with SPECTRALOCK **2000 IG**

a. Ensure that joints are clean, free of grease and oil contaminants, and are fully dry before installing SPECTRALOCK 2000 IG (or call LATICRETE Technical Services for proper grout recommendations).

b. Mix SPECTRALOCK 2000 IG according to DS631.5 (included with each kit of epoxy grout).

c. Apply the grout, filling the joints and compacting fully. Use a hard rubber float to pack the joints full and to remove excess from the surface of the tile (pass the float diagonally across the tile to ensure the joints are packed fully and to avoid material being pulled out of the joint).

d. After the initial setting (hardening time), the surface should be cleaned according to DS631.5.

CAUTION: When grouting cold floors (surface temperatures below 60°F [16°C]), protect the floor from contamination for an extended period of time as the hardening of epoxy is retarded at lower temperatures.

9.5 Protection and Sealing – Water-Repellant Sealers and Coatings

The purpose and performance of these materials is widely misunderstood by design and construction professionals. Generally, clear water-repellant coatings can aid in retarding surface water absorption of porous materials and reduce adhesion of staining materials. However, these sealing materials often give a false sense of security due to the lack of understanding of their suitability, compatibility and performance. Water repellents can reduce water leakage and deterioration in normally porous tile, stone and grouting materials, but they are not a cure to abnormal leakage caused by fundamental defects in detailing and construction.

There are several general principles for use and application of sealers. Water repellent sealers are not waterproof, and generally cannot bridge gaps or hairline cracks in grout joints or building material, so these materials are useless when used over cracks or very porous surfaces. Sealers suitable for use over slab-on-grade concrete must be vapor permeable and allow the floor to "breathe" and allow vapor to pass through the system. Sealers can also create functional or aesthetic defects that are intended to be prevented or corrected by their application.

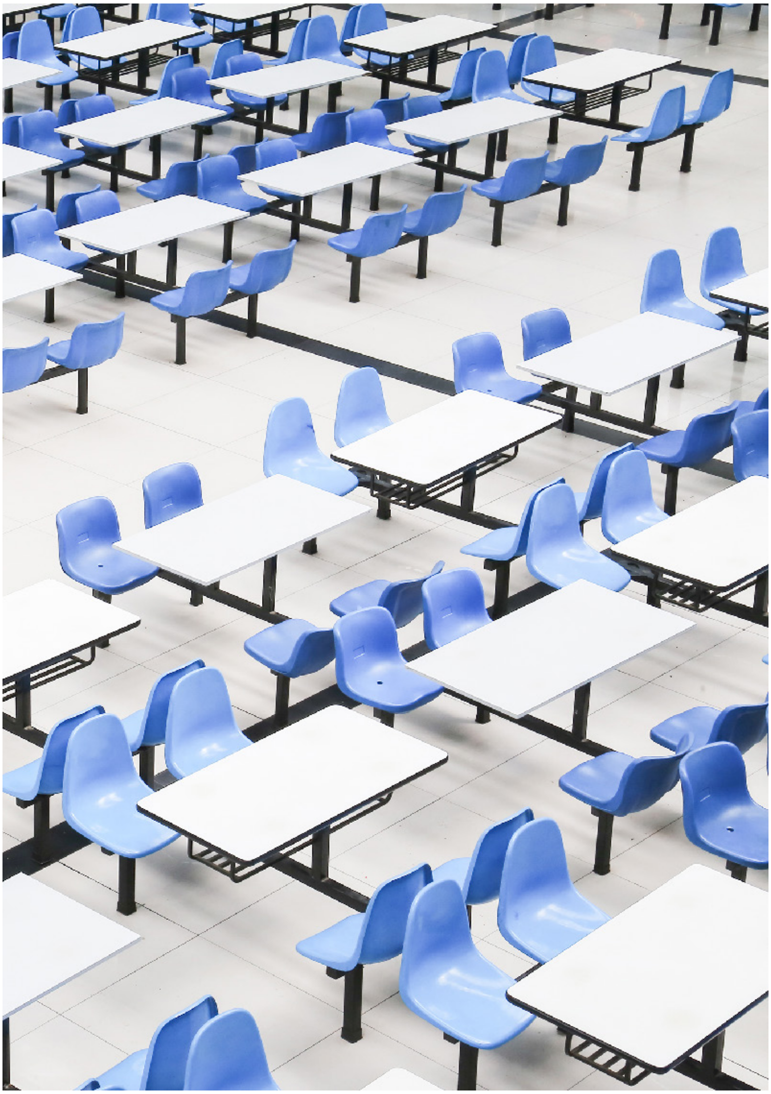
As sealers age, wear out or weather, several other problems can occur. Effectiveness is typically reduced over time, so periodic reapplication (depending on the manufacturers formulation and recommendations) is necessary; effective service life ranges from 1–5 years. Sealers may also allow variable wetting of a portland cement grout or tile from poor application or weathering; this can produce a blotchy appearance. In some cases, the sealer can be reapplied; in others, it may be necessary to allow it to completely weather off, or be removed chemically to restore a uniform appearance. Check with the sealer manufacturer for complete information on their products.

