

TESTING

Evaluation of mortar types used with Schluter®-DITRA

07 As stated previously in this Handbook, Schluter®-Systems recommends the use of unmodified thin-set mortar between Schluter®-DITRA and the ceramic or porcelain tile covering. In this section, we will address concerns regarding the use of unmodified mortar over DITRA and provide insight into the overall function of the tile assembly using experimental data. The Tile Council of North America was contracted to perform independent testing of all experimental setups described hereafter.

A popular misconception in the tile industry is that porcelain tile cannot be bonded using unmodified mortar. To show that unmodified mortar will provide the necessary performance in Schluter®-DITRA installation systems, the following tests were performed. First, unmodified mortars from two different manufacturers were used to bond porcelain tile to DITRA over a single layer of 3/4" plywood with joists spaced at 19.2" o.c. The two installations were tested according to the ASTM C627 "Standard Test Method for Evaluating Ceramic Floor Tile Installation Systems Using the Robinson Type Floor Tester" and produced ratings of *heavy* and *light*. *Heavy* indicates a performance level acceptable for shopping malls, stores, commercial kitchens, work areas, laboratories, auto showrooms and service areas, shipping/receiving, and exterior decks, while *light* indicates a performance level acceptable for light commercial use in office space, reception areas, kitchens, and bathrooms. Given that the test assemblies only utilized a single layer of plywood, these high-performance ratings demonstrate that unmodified mortar can provide a secure bond even over a bending and deflecting substrate. Tiles were removed from each of the ASTM C627 specimens after the Robinson test was complete, and then used to evaluate shear bond strength between the unmodified mortar and the tile. Test results are summarized in the table below.

Mortar Type (Applicable ANSI Standard)	TCA Test Report Number	ASTM C627 Test Rating*	TCA Test Report Number	Shear Test Results† (psi)	
				Specimens:	
Manufacturer 1 Unmodified (A118.1)	TCA-046-03 (B)	Heavy (13 cycles)	TCA-073-03	Specimens:	327, 267, 267, 246
				Average:	277
Manufacturer 2 Unmodified (A118.1)	TCA-126-03 (A)	Light (9 cycles)	TCA-186-03	Specimens:	425, 381, 275, 377
				Average:	365

***Test Setup:**

1. 2" x 2" joists spaced 19.2" o.c.
2. APA-rated "Exposure 1" tongue-and-groove plywood subfloor; 3/4" thickness
3. Spray-dried latex-modified mortar in Test TCA-046-03 and liquid-emulsion latex-modified mortar in Test TCA-126-03 (ANSI A118.4)
4. Schluter®-DITRA mat
5. Unmodified mortar, as indicated in table above (ANSI A118.1)
6. 12" x 12" porcelain tile; 3/8" nominal thickness
7. Sanded, spray-dried latex-modified portland cement grout (ANSI A118.7)

† Tile samples removed from ASTM C627 test specimens and evaluated for shear bond strength between mortar and tile

07 Tests were also performed on Schluter®-DITRA assemblies using unmodified thin-set mortar over concrete according to ASTM C627. The two assemblies produced ratings of *Extra Heavy*, indicating a performance level acceptable for extra heavy and high impact use in food plants, dairies, breweries, and kitchens, and *Light*, indicating a performance level suitable for light commercial use in office space, reception areas, kitchens, and bathrooms. Variation in the performance levels achieved is attributable to the different tile used. Test results are summarized in the table below.

Substrate	Mortar Type (Applicable ANSI Standard)	Tile	Grout (Applicable ANSI Standard)	ASTM C627 Test Rating	TCNA Test Report Number
Concrete	Unmodified (A118.1)	12" x 12" porcelain; 5/16" nominal thickness	Polymer Modified Cement Grout (A118.7)	Extra Heavy (14 cycles)	TCNA-039-06
Concrete	Unmodified (A118.1)	2" x 2" porcelain; 1/4" nominal thickness	Polymer Modified Cement Grout (A118.7)	Light (6 cycles)	TCNA-057-06

Given concern over freeze/thaw performance of unmodified mortar, the next set of tests included shear bond tests of porcelain tile bonded to concrete with and without Schluter®-DITRA after exposure to freeze-thaw cycles in accordance with ANSI A118.4 (F5.2.6). An unmodified mortar was used in one installation, while a liquid-emulsion latex-modified mortar from the same manufacturer was used in the other. It should be noted that when used between two impervious materials, such as porcelain tile and DITRA, latex-modified mortars must be afforded extended drying times. According to the *TCA Handbook for Ceramic Tile Installation*, the necessary drying period can fluctuate from 14 days to over 60 days when using latex-modified mortar. Since unmodified mortars do not require a drying period (and actually benefit from continued water presence), they allow for normal use of the tile installation in a fraction of the time and, as shown in the test data in the table below, provide more than adequate performance.

