CRITICAL POINTS OF TILE DESIGN AND INSTALLATION

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1. ABSTRACT

With the advent of larger tiles, advanced setting materials and grouts, marginally acceptable substrate conditions, and accelerated construction schedules, tile contractors and installers are faced with increasing challenges to deliver high quality and permanent tile installations. Specialty applications like large format tile with intricate bonding patterns, the strict material handling requirements of ultra-large units, and the potential liability associated with watertight assemblies pose new challenges to installers of tile. This paper examines the critical points of today's complex tile

assemblies from preliminary design through the finished installation, resulting in a successful tile project.

Using the framework of the evaluation criteria of the Advanced Certifications for Tile Installers (ACT) applied to real projects and case studies, the paper examines the critical requirements of ACT's specialty areas of large format tile, gauged porcelain tile, membranes, mud floors and walls, shower receptors, and grouts. The paper takes a detailed look the ACT certifications which test tile installers on their knowledge and ability to properly construct the most critical conditions of complex tile assemblies.

The paper addresses general design and installation requirements applicable to all ceramic tile projects as set forth in ANSI A108 Installation Standards for Ceramic Tile, the Tile Council of North America (TCNA) Handbook for the Installation of Ceramic, Glass and Stone Tile, and the Advanced Certifications for Tile Installers.

Finally, the paper addresses quality assurance procedures and specification language that design professionals can implement to ensure that each of these critical points are achieved in the field.

2. INTRODUCTION

In recent years, technological advancements in the manufacturing of tile, setting materials, grouts, and other components of tile assemblies, along with more sophisticated design applications and installation techniques, have significantly changed how ceramic tile work is designed, specified, and installed in the United States. Successful tile installations are more challenging now than ever, and it is widely recognized that the element of qualified labor, in both tile contractors and tile installers, plays a critical role in the success of a tile project.

To optimize the successful use of tile even as the materials and technology grow increasingly complex, the U.S. tile industry[1] has taken steps to identify the most important skill areas of tile installation, and it has developed a universally recognized installer certification program that tests installers' abilities to deliver work that meets the critical points within each skill area.

2.1. SKILL AREAS, DEFINITION

Based on anecdotal analyses of project failures from the early 2000s, the U.S. tile industry[1] has identified seven important skill areas within the craft of tile setting. This is not to imply that all skills associated with setting tile are not important, as indeed they are. For the purpose of this paper, important skill areas are defined as those skill areas that, if executed improperly, hold the potential for costly failure of the tile project. The important skill areas address the installation of the following components:

- Large format tile
- Gauged Porcelain Tile (GPT) and GPT Slabs/Panels
- Membranes
- Mud floors
- Mud walls
- Shower receptors
- Grouts

2.2. CRITICAL POINTS, DEFINITION

Within each of the general skill areas listed, there are many critical points that inform an installer's mastery of the respective skill area. This is not to imply that all installation tasks associated with a particular skill area are not critical, as indeed they are. For the purpose of this paper, critical points are defined as installation techniques and procedures that, if executed improperly, hold the potential for costly failure within the respective skill area.

2.3. ACT CERTIFICATIONS

The identification of the seven important skill areas and the dozens of critical points that inform each respective skill area were developed by the U.S. tile industry[1] with the goal of creating a set of universally recognized tile installer certifications that would measure and attest to an installer's mastery of the skill areas. These are the Advanced Certifications for Tile Installers, or ACT. There is an ACT certification for each of the seven skill areas, and each certification is independent of the others. That is to say an individual tile installer may become certified in one or more of the important skill areas.

Each ACT certification is a three step process: the candidate must be a Journeyman tile setter or have equivalent experience in the field; he must pass a written test on the applicable codes and standards of the skill area he is being tested for as set forth in the ANSI standards[2] and the TCNA Handbook[3]; and finally, once the first two requirements are met, the installer must demonstrate his skills on a field-constructed module representative of the skill area. The candidate's work on the hands-on module is assessed by a certified ACT evaluator during and after construction. The evaluator examines how the installer handles the critical points of the respective skill area when assessing the workmanship on the module, and whether the work complies with ANSI, TCNA, and product manufacturer requirements.