Compatibility of sealers is also important, with not only the materials to be sealed but also with adjacent and underlying components of the system. The appearance of certain tile or grout can be affected by sealers. Poor application or poor quality products can darken or change the appearance of the tile or grout. Application (or overspray) of sealers onto nonporous tile, such as porcelain, will result in visible residue or a dripping, wet appearance from sealers that do not absorb (e.g. urethanes or acrylics). Sealant joints, waterproofing membranes and metal are some of the system components, which might be affected by solvents in some formulations.

9.6 Alternative to Using Sealers

Use a low absorption tile (e.g. porcelain or quarry tile) and SPECTRALOCK 2000 IG. These installation system materials never require sealing and can greatly lower the long-term, overall cost usually required to maintain the tile installation.

Section 10: Industry Standards, Building Regulation and Specifications



10.1 Background

Significant progress has been made on adopting a uniformly accepted building code and industry standards. However, the scope and content of existing standards varies substantially from country to country. Even the best standards for tile applications have had a difficult time keeping pace with new construction adhesive technology and ceramic tile and paver products available in the marketplace. In many countries, the absence of standards specific to ceramic tile installations requires the adaptation of industry standards for the performance and use of ceramic tile adhesives.

Fortunately, the trend in the United States and other countries is the development of a single model building code. The United States has adopted the International Building Code (refer to IBC latest version). This code, has eased the regulatory problems associated with multiple building codes on which thousands of country, state and local jurisdictions base their individual building codes. In addition, the International Standards Organization (ISO) standards for ceramic tile are moving in this direction to create a common global building code.

10.2 Building Codes and Regulations

Building codes are mandatory laws, which either prescribe or set minimum performance criteria for construction in order to protect the health and welfare of the public. Building codes are usually conceived by private, non-governmental organizations that have no legal enforcement powers; these powers rest in the local building departments. Building codes typically are conceived in two distinct formats; a "prescriptive" or a "performance" code. The International Building Code (IBC) sets forth a level of performance that ceramic tile installations must meet. The IBC references the American National Standards Institute (ANSI) Specification for the Installation of Ceramic Tile for the prescriptive and performance criteria. The ANSI A108 Series deals with the installation methodology of the various products and the ANSI A118 Series deals with the actual product design and minimum performance levels. It is important to remember that the ANSI standards set the minimum performance levels for ceramic tile installation products. Industrial applications are much more demanding and will require products that exceed the minimum industry standards. The manufacturer's of the installation products can provide detailed information on how to achieve the maximum performance from the ceramic tile or paver installation in an industrial application. In addition, the IBC sets forth the substrate and structural design requirements for all applications including the appropriate live, dead, impact and total load and deflection criterion.

