CERAMIC TILE INSTITUTE OF AMERICA, INC.

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SUBJECT: The Installation of Ceramic Tiles on Gypsum Substrates: Problems and Remedies
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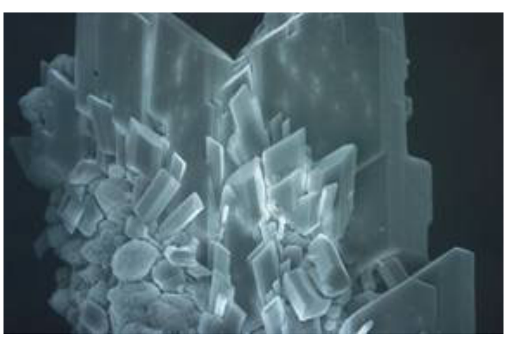
My presentation today concerns the installation of ceramic tile on gypsum substrates. This underlayment material is not recognized as a suitable substrate by the current A.N.S.I. specifications; yet, it is not strange or unusual today to be confronted with this type of substrate intended to be tiled either on a commercial or a residential job site. The question then becomes…. "If I tile over the gypsum underlayment, will I be successful?"

The answer is, "Yes;" but only if you understand the nature of the gypsum underlayment, the dangers that it presents, and finally, the necessary precautions to insure the success of your installation.

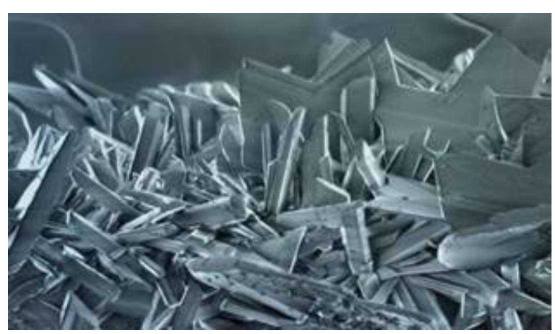
The Nature of Gypsum

Gypsum is a relatively abundant and accessible mineral in nature. It has been used for various aspects of construction for around 6,000 years.

When used properly, it is a good thermal and sound insulator, and it can also be a good fire barrier. Chemically, gypsum is calcium sulfate dehydrate. It has a characteristic crystalline shape as seen in these electron photomicrographs. The first slide shows its crystalline structure, magnified one hundred times (slide 1) while the second slide is a higher magnification of gypsum (slide 2).



Slide 1



Slide 2

Another of this mineral's physical characteristics is its partial solubility in water. Because of this solubility, gypsum underlayments lose considerable strength, even when exposed to low levels of moisture. Fully one half of its compressive strength can be lost when it is wet!

Precautions Before Proceeding

All of this does not mean that it is impossible, or even inadvisable to install ceramic tile on gypsum-based underlayments. We must simply observe some necessary precautions before we proceed.

First, it is essential to determine that the underlayment is dry. Some gypsum underlayment manufacturers recommend maximum water content of 5% or less. Yet, it is my experience that moisture content not exceeding one-half percent is better. But, the most accurate and reliable instrument available for this critical test is a calcium carbide hygrometer. The apparatus is fully described in ASTM D-4944. This drying period can take five (5) to seven (7) days for a two (2) centimeter thick screed and increases with the thickness of the screed.

The next step is to determine the surface hardness of the gypsum underlayment. This can be accomplished by the use of an appropriate tool, such as a common nail or chisel. When pressed firmly against the surface and pulled, it should meet considerable resistance and leave a shallow indentation. If the surface is gouged easily, the underlayment may be considered unsuitable for our ceramic tile installation.

Finally, we must consider the environment where our gypsum underlayment is located; for ultimately, it influences our selection of surface preparation materials.

If the gypsum-based underlayment is located in a wet area, it must, due to its very nature, be covered by a water-impermeable cold liquid, trowel applied or pre-formed waterproof membrane conforming to ANSI A118.10 before we can proceed.

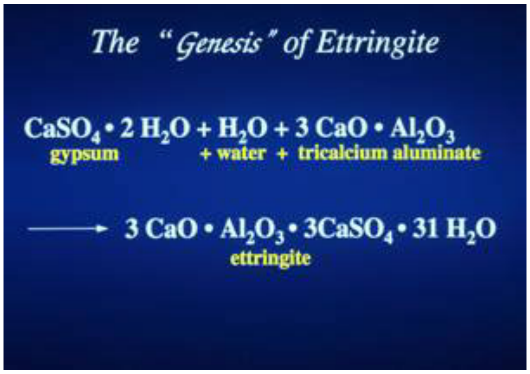
If the gypsum-based underlayment is located on a wood-framed floor or contains an integral heating system, it must be covered with a crack isolation membrane to mitigate the potential of cracks from structural movement telegraphing through the finished tile work. In all other instances, it is necessary to apply a latex primer to the underlayment's surface to prevent the direct contact between gypsum and Portland cement.