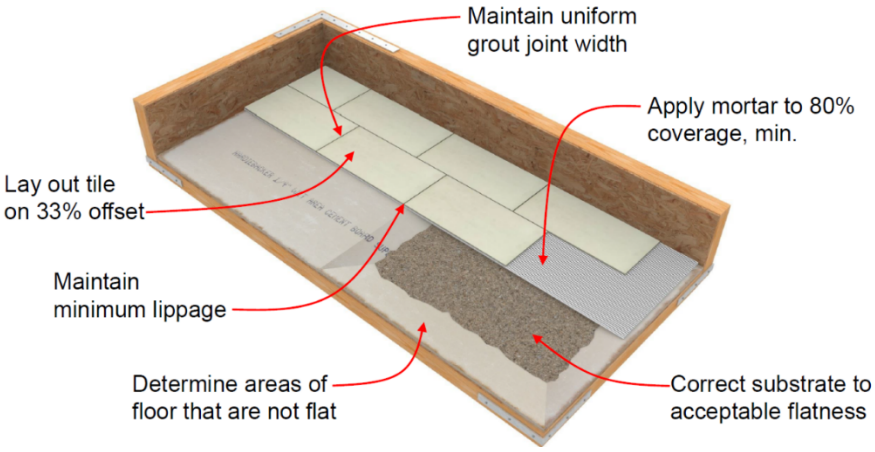
In the few years since ACT's inception, the program has quickly taken a foothold in the U.S. ACT certification is a sought-after credential among installers, as it is recognized as an indicator of qualified labor in the ANSI standards[2], the TCNA Handbook[3], and MasterSpec, the master guide specification service affiliated with the American Institute of Architects (AIA). Today, many architecture and design firms require installers to be ACT certified in the Quality Assurance section of the Tiling specifications.

One reason ACT certifications have emerged as a leading indicator of qualified labor so quickly is the integrity and consistency of the certification program. No matter where in the U.S. the installers are tested, the test is administered the same way. The testing module is consistent, the time allocated for completion is consistent, and most importantly, the grading criteria, i.e. the critical points on which the installers are evaluated, are consistent.

3. CRITICAL POINTS

The remainder of this paper will examine the critical points of installation for each of the seven skill areas of tile installation. The ACT certification modules provide the framework for this paper, but the skill areas and critical points discussed herein can be applied to real-world tile projects. Additionally, most of the examples in this paper address installation, but it is equally important for design professionals to be familiar with the critical points in each of the skill areas and to design their projects to those specifications.

3.1. CRITICAL POINTS OF LARGE FORMAT TILE



Design trends have been favoring large format tile (LFT) for the last decade, producing spaces that are visually stunning and easy to maintain, but oftentimes are more challenging to install. While the U.S. tile industry has not officially agreed on a definition for LFT, for the purposes of this paper we will define it as any tile greater than 15 in. (380 mm) on any one side, since that is the dimension that triggers certain limitations in design and construction.

3.1.1. TILE LAYOUT

Due to the inherent warpage of many large format tiles, especially warpage in the long direction of plank tile, ANSI standards[2] recommend that LFT be laid out with a maximum offset of 33% to minimize lippage occurring as a result of warpage. If a tile pattern was incorrectly laid out with an offset of greater than 33%, for example 50% offset (running bond), the high point at the center of a tile would align with the low points at the corners of the adjacent tiles, possibly resulting in unacceptable or undesirable lippage. Qualified installers are expected to be familiar with this concept and to lay out their installations on 33% offset or less. If the design drawings or specifications call for a pattern with offsets greater than 33%, the installer should alert the designer to the increased potential for lippage, and a mockup may be required to evaluate the actual warpage and resulting lippage.

3.1.2. GROUT JOINT WIDTH, ALIGNMENT, AND UNIFORMITY

Qualified installers are expected to provide grout joints that are of the nominal width specified, that are aligned, and that are relatively consistent in width. In reality, it is impossible to achieve all three of these criteria with 100% accuracy, since each of these factors can be at odds with the others. Due to allowable fluctuations in tile sizes, rooms that are out of square, and other site conditions, the grout joint widths naturally must vary to a certain degree. Minimum grout joint width is set by ANSI standards[2] and those minimum widths factor in the allowable variation of the tile size. Maintaining grout joint alignment is more important in installations with continuous grout joints, i.e. no offset tiles, and can best be achieved by laying the tiles to grid lines rather than by using tile spacers. The grout joint widths should be relatively uniform across the installation, but they will vary slightly to accommodate site variations and tile size variations and to ensure grout joint alignment. A qualified installer will be able to balance all three of these criteria within allowable tolerance.

3.1.3. SUBSTRATE PREPARATION

Skilled installers must be able to assess the quality and flatness of the substrate that is to receive tile and correct it if necessary before installing tile. LFT is particularly unforgiving of substrates that are not suitably flat, therefore floor preparation is a critical part of the tile installer's skill set. For walls and floors to receive LFT, ANSI requires that the substrate be flat within no more than 1/8 in in 10 feet (3 mm in 1,048 mm) from the required plane, and to have no change of plane that is more drastic than 1/16 in. in 2 feet (1.5 mm in 610 mm)[2]. In order to achieve their LFT certification, ACT candidates are evaluated on their ability to identify areas of an existing subfloor that do not meet these criteria and to correct those areas by installing a cementitious patch or flowable underlayment that will bring the floor to the required flatness.

