HISTORICAL EVOLUTION OF CERAMIC TILE ADHESIVES AND THEIR CONTRIBUTION TO EXPANDING THE MARKET FOR CERAMIC TILE

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Henry M. Rothberg recelved his degree in Chemical Engineering and attended Harvad University Graduate School of Business Administration. He has been closely associated with the construction industry in the ceramic tile, marble and stone areas for over forty-five years beginnig with his early days as a ceramic tile, marble and terrazzo contractor.

He developed and introduced the first latex Portland cement adhesives used in the tile industry in North America, and also introduced this technology to Europe, the Pacific Region, Autralia, New Zeland and Southeast Asia in the early 1960's.

He also developed the first water cleanable, non-toxic exposy modified Portland cement mortars and introduced them to the construction trade as adhesives, concrete repair materials and coating. His developments include the first thin load bearing waterproof menbranes as well as sound control underlayments for use under ceramic tile.

Mr. Rothberg is the holder of many patents and is reconigzed worldwide as one of the leading authorities in latex and polymer modified Portland cement technology. His articles and technical reports has been traslated into many languages and distributed worldwide.

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The introduction of adhesives has dramatically changed many phases of construction. With adhesives, the floor surfaces must first be flat, true and level or the walls must be flat and plumb. This is usually the responsibility of the concrete worker for floors, and the plastering worker for preparing the walls. It is necessary for the architect and builder to understand the adhesive technology limitations so they can prepare the building properly.

The adhesive method for installing ceramic tile differs greatly from the traditional mortar method. Prior to the introduction of adhesives, mortar was the material of choice for installing ceramic tile. The mortar method requires an application of Portland cement and sand with a minimum thickness of 25 mm. This thickness ensures that the cement will retain moisture over a period of time in order to develop strength and cure. However, thin layers of cement/sand mortars, applied in the traditional method never develop high strength. Losing moisture through evaporation, Portland cement never develops its full strength when prepared in the traditional manner.

The traditional method accommodates variations in wall or floor surfaces because mortar can be applied from 20 to 70 mm in thickness. This allows the tile installer to accommodate poor quality concrete floors, or uneven brick and masonry walls. This method requires that the tile installer be competent in order to ensure a flat wall or level floor with uniform joints in ceramic tile.

What is the Adhesive Method?

The adhesive method calls for applying a thin layer of adhesive to bond or adhere the ceramic tile to a clean and stable surface, generally a floor or wall. It is essential to have a strong, sound and flat surface. The adhesive method uses a paste applied in a layer as thin as 3 mm, or even as thick as 12 mm. In order to apply the adhesive mixture in a uniform layer, a notched trowel is used, its teeth giving the proper depth of adhesive. A trowel with notches of 6x6 mm will apply a series of ribs, which when flattened under the pressure of the ceramic tile, will become a uniform layer approximately 3 mm in thickness.

Remember that the finish or appearance of the ceramic surface is only be as good as the condition of the surface to which it is attached. Ceramic tiles installed by the adhesive method will follow the contour of the wall or floor, and reflect any unevenness that occurs in the sub-surface. The skill of the installer is very important— he must judge the suitability of the surface before installing ceramic tile by adhesive method.

Adhesives can be classified in the following groups:

1. Thin-set Mortar Cement Adhesives or Hydraulically Hardened Mortars—are usually a mixture of Portland cement, mineral aggregates and organic additives. They consist of a dry powder that is site-mixed with water to make an adhesive that is then be applied with a notched trowel. When hard, it becomes a very strong, durable adhesive for ceramic tile. These adhesives are water-resistant.

In the past 20 years, many manufacturers have introduced these cement adhesives so that now "cement adhesive" is readily available in many countries.

2. Paste/Mastic Adhesives or Organic Adhesives—commonly called "one-part" adhesives, consist of mixtures of latex or resins containing fillers such as quartz flour, or marble dust. This produces a thick mastic paste or organic adhesive suitable for application

with a notched trowel. Generally these pastes are easy to use but have one major weakness. They are not suitable for ceramic tile installations that are continually exposed to water, such as showers, baths, fountains or swimming pools. They are frequently used in dry areas such as kitchen, hospital and bathroom walls which are not exposed to shower water. These organic adhesives are not suitable for installing floor tiles which will be exposed to heavy traffic in commercial or industrial service.

3. Latex Thin-Set or Dispersion/Cement Adhesives—were the earliest Portland cement adhesive compositions to provide weather-proof, frost-proof adhesive suitable for installing ceramic tiles on interiors, exteriors and under a wide range of weather conditions.

They consist of a liquid latex which is site-mixed with ordinary Portland cement or a mixture of Portland cement and sand. The liquid latex can also be mixed on-site with a prepared, pre-packaged sand/cement powder.