It is important to note that the intended use of a given area dictates the structural requirement. In many cases, L/360 is the maximum allowable standard for deflection, total load and impact load for ceramic tile applications. The design professional must take all of the buildings structural factors into consideration when designing the structure to ensure that the ceramic tile floor and wall areas will stand up to the stresses of the application.

10.3 Industry Standards

Industry standards are methods for the design, specification, construction, and testing of building materials and construction assemblies that are developed by "public consensus" organizations. Industry standards typically are much more comprehensive than building codes and recognize the latest technology in a given field of construction. As a result, it is common practice today that building codes are based primarily on the industry standards that are developed by specialist public consensus organizations. Examples of such organizations in the United States are the Tile Council of North America (TCNA), the American National Standards for the Installation of Ceramic Tile approved by the American National Standards Institute (ANSI) and the American Society for Testing Materials (ASTM). An example of the standards that are applicable in Europe includes European Union Norms (EN). The International Standards Organization (ISO) is a global standard concept that is gaining momentum. There are distinct differences between building codes and industry standards. However, for the purposes of this manual, building codes and standards will be presented without distinction between mandatory (legal) or voluntary compliance.

10.4 Sample Specification

Click here to view **LATICRETE master format Specification** for a ceramic tile installation specification for an industrial application.

Cut-A-Way Details:

Click on the appropriate Detail Drawings to view a layered detail of proper process.

Detail ES-F111

Detail ES-F114

Detail ES-F115

Detail ES-F115B

Detail ES-F133

Detail ES-F134

Detail ES-F312

Detail ES-W201(I)

Detail ES-W202(I)

Detail ES-W221(I)

Detail ES-W241(I)

Detail ES-W244(I)

Detail ES-W260

Detail ES-W215

Movement Joints

Expansion and Control Joints: Provide control or expansion joints as located in contract drawings and in full conformity, especially in width and depth, with architectural details.

1. Substrate joints must carry through, full width, to surface of tile, brick or stone.
2. Install expansion joints in tile, brick or stone work over construction/cold joints or control joints in substrates.
3. Install expansion joints where tile, brick or stone abut restraining surfaces (such as perimeter walls, curbs, columns), changes in plane and corners.
4. Joint width and spacing depends on application – follow TCNA "Handbook for Ceramic Tile Installation" Detail "EJ-171 Expansion Joints" or consult sealant manufacturer for recommendation based on project parameters.
5. Joint width: ≥1/8" (3mm) and ≤1" (25 mm).
6. Joint width: depth ~2:1 but joint depth must be ≥1/8" (3 mm) and ≤1/2" (13 mm).
7. Layout (field defined by joints): 1:1 length: width is optimum but must be ≤2:1.

Remove all contaminants and foreign material from joint spaces/surfaces, such as dirt, dust, oil, water, frost, setting/grouting materials, sealers and old sealant/backer. Use Latasil™ 9118 Primer for underwater and permanent wet area applications, or for porous stone (e.g. limestone, sandstone etc…) installations. Install appropriate Backing Material (e.g. closed cell backer rod) based on expansion joint design and as specified in § 07920. Apply masking tape to face of tile, brick or stone veneer. Use caulking gun, or other applicator, to completely fill joints with sealant.

Within 5–10 minutes of filling joint, 'tool' sealant surface to a smooth finish. Remove masking tape immediately after tooling joint. Wipe smears or excess sealant off the face of non-glazed tile, brick, stone or other absorptive surfaces immediately.

Use the following LATICRETE® System Materials

Latasil™

Latasil 9118 Primer

References

Applicable Standard: current revision of ASTM C920

LATICRETE Detail Drawings: WP300 through WP303, EJ-01 through EJ-15 (Sealant treatments only)