3.1.4. LIPPAGE

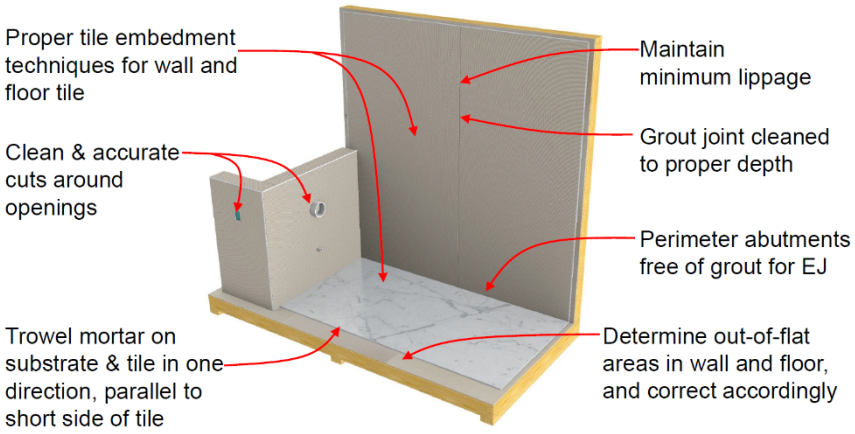
Even with proper tile layout and floor preparation, keeping lippage of the tile assembly within standards of acceptability can present an installation challenge, especially with LFT. ANSI standards currently allow 1/16 in. (1.5 mm) or 1/32 in. (0.8 mm) lippage in addition to the inherent warpage of the tile, depending on the type of tile, size of tile, and width of grout joint. A good installer will be adept at maintaining lippage of the assembly within these tolerances and will be able to properly use a mechanical lippage control system as an installation aid. Outside the scope of installation, designers should bear in mind that architectural lighting placed closer than 24 in. (610 mm) to a tile wall, sometimes known as wall wash lighting, is likely to exaggerate the perception of lippage due to the drastic angle of the light, and therefore should be avoided.

3.1.5. MORTAR COVERAGE

One of the leading causes of failure in LFT installations is insufficient mortar coverage. Without adequate coverage on walls, tiles may become unbonded and fall; and without adequate coverage on floors, tiles may lack support and crack under impact or service loads. A qualified installer will apply mortar to 80% coverage for interior non-wet areas or 95% coverage for interior wet areas and exteriors[2]. ACT candidates for LFT certification are evaluated on their ability to provide mortar coverage to these levels.

3.2. CRITICAL POINTS OF GAUGED PORCELAIN TILE (GPT) AND GPT SLABS/PANELS

Gauged porcelain tile (GPT) and GPT panels/slabs have been gaining momentum in the U.S. market since the development of the product standard (ANSI A137.3) and the installation standard (ANSI A108.19), both approved in 2017. A GPT panel or slab is defined as a GPT unit with facial area larger than or equal to 10.75 square feet (1 square meter). Because this material is so large and often extremely thin, its installation requires specialized skills that differ from the skills used in laying conventional tile. Some of GPT's critical points installers must master are similar to those for large format tile, but others are unique to GPT and GPT panels.



3.2.1. SUBSTRATE PREPARATION AND LIPPAGE CONTROL

As in any LFT installation, substrate preparation and lippage control are critical to the success of a GPT installation. Candidates for ACT certification in GPT are evaluated on each of these according to the criteria described in sections 3.1.3 and 3.1.4.

3.2.2. PROPER USE OF TOOLS AND EQUIPMENT

Due to its large size, GPT panels/slabs require specialty equipment and techniques to transport it to and around the jobsite. ACT candidates for GPT certification must demonstrate their knowledge of the equipment. Examples include the proper use of forklift extensions to support transportation of A-frames and crates loaded with GPT panels, the proper use of suction cup racks to move and place individual slabs, and proficiency with specialized cutters, specially shaped notched trowels, and other specialty tools and devices created for working with GPT.

3.2.3. MORTAR APPLICATION

Whereas conventional LFT and smaller tiles may be installed using a variety of individual troweling techniques and styles and still achieve adequate embedment and bond, GPT and GPT panels require very specific mortar application techniques to facilitate embedment and bond. ACT candidates for GPT certification are evaluated on their troweling techniques as they test for the certification. A qualified installer will apply mortar to the substrate and to the back of the GPT panel using a specially notched

trowel in the direction parallel to the short side of the slab, working from the centerline of the slab outward, and holding the trowel at a consistent 45° angle. They will spread mortar all the way to the edge of the slab, and they will avoid clearing away the overspread mortar with a margin trowel, which may otherwise create a dam of mortar along the tile edge and interfere with ridge collapse. Each of these techniques, if executed properly, will help the ridges in the troweled-on mortar to more easily collapse as the tile is subsequently embedded, engaging the mortar and facilitating a permanent bond between tile and substrate.