Yet, be careful about your selection of primers, because not all emulsion polymers are appropriate for this purpose. Ideally, the primer latex must have a small polymer particle diameter. This is necessary because the primer must penetrate the pores of the underlayment, this closing them, and not just form a superficial skin that can easily be removed or abraded, allowing a penetration or ingress of water later. Consult with the gypsum underlayment manufacturer or your mortar manufacturer and follow their directions implicitly.

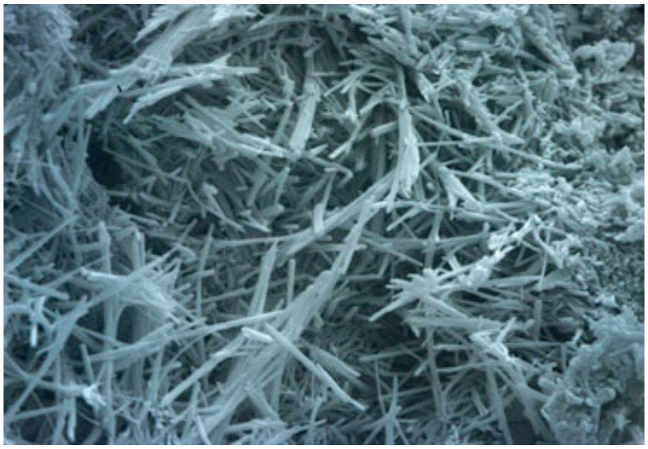
With the use of an appropriate primer, our installation can now proceed, and we can be confident that it is capable of resisting the sporadic water infiltration that will occur even in dry areas during routine operations or foot traffic during inclement weather.

But, the ultimate danger is represented by the possibility that occurs when gypsum, in combination with components of Portland cement and water, can react to produce another chemical compound known as ettringite. This reaction can be systematically represented as follows: (slide 3)

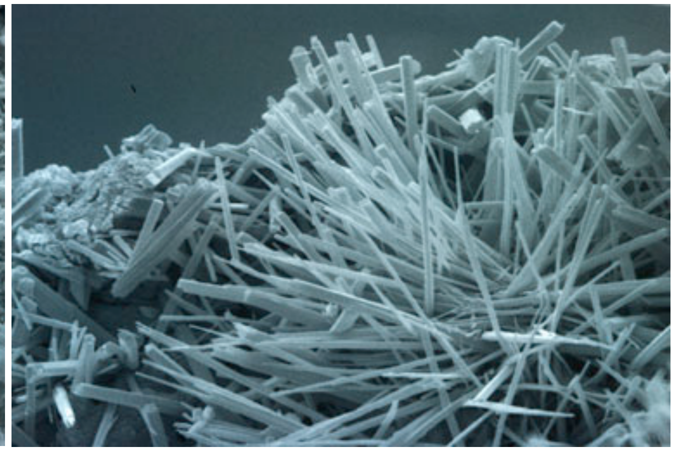
Ettringite is a salt which crystallized with a great increase in volume, i.e. the ettringite occupies more volume than the original reactants. Its crystalline structure is acicular with a hexagonal aspect as illustrated in these slides (slides 4 and 5)



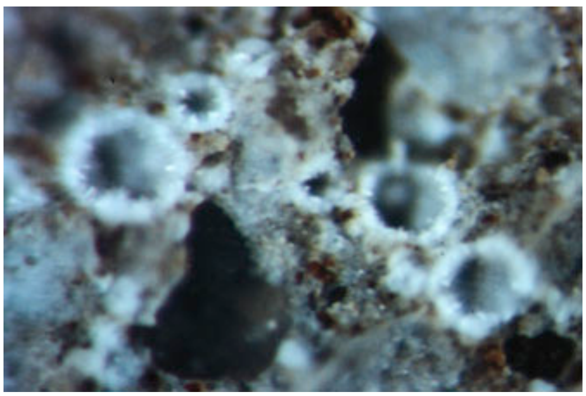
Slide 3



Slide 4



Slide 5



Slide 6

This slide (slide 6) is a photomicrograph of a fragment of a latex Portland cement mortar. Some of the air voids in the mortar are lined by the infiltrating ettringite crystals. Eventually, these developing crystals will fill these voids, and ultimately expand, disrupting the integrity of the mortar.

It is the formation of ettringite and its subsequent expansion that causes a disbanding to occur between Portland cement-based adhesives and gypsum-based underlayments, and not the lack of bond between gypsum-based underlayments and Portland cement-containing mortars.

A wise man once stated "Rust never sleeps!" and this is the case with the potential for ettringite formation. If all of the reactants necessary for ettringite formation are available, i.e. water, gypsum, and Portland cement, it will form with expansive destruction months, even years after the initial installation.

We wish to thank Craig Hamilton for his permission to reproduce this report.