LATICRETE Data Sheets: 6200.1, 6528.1

LATICRETE Technical Data Sheets: none

Detail ES-WP300

Detail ES-WP301

Detail ES-WP302

Detail ES-EJ01

Detail ES-EJ02

Detail ES-EJ03

Detail ES-EJ04

Detail ES-EJ05

Detail ES-EJ06

Detail ES-EJ07

Detail ES-EJ08

Detail ES-EJ09

Detail ES-EJ10

Detail ES-EJ11

Detail ES-EJ14

Detail ES-EJ15

10.6 LATICRETE® Architectural Guidebook

Click here to view the LATICRETE Architectural Guidebook

10.7 LATICRETE LEED Project Certification Assistant

Click here to view the LATICRETE LEED Project Certification Assistant

10.8 Industry References

All industry references are the intellectual property of their respective owners:

TCA Handbook for Ceramic Tile Installation 45th Edition. Tile Council of North America, Inc. Anderson, SC, 2008.

American National Standard Specifications for Installation of Ceramic Tile. Tile Council of North America, Inc. Anderson, SC, 2006.

Annual Book of ASTM Standards. American Society for Testing and Materials. West Conshohocken, PA, 2001.

Floor and Trench Drains – ASME A112.6.3-2001. American Society of Mechanical Engineers. New York, NY, 2001

International Building Code, International Code Council. Country Club Hills, IL, 2006.

International Residential Code for One- and Two-Family Dwellings, International Code Council. Country Club Hills, IL, 2006.

LEED NC for New Construction Reference Guide v 2.2. U.S Green Building Council. Washington, D.C., 2005.

LEED Schools Reference Guide. U.S. Green Building Council. Washington, D.C. 2007.

Lightweight Steel Framing Binder. Canadian Sheet Steel Building Institute. Cambridge, ON, Canada, 1991.

North American Specification for the Design of Cold-Formed Steel Structural Members. American Iron and Steel Institute. Washington D.C., 2001.

ICBO ER-4943P Product Technical Information. Steel Stud Manufacturers Association. Chicago, IL, 2001.

Steel Framing Systems Manual. Metal Lath Steel Framing Association. Chicago, IL. 10.7

FEATURES	BENEFITS
Over 100 complete installation specifications fully customizable	Installation specifications are based on approved installation methods and systems.
Customizable detail drawings available in CAD, PDF and jpg formats	Tailor the details to fit your project needs.
Complete reference section	Your source for all code and industry-related standards for tile and stone applications.
Warranted installation systems*	All of the specifications included in the **LATICRETE® Architectural Guidebook** are based on LATICRETE warranted systems.
Generate a complete specification with just a few clicks of a mouse	Productivity will increase with the quickest means of creating tile and stone specifications.
Generate submittal package	A complete submittal package can be generated, sent electronically and used for projects.

** GREENGUARD Indoor Air Quality Certified® and GREENGUARD for Schools & Children Indoor Air Quality Certified Product

† United States Patent No.: 6881768 (and other Patents).

^ United States Patent No.: 6784229 B2 (and other Patents).

Section 11: Appendix, Glossary and Resources

11.1 INDUSTRIAL APPLICATIONS FREQUENTLY ASKED QUESTIONS

Q: Why is tile a good choice for use in Industrial and Commercial applications?

Properly installed quarry tile, dairy brick and porcelain pavers stand up to the demanding rigors of industrial applications. Tile installations are sanitary, easy to maintain and are impact, thermal shock, and chemical resistant. Tile can last a lifetime as long as regular and proper maintenance is performed.

Q: Why use an industrial epoxy grout like SPECTRALOCK® 2000 IG?

Cement grouts, by their very nature are absorbent, even if sealed with a high quality sealer on a regular basis. This means that they can easily be stained and become saturated with all manner of matter. Lesser performing epoxy grouts meeting ANSI A118.3 may be affected by exposure to harsh chemical cleaners, high heat and aggressive cleaning regimens. **SPECTRALOCK®** 2000 IG, which meets the more demanding physical characteristics of ANSI A118.5, can withstand exposure to harsh chemicals, high temperature, and chlorinated cleaners. An extremely low absorption rate means that any material on the surface of the grout stays on the grout and does not absorb into the grout.

Q: Is regular maintenance of the SPECTRALOCK 2000 IG required?