3.2.4. EMBEDMENT OF THE GPT PANEL

Embedment techniques work in concert with mortar application techniques to ensure that the GPT or GPT panel stays bonded to the substrate. Due to the large unit size, conventional techniques like tapping the tile or rocking it perpendicular to the mortar ridges are not effective at collapsing the ridges of the mortar and pulling the unit into bond. Instead, installers need to be familiar with approved techniques for embedment, like vibrating GPT panels on vertical surfaces and walking on GPT panels on horizontal surfaces, both done from the center outward. Each of these methods is described in detail in ANSI A108.19, and their adherence is critical for the success of GPT installation.

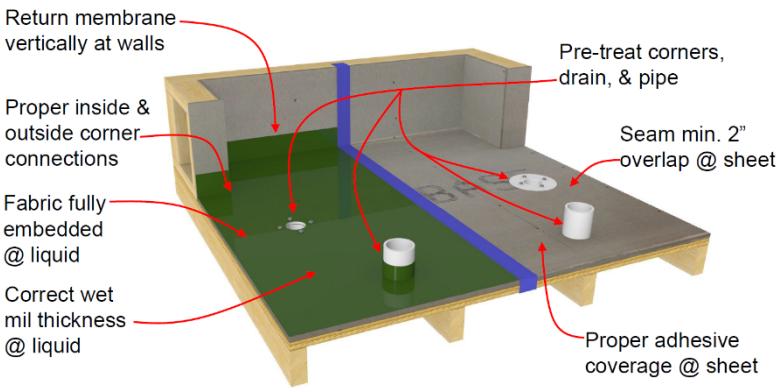
3.2.5. CUTS FOR PENETRATIONS

ACT candidates for GPT certification are evaluated on the quality and accuracy of the cuts they make in the GPT to accommodate penetrations for pipes and other fixtures. If cuts are not accurate or sufficiently tight around the penetration, the installation will look unprofessional. With conventional tile, incorrect cuts can be easily re-worked using replacement tile; with GPT panels, however, the larger unit size and higher unit cost make unnecessary waste unacceptable, and installers are expected to get the cuts right the first time.

3.2.6. GROUT JOINTS AND MOVEMENT JOINTS

As explained in section 3.2.3, it is critical to apply mortar all the way to the edges of the GPT. Such full coverage invariably results in mortar getting squeezed out of the joints between units as the units are embedded. If not cleaned out prior to its cure, this excess mortar may interfere with the grout joints, and more seriously, with the movement joints. Therefore, qualified installers are expected to keep grout joints and movement joints free of mortar and other debris.

3.3. CRITICAL POINTS OF MEMBRANES



Waterproofing, crack isolation, noise reduction, and other types of membranes are a critical part of many tile assemblies and must be installed properly if they are to be effective. Qualified installers are expected to be conversant with the many specialty conditions in sheet-applied and liquid-applied membranes, which are the two primary types of membrane systems. The ACT certification for Membranes tests the candidate in his ability to install both sheet-applied and liquid-applied waterproofing membrane in the field of the floor and also at special conditions like changes in plane, terminations, and penetrations through the membrane.

3.3.1. VERTICAL RETURNS AND CHANGES IN PLANE

The required height of a membrane's vertical return varies from job to job depending on the category of use and the membrane manufacturer. For waterproof membranes, a vertical return of some distance is generally recommended if only to ensure full membrane coverage horizontally. The installers must demonstrate their ability to avoid a seam at the vertical return and to maintain continuity across the change in direction, as well as to terminate the vertical membrane at an elevation lower than the specified height of the tile base if the wall is not to be tiled.

A similar condition for membranes is the change in plane at inside and outside corners. Installers must take care to pre-treat the corners with continuous embedded reinforcement fabric where applicable at liquid-applied systems, and to keep the entire liquid and sheet-applied membrane systems continuous and free of seams at the corners.

3.3.2. FULLY EMBED FABRIC AT LIQUID-APPLIED MEMBRANE

For liquid membrane systems requiring reinforcement fabric, the fabric must be lapped and embedded in the liquid membrane per the membrane manufacturer's instructions. Full embedment requires that the installer apply a layer of liquid, then the continuous fabric, then another layer of liquid. Each layer of liquid must be applied to the wet mil thickness specified by the manufacturer. Failure to engage the fabric with the liquid may result in a liquid-applied membrane system that does not function as expected.

3.3.3. PRE-TREAT DRAIN AND PIPE PENETRATIONS

In addition to changes in plane, penetrations and terminations in the membrane system represent potential for failure. Pre-treating the membrane at these conditions is the process of cutting the sheet membrane or fabric component of liquid membrane into special configurations that securely bond to the penetrating element, and to adhere the membrane to the penetrating element to form a watertight connection per the membrane manufacturer's directions. Even if the field of the membrane is watertight, the entire membrane system may be compromised if the connection details are not installed properly, therefore it is critical that installers pay close attention to these details.