Mortar Type (Applicable ANSI Standard)	Shear Test Results† (psi) Test Report TCA-145-03			
	Tile Bonded to Concrete (ANSI A118.4)‡		Tile and DITRA Bonded to Concrete (ANSI A118.10)°	
Manufacturer 1 Unmodified (A118.1)	208	Specimens:	66, 61, 70, 62	
		Average:	65	
Manufacturer 1 Liquid-Emulsion Latex-modified (A118.4)	199	Specimens:	53, 57, 58, 75	
		Average:	61	

‡ All specimens subjected to freeze/thaw cycles in accordance with ANSI A118.4 (F5.2.6)

– ANSI A118.4 requires minimum shear bond strength of 175 psi

° ANSI A118.10 requires minimum shear bond strength of 50 psi

HOW DOES IT WORK?

Explanation of how Schluter®-DITRA functions

To understand how the DITRA system works, it is important to first understand what a tile assembly is, how it functions, and how stresses occur within the assembly. A tile installation is a composite assembly that consists of layered components (underlayments, bonding mortars, tile, etc.). The primary sources of stress in this composite system are movements due to loading, changes in temperature, and changes in moisture content (either in the substructure or in the components of the tile assembly, including the tile itself). When an installation is subjected to these movements, compressive and tensile stresses develop within the assembly and interact to produce shear stresses at the interfaces between the layered components. Therefore, a tile assembly must be able to perform well under load and, at the same time, provide flexibility within the shear plane.

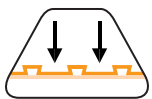
The method used to establish the overall performance of a tile assembly under loading is the ASTM C627 "Standard Test Method for Evaluating Ceramic Floor Tile Installation Systems Using the Robinson Type Floor Tester." The assembly is tested in cycles using a loaded, revolving carriage. Load, wheel hardness, and number of revolutions vary with each cycle. Once a specified level of damage is exceeded, the test is stopped. The Tile Council of North America (TCA) Handbook for Ceramic Tile Installation assigns performance levels to an assembly based on the number of cycles successfully completed. The ratings include *residential*, *light*, *moderate*, *heavy*, and *extra heavy*, in order of improving performance.

The TCA conducted the tests shown below, which included a single layer of plywood (3/4" thick) over joists spaced at 19.2" o.c., Schluter®-DITRA bonded using modified thin-set mortar (ANSI A118.4), 12" x 12" porcelain tile (3/8" thick) bonded using unmodified thin-set mortar (ANSI A118.1), and modified portland cement grout (ANSI A118.7).

TCA Test Report Number	Number of Cycles Passed	Rating
TCA-046-03 (B)	13	Heavy
TCA-126-03 (A)	9	Light

The two installations produced ratings of *heavy* and *light*, according to the TCA Handbook for Ceramic Tile Installation. "Heavy" indicates a performance level acceptable for shopping malls, stores, commercial kitchens, work areas, laboratories, auto showrooms and service areas, shipping/receiving, and exterior decks, while "light" indicates a performance level acceptable for light commercial use in office space, reception areas, kitchens, and bathrooms.

Given that the test assemblies consisted of only a single layer of plywood over joists spaced at 19.2" o.c. (a bending and deflecting substrate), these ratings demonstrate that Schluter®-DITRA performs extremely well under load while at the same time providing flexibility within the shear plane.



When placed on a solid foundation, columns or pillars can support tremendous loads. The same physical principle applies to DITRA installations. Column-like mortar structures are formed in the cutback cavities of the matting. Loads are transferred from the tile covering through these column-like mortar structures to the substrate. Since mortar has a very high compressive strength, DITRA becomes virtually incompressible within the tile assembly and, therefore, doesn't sacrifice load-distribution capabilities of the system.



DITRA provides uncoupling (geometric flexibility) through its open rib structure, which allows for in-plane movement that effectively neutralizes the differential movement stresses between the substrate and the tile.

This flexibility is readily apparent when the overall DITRA assembly is subjected to shear testing. In the tests shown below, porcelain tile was bonded to concrete using unmodified thin-set mortar meeting ANSI A118.1. One specimen included Schluter®-DITRA, while the other did not. The results show that the amount of stress developed in the system when the tile layer is displaced is significantly reduced through the inclusion of DITRA, which is due to the product's flexibility in the shear plane.

Assembly	Average Maximum Shear Stress (psi)
Tile over concrete	208
Tile and DITRA over concrete	65

Tile has been successfully installed for thousands of years by incorporating an uncoupling layer, or forgiving shear interface, between the tile assembly and the substrate. This practice has evolved from the sand-strata method (tile set in mortar over a layer of tamped sand) to the unbonded mortar bed method (tile set in mortar over a cleavage membrane). However, this alone does not ensure a high-performance tile installation. The tile covering must be well supported so that loads can be distributed through the assembly to the substructure without damaging the tile covering. Therefore, a viable tile assembly must be designed to incorporate both support/ load distribution of the tile layer and flexibility within the shear plane (e.g., a traditional unbonded mortar bed allows for flexibility at the shear plane through a cleavage membrane, but still provides a solid base for the tile layer).

Since Schluter®-DITRA utilizes geometric flexibility in the shear plane rather than material flexibility, the advantages of uncoupling are achieved without sacrificing load-distribution capabilities of the tile assembly. Thus, it is the combination of geometric flexibility in the shear plane and support in the normal direction that allows Schluter®-DITRA to protect the tile layer from stresses due to loading and changes in temperature and moisture.