Yes. Regular cleaning is required to maintain health and safety and to keep consistent appearance of your tile installation. For more information please refer to LATICRETE TDS 400 "Grout Selection and Maintenance Guide" at www.laticrete.com.

Q: Can I use SPECTRALOCK PRO Premium Grout on walls?

Yes. Because grout on walls is not subjected to the same type of exposure as floor grout, means that SPECTRALOCK PRO Grout† or LATAPOXY® SP-100 Epoxy Grout can be used on walls. We would recommend though that **SPECTRALOCK** 2000 IG be used on cove base tile and any other areas that may experience the same harsh treatment as the floors and base areas.

Q: Do I need to seal LATAPOXY® 2000 Industrial Grout?

No. **SPECTRALOCK** 2000 IG does not require sealing. Because it is an epoxy grout, it has an extremely low absorption rate, which means that any sealer applied to the surface of the grout will just sit on the surface.

Q: What thin-sets can be used for industrial applications?

LATICRETE manufactures several thin-sets that would be ideal for these applications. For best performance and for installations that will be exposed to extremely harsh chemicals or conditions, use LATAPOXY 300 Adhesive. If an industrial application will not be subject to chemical attack, then 257 TITANIUM™ or TRI-LITE™ would be an alternative.

Q: Can SPECTRALOCK 2000 IG be steam cleaned?

Yes. **SPECTRALOCK** 2000 IG can withstand exposure up to 360°F (182°C) intermittently or a constant 185°F (80°C).

Q: How long does it take SPECTRALOCK 2000 IG to cure?

At 70°F (21°C), **SPECTRALOCK** 2000 IG will be ready in approximately 5 hours for light foot traffic, 10 hours for heavy foot traffic and 5 days for full cure. The substrate must be protected from exposure to chemicals, cleaners, other trades, airborne dust and debris and other factors that may damage the grout until allowed to set until firm. Lower temperatures will slow cure times and higher temperatures will accelerate cure times. Please refer to LATICRETE DS 634.0 and 631.5 INTL for more information.

11.2 GLOSSARY

ABSORPTION – the relationship of the weight of water absorbed to the weight of the dry specimen, expressed in percentages

AGGLOMERATE TILE – a man-made stone product generally consisting of either crushed marble, granite or quartz chips with a matrix of resins and mineral pigments. Usually available in assorted sizes as well as large slabs

ANSI – American National Standards Institute

APA – American Plywood Association

ASME – American Society of Mechanical Engineers

ASTM – American Society for Testing and Materials

BACK-BUTTER – the spreading of a bond coat to the back of ceramic tile and stone just before the tile is placed

BACK MOUNTED MOSAIC TILE – mosaic tile which may have perforated paper, fiber mesh, resin or other suitable material bonded to the back of each tile which becomes an integral part of the tile installation

BICOTTURA – method for producing tile by firing it twice (first fire is for body, second is to fuse glazes or patterns in glaze onto the body).

BISQUE – the refined mixture of clay, water and additives that has been shaped into the body of a tile

BODY – the structural portion of a ceramic tile

BOND COAT – a material used between the back of a tile and the substrate. Suitable bond coats for a steam room application include latex portland cement mortar and epoxy adhesive

BOND STRENGTH – a bond coat's ability to resist separating from the tile and underlayment, measured in pounds per square inch (psi)

BROWN COAT – the second coat in a three-coat render or mortar application

BULLNOSE – a trim tile with a convex radius on one edge

CAULK – see sealant

CEILING SLOPE – steam rooms require ceilings to be pitched 2" per foot (150mm per m) to prevent condensation from dripping on steam room occupants

CEMENT – binding component of mortars and concrete (usually portland cement)

CEMENT BACKER BOARD – a backer board, usually composed of cement, fillers and fiberglass mesh, designed for use with ceramic tile in wet areas

CEMENT GROUT – a cementitious mixture of portland cement, sand or other ingredients, pigments and water, to produce a water resistant, uniformly colored material used to fill the joints between tile units