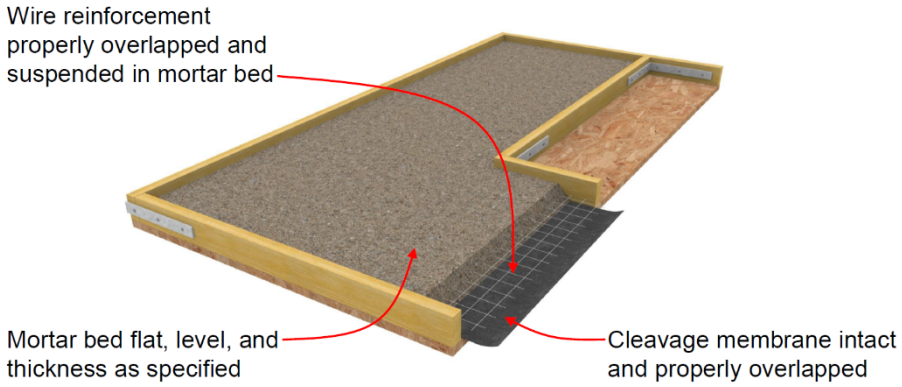
3.3.4. CORRECT WET MIL THICKNESS AT LIQUID MEMBRANES

The field of a liquid membrane is simpler to install than the specialty conditions described above, but it is not foolproof. Installers must take care to monitor the thickness of the liquid as they roll or brush it on by using a wet mil gauge. Estimating or "eyeballing" the thickness is not an approved method. If the membrane is installed exceedingly thin or exceedingly heavy, problems in performance may result. A liquid membrane's required wet mil thickness varies by membrane system and by manufacturer, so installers must be conscientious about reading and following the manufacturer's installation instructions.

3.3.5. LAPS AND SEAMS AT SHEET-APPLIED MEMBRANES

Sheet membranes often require seams, and unless they are properly applied, seams can become a natural source for leaks in the system. ACT candidates for Membranes certification are tested on their ability to adhere the sheet membrane to the substrate, to overlap the sheets by 2 in. (50 mm) minimum at the seams, and to properly adhere the overlapping sheet to the sheet below.

3.4. CRITICAL POINTS OF MORTAR BED (MUD) FLOORS AND WALLS



The age-old method of laying tile floors and walls in setting beds built up of sand, cement, and sometimes wire or lath reinforcement over the floor or wall structure is a work technique that has declined in recent years as thinset mortars and thinset installation methods have been improved and become more prevalent. However, mortar bed techniques for installing tile will never disappear completely as they remain appropriate for certain types of applications such as heavy duty areas of use, cases where the variable thickness of the mortar (mud) bed is appropriately used to correct an irregular substrate, and other instances where the design professional or building owner has a preference for this classic method of

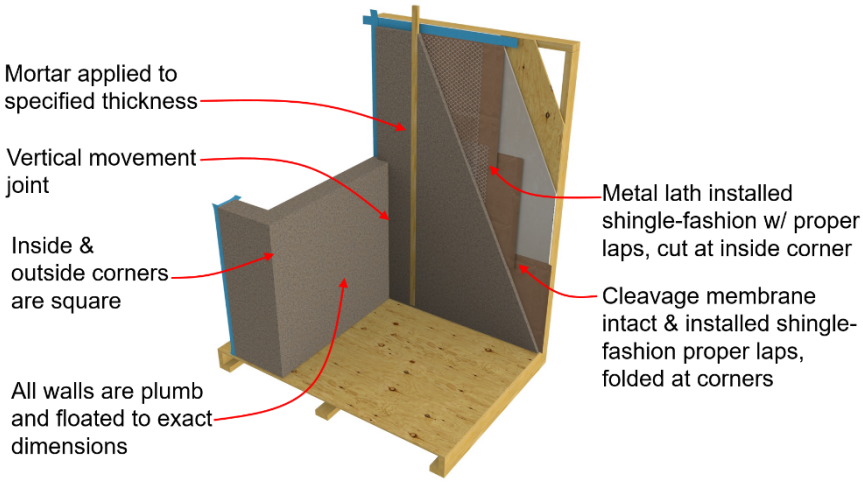
installation. Today's qualified tile installer must be able to demonstrate knowledge and skills to propertly install all elements of mud floors and walls. There are two distinct ACT certifications: one for Mud Floors and one for Mud Walls, and the critical points for each will be discussed in this section.

3.4.1. CORRECTLY INSTALL CLEAVAGE MEMBRANE

A cleavage membrane is often specified to provide a bond break in mud set floor and wall assemblies if differential movement is expected between the tile assembly and the substrate. Cleavage membrane materials vary, but they are often paper-based, delicate, and easily damaged. A qualified tile installer will take care not to tear, puncture, or otherwise damage the cleavage membrane during the installation process, and if damage does occur, the installer will replace and reinstall the material. Floors and walls both require minimum overlaps in the cleavage membrane, generally 4 in. (100 mm) for floors and 2 in. (50 mm) for walls; and the laps at walls must be applied shingle-fashion. Failure to install the cleavage membrane to these criteria may result in ineffective bond break or moisture intrusion into the wall or floor structure.