These latex Portland cement adhesives provide a high level of service and intiated the concept of using adhesives for installing small and large ceramic tiles on exterior facades and industrial floors.

Over the years, producers in many countries have marketed a range of cement powder adhesives.

4. Solvent-based or Dissolved Resin Adhesives—are factory-prepared, ready-to-use mixtures consisting of fillers dispersed in a solution of an organic binding agent in volatile solvent. These adhesives have declined in popularity because of environmental problems.

5. Epoxy Adhesives or Reactive Resin Adhesives— provide high chemical resistance and are used primarily in dairies, cheese and other food factories. In industrial applications, where ceramic tile is exposed to severe chemicals, epoxy resin adhesives are used as adhesive and grouting materials because of their chemical resistance.

When I developed the first latex Portland cement adhesive suitable for both exterior and interior ceramic tile installations, I met great resistance from the construction industry because it was not traditional. Forty years ago, it was necessary to instruct both architects and building contractors in floor and wall surface preparation. I would then teach ceramic tile installers how to use a notched trowel in applying a thin layer of cement based adhesive.

Over the years, the many ceramic tile and epoxy resin adhesive manufacturers have accelerated the acceptance of this adhesive method.

In the last 10 to 15 years, many companies have introduced latex cement adhesives for exterior and commercial ceramic tile installations. The wide availability of these adhesives has helped expand the ceramic tile market.

Today, advanced countries in North America and western Europe and less advanced countries accept adhesive technology for ceramic installations. In many countries, adhesives represent more than 50 percent of the ceramic tile installations.

Changes in Ceramic Materials

Ceramic tile adhesives have changed the ceramic tile industry dramatically in the last 30 years. Traditionally, small mosaic tiles were fixed in cement mortar. The mortar came up

around the edges providing additional adhesion. Their rough-finished backs facilitated a mechanical bond. These tiles have been replaced with larger (200x200 mm, 300x300 mm, and even 600x600 mm) porcelain tiles. Consequently, the old method of fixing tiles in cement would not provide long-lasting service with the new, large tiles.

Technology advances in the adhesives industry supported technology advances in the ceramic industry. As the ceramic industry produced larger and more impervious tiles, they required new adhesive technology to provide problem-free installations.

So, adhesives technology moved hand in hand with ceramic technology.

Construction technology also advanced to accept the newer adhesive technology and ceramic technology. As in all industries, an advance in technology in one area assists the advance in technology in another area.

What changes has adhesive technology created in the ceramic industry?

Adhesive technology opened up vast new markets for ceramic tile that were not accessible without this new technology. For example, 30 years ago, I met with the designers, including the architect I.M. PEI, who were developing two 100-story buildings in New York City. We reviewed the problems of ceramic tile in such structures when installed by the traditional mortar method. We created a study reviewing costs and savings of ceramic installation with the new adhesive method and traditional mortar method. These were the results:

TRADITIONAL METHOD
25 tons of mortar are required on each floor; 100 floors total 2,500 tons. This would require:

Elevator time of approximately 600 hours at $US200/hr.....	$120,000
Four men to load and unload the elevators with sand and cement. Estimated time 600 hours X 4 men, at US$20 /hr (not including taxes and pension) benefits.....	$48,000
TOTAL LABOR AND ELEVATOR COST.....	$168,000

After reviewing the cement adhesive method, we concluded that only 10 percent of the mortar weight would be required using the adhesive method. This represented approximately 250 tons of adhesive in the building, not 2,500 tons as required by the traditional mortar method.