CEMENTITIOUS – having the properties of cement

CERAMIC TILE – a surfacing unit, usually relatively thin in relation to facial area, made from clay or a mixture of clay and other materials called the body of the tile, and having either a glazed or unglazed face

CHEMICAL RESISTANCE – the resistance offered by products to physical or chemical reactions as a result of contact with or immersion in various solvents, acids, alkalis, salts, etc…

CLEAVAGE MEMBRANE – a membrane that provides a separation and slip sheet between a mortar bed and the substrate

COLD JOINT – any point in concrete construction where a pour is terminated and the surface lost plasticity before work continued

COMPACTION – the process where a freshly placed mortar is reduced to the minimum practical space to form a stronger, denser mass

COMPRESSIVE STRENGTH – a material's ability to withstand a load force, measured in pounds per square inch (psi)

CONTROL JOINTS – a joint physically cut into concrete to help control cracking during the curing of the concrete

CRAZING – the cracking that occurs in fired glazes or other ceramic coatings due to critical tensile stresses

CURING – maintenance of humidity and temperature of freshly placed mortar or grout to assure satisfactory hydration of cement and proper hardening of mortar or grout

CUSHIONED EDGED TILE – tile on which the facial edges have a distinct curvature that results in a slightly recessed grout joint

DEFLECTION – a variation in the position or shape of a structure element due to the effect of loads or volume change

DOT MOUNTED MOSAICS – tile packaged in sheets and held together by plastic or rubber dots between tiles

Dynamic Coefficient of Friction (DCOF) – ANSI A326.3 is the industry standard for measuring slip resistance for hard surfaces flooring materials. DCOF measures slip resistance during motion while COF measure slip resistance to put an object in motion. This standard more accurately measures a surface's slip resistance when walking.

EFFLORSECENCE – the residue deposited on the surface of a material (usually cement grout) by crystallization of soluble salts

EPOXY ADHESIVE – an adhesive system that employs epoxy hardening portions

EPOXY GROUT – a mortar system that employs epoxy hardening portions

EXPANSION JOINT – a joint through tile, mortar and substrate to allow for excessive movement

FACE-MOUNTED MOSAICS – mosaic tile sheets that have paper or other suitable material applied to the face of the mosaic sheets, usually with water soluble adhesives for easy removal after installation and prior to grouting

GLASS MOSAIC TILE – tile made of glass, usually not over 2" x 2" (50 mm x 50 mm) and 1/4" (6 mm) thick and mounted on sheets. Sheets are typically 12" x 12" (300 mm x 300 mm)

GLAZED TILE – tile with a fused impervious facial finish composed of ceramic materials fused to the body of the tile

GROUT – a material used for filling the joints between tile

GROUTING – the process of filling tile joints with grout

IAPMO – International Association of Plumbing and Mechanical Officers

INDUSTRIAL GROUT – epoxy grout specifically manufactured to withstand exposure to harsh chemicals, high temperatures and other extreme conditions (e.g. animal health and wellness facilities)

Large and Heavy Tile Method (LHT) – tile setting material that has a finished thickness between 3/8" (9 mm) and 3/8" (19 mm)

LATEX-PORTLAND CEMENT GROUT – a mixture of portland cement grout with a latex additive or polymer

LATEX PORTLAND CEMENT MORTAR – a mixture of portland cement, sand and a latex additive

MARBLE TILE – marble cut into tiles and available in various finishes

METAL LATH – expandable diamond metal lath material which is mechanically fastened to a surface and onto which a mortar bed is applied

MONOCOTTURA – method of producing tile by a single firing

MORTAR BED – the final coat of mortar on a wall, floor or ceiling before the installation of tile

MOSAIC TILE – any tile (ceramic, porcelain or stone) with a facial dimension of less than 6 in2 which usually comes in sheets (paper face mounted, dot mounted, back mounted, etc…)