3.4.2. CORRECTLY INSTALL WIRE REINFORCEMENT AND LATH

Except for very small mud installations like single shower receptors, reinforcement is generally required within mortar bed floors and walls to impart flexural strength, to control shrinkage of the mortar and prevent cracking, and in the case of walls, to support the vertical mortar bed.



3.4.2.1. REINFORCEMENT AND LATH IN TILE INTALLER'S WORK SCOPE

Proper installation of galvanized wire mesh reinforcement in mud floors is a critical skill that is always within the work scope of tile installers. Installation of metal lath on a wall's structural backing often falls outside the scope of a tile installer's work, but it is a related skill that tile installers must at least have knowledge of since it affects the performance of the tile assembly, and in some cases the lath installation does fall in the tile work scope.

3.4.2.2. CONTINUITY OF REINFORCEMENT AND LATH

In order to function properly, the reinforcement and lath must be continuous (except at inside corners of walls) and properly lapped by 2 in. (50 mm) minimum. In the case of walls, the lath must be installed shingle-fashion. At inside corners of any mud wall, the lath must terminate at the corner, allowing a small gap in reinforcement

to allow for independent movement of each wall and directing cracks to the vertical perimeter expansion joint of the tile assembly.

3.4.2.3. POSITIONING AND FASTENING OF REINFORCEMENT AND LATH

The positioning of the reinforcement in mud floors is critical to the performance of the floor. If the reinforcement is too high or too low from the center of the mortar bed, its ability to add flexural strength and adequately reinforce the system may be compromised. ACT candidates for Mud Floors certification are evaluated on their ability to maintain the vertical position of the reinforcement in the center 1/3 of the mortar bed. Similarly, the fastening pattern of the metal lath on walls must be installed and spaced as specified.

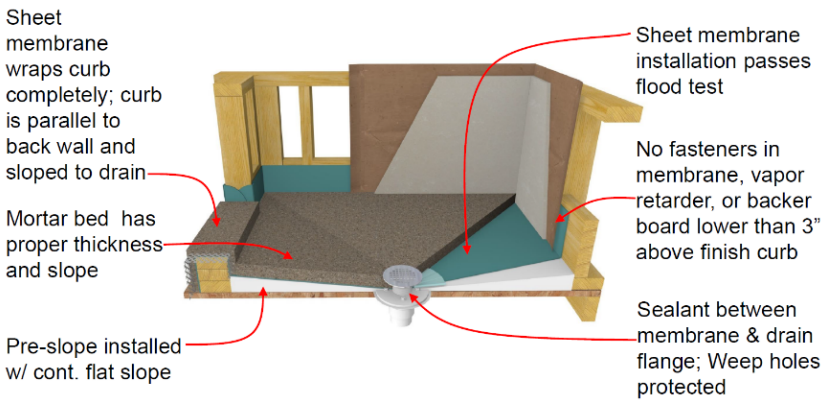
3.4.3. FLOATING MUD FLOORS AND WALLS

While installation of the cleavage membrane, reinforcement, and lath is important, the primary task faced by installers of mud floors and walls is to properly float the mortar beds flat, level, plumb, and to the specified thickness. The ability to float floors and walls accurately is a true skill that takes years to master, and it is the hallmark of a skilled tile installer.

ACT candidates for Mud Floors and Mud Walls certifications are tested on their ability to float the mortar to the proper thickness at key benchmarks, and to vary the thickness as necessary to correct substrates that are out of flat or out of plumb. At walls, installers must float inside and outside corners that are plumb, as well as maintain plumbness within tolerance in the field of the wall. Dimensions of wall mud must be accurate per the construction documents in order to maintain accurate finish dimensions. Mud floors must be flat and level upon completion, and ready to receive a tile finish. Each of these skills is critical for mortar bed installations.

3.5. CRITICAL POINTS OF SHOWER RECEPTORS

Proper design and construction of tiled shower assemblies is imperative, since the failure of a single shower could potentially cause widespread damage in apartment housing, hotel, senior housing, dormitory, and other commercial and multifamily residential buildings. Successful installation of a watertight assembly can be complex and challenging, but is a required skill for a qualified tile setter.