MUD – see mortar bed

NON-VITREOUS TILE – tile with an absorption rate greater than 7.0%

NOTCHED TROWEL – a trowel with a serrated or notched edge which is used to gauge the amount of mortar or adhesive to a specific thickness when setting tile

OPEN TIME – the period of time that a bond coat retains its ability to adhere to the tile and bond the tile to the substrate

PENCIL ROD – reinforcing rod with a diameter no greater than 1/4" (6 mm)

PINHOLES – imperfections in the surface of tile or grout

PLASTER – a cementitious material and aggregate that, when mixed with a gauging liquid, forms a plastic mass or paste which when applied to a surface, adheres to it and subsequently hardens, preserving in a rigid state the form or texture imposed during installation

PLUMB – perpendicular to a true level

PORCELAIN TILE – a ceramic tile that is dense, impervious and has an absorption rate of <0.5%

POT LIFE – the period of time during which a material maintains its workable properties after it has been mixed

SCRATCH COAT – a mortar bed, applied as the first coat of a mortar on a wall or ceiling, whose surface is scratched or roughened so that subsequent mortar coats will bond properly

SEALANT – an elastomeric material used to fill and seal expansion and control joints, prevents the passage of moisture and does not allow horizontal and lateral movement to affect the tile installation

SELF-SPACING TILE – tile with lugs, spacers or protuberances on the sides which automatically space the tile for the grout joint

SEMI-VITREOUS TILE – tile with an absorption rate between 3.0 to 7.0%

SHELF LIFE – the maximum period of time that an item can be stored before it is used

SHOWER PAN – a waterproof shower floor membrane which is specifically recognized for use in this application – required for steam rooms as well as showers per local building code

SLAKE – the process of mixing a cementitious mortar or grout, allowing it to stand for 5–10 minutes and then remixing. This process makes sure that the moisture in the mix penetrates lumps in the dry components, making it easier to complete the mixing procedure

SLOPE TO DRAIN – a pitch placed in a floor used to evacuate water. 1/4" per foot (6 mm per 300 mm) is the industry recognized standard for floors

SLURRY COAT – a coat of thin-set used to bond a mortar bed to a cementitious substrate

SPACERS – plastic or rubber units used to separate and provide consistent spacing between tiles

SUBFLOOR – a rough floor, plywood or boards, laid directly on joists and to which an underlayment or substrate is installed

SUBSTRATE – the underlying material to which a tile installation is bonded

TCNA – Tile Council of North America

THICK BED MORTAR – a thick layer of mortar that is used for leveling (see mortar bed)

THIN-SET – tile setting material that has a final thickness not greater than 3/8" (9mm)

VAPOR BARRIER – an impervious sheet material that is placed under the substrate to prevent moisture vapor from transgressing through a wall, ceiling or floor

VITREOUS TILE – tile with an absorption rate of between 0.5 – 3.0%

WALL TILE – a glazed tile with a body that is suitable for interior use only and has an absorption rate of greater than 7.0%

WATERPROOFING MEMBRANE – a material applied to a substrate before tiling to protect the substrate and supporting structure from damage by water

WET AREA – surfaces that are either soaked, saturated, or regularly and frequently subjected to moisture or liquids (usually water), such as saunas, steam rooms, showers, swimming pools, dog washing rooms, and more

11.3 RESOURCE GUIDE – TRADE ORGANIZATIONS AND TECHNICAL RESOURCES

Ceramic Tile Materials and Methods

Tile Council of North America, Inc. (TCNA)
100 Clemson Research Blvd.
Anderson, SC 29625
+1.864.646.8453
www.tileusa.com

Terrazzo, Tile & Marble Association of Canada (TTMAC)
30 Capston Gate, Unit 5
Concord, Ontario, Canada L4K 3E8
+1.905.660.9640
www.ttmac.com

Ceramic Tile Institute of America, Inc.
12061 West Jefferson
Culver City, CA 90230-6219
+1.310.574.7800
www.ctioa.org

Tile Contractors Association of America (TCAA)
4 East 113th Terrace
Kansas City, MO 64114
800.655.8453
www.tcaainc.org