When it comes to tiled shower assemblies, there is no standard design, rather there are varying methodologies and materials such as whether water is directed to a conventional drain with weep holes via a "water in, water out" approach or a flanged drain via a single line of defense approach; whether the slope to drain is provided by a mortar bed or a prefabricated "pre-slope" mechanism; whether the slope is in four directions to a centrally located drain or in one direction to a linear drain; whether the shower has a curb at the front to contain the water or it curbless for handicapped accessibility; whether the waterproofing is in the form of a sheet pan liner or a liquid, and whether it is sandwiched between the pre-slope and the finish mortar bed or it is topical, i.e. bonded to the top of the finish mortar bed; whether the bottom edge of the backer board on the shower walls is buried in the mortar bed or it is elevated above the top of the mortar bed; as well as many other variables. Some commonly specified shower assemblies are documented in the TCNA Handbook[3], but there are also many variations of successful showers that do not appear in the Handbook. A qualified tile setter should be able to install any type of shower to exacting performance criteria. While a comprehensive analysis of shower receptors is out of this paper's scope, it will examine the one specific shower, the TCNA B415 shower[3], and this shower's critical points of design and installation.

3.5.1. INSTALLATION OF PRE-SLOPE

The shower's ability to direct water to the drain relies on the slope of the finish tile. The pre-slope sets the slope of the entire shower assembly, so it is critical that it be accurate. The pre-slope must have a uniform slope of 1/4 in. per ft. (20 mm per m) (2% slope) to the drain. A prefabricated pre-slope device simplifies this task, but if a mortar bed pre-slope is floated, it must have the correct and consistent slope without even slight humps or valleys that could impede flow, and it should be bonded to the substrate with modified thinset mortar or a cement slurry.

3.5.2. INSTALLATION OF SHEET MEMBRANE

The sheet membrane, also known as the shower pan liner or the waterproofing membrane, is the component in the assembly that protects the substructure from contact with water. In the B415 shower it is loose laid and continuous.

The membrane must be installed seamlessly inside the receptor, returning vertically up the perimeter walls the distance specified. If separate pieces of membrane are required to create the vertical returns, the membrane must be adequately lapped and sealed. If the membrane is folded at the inside corners to avoid seams, the folds should be consistent at each corner in order to achieve a square finish once the backer board is installed on the walls. Folding the membrane at corners may create an excessively thick condition that would need to be corrected with shims at the time the backer board is installed (see section 3.5.5). The membrane is mechanically fastened to the vertical framing or blocking, with the fasteners no lower than 3 in. (76 mm) from the top of the finished curb.

The membrane must be sealed to the drain collar with approved sealant rather than simply laid loose, to prevent water from becoming redirected to underneath the membrane where it may never reach the drain. Once this task is complete, the drain's clamping ring is installed, providing the critical watertight connection between the membrane and the drain.

The membrane must completely cover the rough curb, including the entire front face of the curb. There should be no fasteners on the top or inside surface of the curb. Installers must use preformed membrane corner pieces to ensure continuity at the top ends of the curb.

3.5.3. FLOOD TESTING

After the installation of the membrane (including all transitions and terminations) and weep hole protection, the in-progress shower receptor should be flood tested to ensure watertightness. Methods of flood testing vary, but they are generally based on ANSI D5957[4]. This test method calls for the shower drain to be temporarily plugged and the shower receptor filled with approximately 1 in. (25 mm) of water and allowed to stand for 1 to 2 hours. The assembly is considered to have passed the flood test if no leaks are determined to have occurred during the test period.

3.5.4. INSTALLATION OF VAPOR RETARDER AND BACKER BOARD

Although these components don't always fall in the scope of the tile work, qualified tile installers should be versed in installing vapor retarder and backer board since these tasks may occur as the shower assembly is constructed, and their construction often defaults to the tile trade.

When vapor barrier is specified, it should be free of rips and tears, shingled over the shower pan liner, and adequately fastened to the backing, but with no fasteners lower than 3 in. (76 mm) above the top of the finish curb.

The backer board is installed over the vapor barrier, or if there is no vapor barrier, it is installed directly over the pan liner using shims if necessary to maintain plumb, and mechanically fastened to the framing. If the backer board is a cementitious backer unit (CBU) conforming to ASTM C1325, it may be buried in the finish mortar bed. Alternatively, if a more moisture sensitive backer boards is used, such as fiber-cement backer board (ASTM C1278, ASTM C1288), coated or uncoated glass mat water-resistant gypsum board (ASTM C1178, ASTM C1658), or cementitious coated extruded foam board (ASTM C578), the backer board should be elevated above the top of the mortar bed so it does not absorb moisture through its bottom edge. In all cases, as with the pan liner and the vapor barrier, the backer board should have no fasteners lower than 3 in. (76 mm) above the top of the finish curb.

3.5.5. INSTALLATION OF WEEP HOLE PROTECTOR

When using a conventional two-stage drain, qualified installers must demonstrate the ability to install weep hole protection. A weep hole protector prevents the weep holes in the drain from becoming clogged with mortar or debris. Keeping the weep holes unobstructed allows them to function as a secondary method of handling any moisture that penetrates the tile surface and is otherwise unable to reach the drain via conventional channeling.

3.5.6. INSTALLATION OF MORTAR BED AND CURB

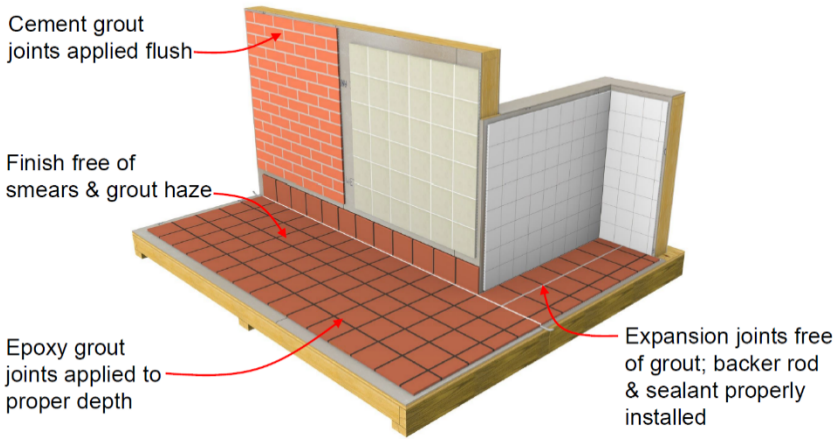
The final step of a B415 shower, before laying the tile itself, is the application of the mortar bed and the mud curb. These activities are typically done at the same time.

Because the installers have already formed the slope (see 3.5.1), the final mortar bed is floated to a consistent thickness and follows the contours of the pre-slope below. The mortar bed should retain the 1/4 in. per foot (20 mm per m) (2%) slope and should be free of humps or valleys that could impede flow of water to the drain.

As the shower receptor is floated, mortar is also applied to the rough curb with metal lath reinforcement embedded. At its completion, the mud-finished curb should be square to the shower, parallel to the back wall, flat in the long direction, and have a cross slope of 1/8 in. (3 mm) toward the shower.

Shower receptors are indeed complex assemblies and require extensive knowledge and many diverse skills even prior to installing the tile finish. Candidates for ACT certification in Showers must demonstrate their ability to install each of these critical details of the assembly.

3.6. CRITICAL POINTS OF GROUTS AND GROUTING



Grouting and cleaning a tile assembly is the final step of any tile installation, and a qualified tile finisher will be adept at applying the various types of grout and sealant, and at keeping the installation clean.

Installers must be skilled at mixing and applying sanded and unsanded cement grout, high performance cement grout, and epoxy grout. The mixing procedures are unique for each of these grout types, as are the grouting and cleaning techniques. Finishers must install the cement grout to a profile flush with the face of the tile or the tile's beveled edge, and they must install epoxy grout to a profile with maximum depression of 3/64 in. (1 mm)

Expansion joints (EJs) are another critical aspect of tile design and installation. The design professional must locate all expansion joints on the construction documents, but it is the responsibility of the installer to properly install them. Proper installation requires keeping the EJ free of debris, thinset mortar, or grout that may otherwise inhibit movement, and installing backer rod or bond breaker tape and sealant to allow for differential movement within the tile assembly. Finally, the overall appearance of the installation must be clean and free of grout haze and other stains on the surface of the tile.

4. CONCLUSION

Failures of tile assemblies occurring 10-20 years ago at a time when manufacturers of tile and setting materials were making advancements has led the U.S. tile industry to take a close look at the sources of failure and to react in an organized effort to create a more qualified workforce able to competently install tile and related materials meeting the many critical points within each of the seven identified important skill areas. While there is no universal definition of qualified labor, the industry's acknowledgement of the seven important skill areas and the critical points of installation contained in each has provided a benchmark for quality. Qualified labor begins with training, is followed by many thousands of hours of field experience, and is now ultimately measured by certifications. The Advanced Certifications for Tile Installers is a set of seven certifications that validate the installers' skills in the respective areas, and these certifications have emerged as reliable indicators of qualified labor.

5. REFERENCES

[1] The U.S. tile industry is defined as the following consortium of organizations: Ceramic Tile Education Foundation (CTEF), National Tile Contractors Association (NTCA), International Masonry Institute (IMI), International Union of Bricklayers and Allied Craftworkers (IUBAC), Tile Contractors' Association of America (TCAA), and Tile Council of North America (TCNA).

[2] ANSI A108 Installation Standards for Ceramic Tile.

[3] Tile Council of North America (TCNA) Handbook for the Installation of Ceramic, Glass and Stone Tile.

[4] ANSI D5957 Standard Guide for Flood Testing Horizontal Waterproofing Installations

[5] ACT Shower Receptor Installer Critical Points grading sheet

[6] ACT Large Format Tile Installer Critical Points grading sheet

[7] ACT Mud Floors Critical Points grading sheet

[8] ACT Mud Walls Critical Points grading sheet

[9] ACT Grouts Critical Points grading sheet

[10] ACT Gauged Porcelain Tile Critical Points grading sheet

[11] ACT Membranes Critical Points grading sheet