National Tile Contractors Association (NTCA)
P.O. Box 13629
626 Lakeland East Dr.
Jackson, MS 39236
+1.601.939.2071
www.tile-assn.com

International Masonry Institute (IMI)
The James Brice House
42 East St.
Annapolis, MD 21401
+1.410.280.1305
www.imiweb.org

Natural Stone Methods and Materials

Natural Stone Institute (NSI)
28901 Clemens Rd.
Westlake, OH 44145
+1.440.250.9222
www.naturalstoneinstitute.org

Masonry Institute of America
22815 Frampton Ave.
Torrance, CA 90501-5034
+1.800.221.4000
www.masonryinstitute.org

Thin Brick Masonry Materials and Methods
Brick Institute of America (BIA)
11490 Commerce Park Dr.
Suite 300
Reston, VA 22091
+1.703.620.0010
www.bia.org

International Masonry Institute (IMI)
The James Brice House
42 East St.
Annapolis, MD 21401
+1.410.280.1305
www.imiweb.org

National Concrete Masonry Association (NCMA)
13750 Sunrise Valley Dr.
Herndon, VA 20171-4662
+1.703.713.1900
www.ncma.org

Concrete, Pre-Cast Concrete

Portland Cement Association
5420 Old Orchard Rd.
Skokie, IL 60077
+1.847.966.6200
www.cement.org

Pre-cast/Pre-stressed Concrete Institute (PCI)
209 West Jackson Blvd.
Chicago, IL 60606
+1.312.786.0300
www.pci.org

Wire Reinforcement Institute (WRI)
942 Main St.
Hartford, CT 06103
800.542.4974
www.wirereinforcement.org

American Concrete Institute (ACI)
P.O. Box 9094
Farmington Hills, MI 48333-9094
+1.248.848.3700
www.concrete.org

Test Standards and Building Codes

American Society for Testing & Materials International (ASTM)
100 Barr Harbor Dr.
P.O. Box C700
West Conshohocken, PA 19428-2959
+1.610.832.9585
www.astm.org

Materials and Methods Standards Association (MMSA)
P.O. Box 350
Grand Haven, MI 49417-0350
+1.616.842.7844
www.mmsa.ws

International Code Council (ICC)
4051 West Flossmoor Rd.
Country Club Hills, IL 60478-5795
888.422.7233
www.iccsafe.org

United States Green Building Council (USGBC)
1015 18th St., NW
Suite 508
Washington DC 20036
+1.202.828.7422
www.usgbc.org

American National Standards Institute (ANSI)
1819 L St., NW 6th Floor
Washington, DC 20036
+1.202.293.8020
www.ansi.org

International Organization for Standardization (ISO)
1, rue de Varembé, Casa postale 56
CH-1211 Geneva 20, Switzerland
41 22 749 01 11
www.iso.org

National Institute of Building Sciences (NIBS)
1090 Vermont Ave., NW
Suite 700
Washington, DC 20005-4905
+1.202.289.7800
www.nibs.org

Sealants, Waterproofing and Adhesives

Sealant, Waterproofing & Restoration Institute (SWRI)
14 West 3rd St.
Suite 200
Kansas City, MO 64105
+1.816.472.7974
www.swrionline.org

Adhesive & Sealant Council, Inc.
7979 Old Georgetown Rd.
Suite 500
Bethesda, MD 20814
+1.301.986.9700
www.ascouncil.org

Cement Plaster/Render
International Institute for Lath & Plaster
P.O. Box 3922
Palm Desert, CA 92260-3922
+1.760.837.9094
www.iilp.org

Expansion Joints
Expansion Joints Manufacturers Association
25 North Broadway
Tarrytown, NY 10591
Fax: +1.914.332.1541
www.ejma.org

LATICRETE International, Inc. ■ One LATICRETE Park North, Bethany, CT 06524-3423 USA ■ 1.800.243.4788 ■ +1.203.393.0010 ■ www.laticrete.com