ADHESIVES METHOD

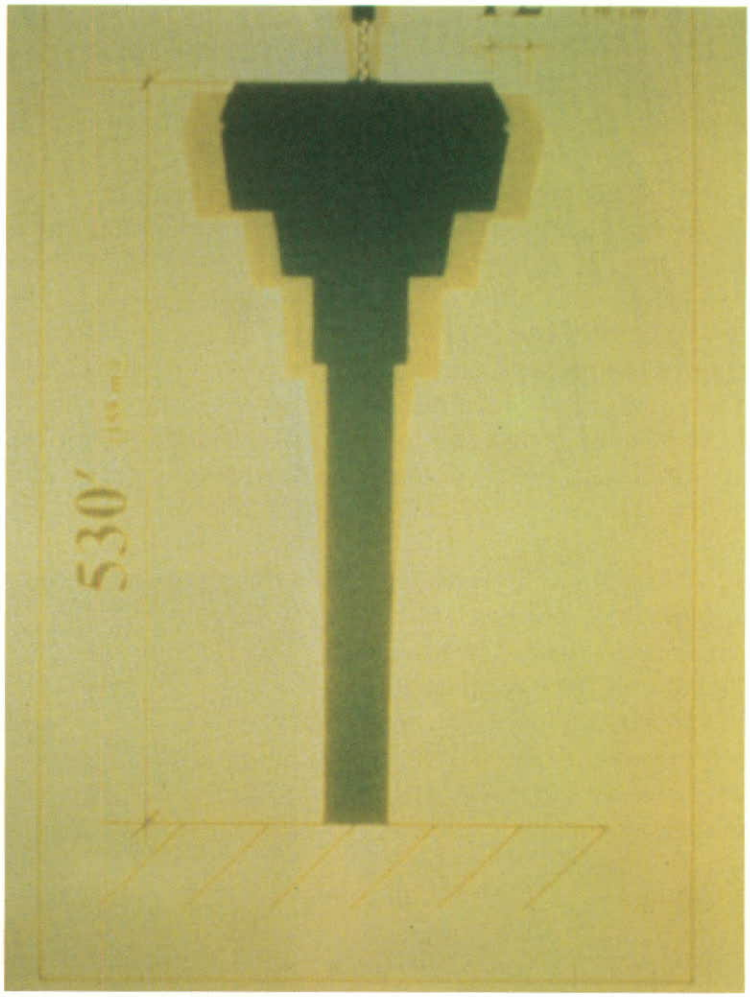
Total for labor and elevator time, approximately 10 percent of traditional method.....	$16,800
The traditional method cost for elevator time and material.....	$168,000
Savings for using adhesives.....	$151,200

The building engineers were quick to point out that if they could remove 2,250 tons of dead weight from this building they could save approximately 100 tons of steel framing. At this time, steel framing cost over $1,000 per ton erected, so there was an additional savings of at least $100,000 using the adhesive method.

The total savings by the adhesive method represented more than $250,000, equal in today's dollars to more than $1 million. These savings represent labor, elevator time and steel framing. There were additional savings because installing ceramic tile by the adhesive method would increase productivity 200-400 percent, saving additional labor.

The architects and engineers quickly accepted the adhesive for ceramic tile throughout these two 100-story buildings.

If the adhesive method was not available for ceramic tile or if the technology was not advanced enough, there would have been little or no ceramic tile sold on this project. The owners would have chosen carpet, vinyl or thermoplastic flooring.



The central column and entire structure of the Tele Diffusion Tower in Paris, France, is designed to move as much as 30 cm. in a strong wind.

What building changes have we seen in the last 25 or 30 years?

As real estate has become more valuable, cities have become more crowded. Buildings have become taller and slimmer to accommodate people and office space. It is now common in many cities to see buildings of 25 to 100 stories in height. These buildings are thinner, lighter, and more flexible. As a result, the buildings "move" more. Consequently, ceramic tile installations must be designed to accommodate the changes in structure and the movement.

For instance, the 100- story World Trade Center in New York City is designed to move as much as 15 cm in a high wind.

Also, the Telediffusion Tower, outside of Paris, France is 160 meters high and is the tallest occupied slip-formed concrete structure in Europe. At the top of this slender, concrete column are three stories of studios, living quarters and administrative offices. Each story consists of approximately 1,200 tons of precast concrete faced with ceramic tile. The central column and entire structure is designed to move as much 30 cm in a strong wind. Latex/Portland cement adhesives made possible the cladding of this tower with ceramic tile.

Seismic Shocks

One of the most severe conditions that ceramic or masonry materials are subjected to is earthquake tremors (seismic shock). Because normal cement mortars are hard, rigid and inflexible they are not able to withstand wracking and vibration that occur in the first 20-30

seconds of a seismic shock. For more than 35 years, our company has proven that latex Portland cement adhesives used for installing ceramic tiles have the qualities and ability to absorb physical shock, wracking and the tremors that occur during earthquakes, and to provide permanent ceramic installations.

Some of the world's most severe earthquake regions are in high population areas. The most severe earthquake region in North America is along the coast of California up to Alaska, along the Pacific Ocean, called the Pacific Ring of Fire.

In California, ceramic facades installed with adhesive mortars have survived seven major earthquakes, each one over 6 on the Richter scale. The Ring of Fire circles the Pacific and comes down through the center of the city of Wellington, the capitol of New Zealand. In Wellington, an earthquake center, there are numerous buildings with ceramic facades installed with the latex cement adhesive method that have survived major earthquakes over the past 20 years with no damage.

The second most severe earthquake region in North America is located in Montreal, Canada. Adhesive installations of ceramic tile in Montreal's Metro system have survived 35 years of earthquake tremors without problems or failures.

There is now a 30-year history of adhesive installations performed in climates from the Artic to the Tropics around the world that confirm the durability of ceramic facades and installations.

The Tele Diffusion Tower in paris, France, is 160 meters high, the tallest, occupied, slip-formed concrete structure in Europe. each story of the tower consist of approximately 1.200 tons of precast concrte faced with ceramic tile.

Thermal Shock

In many climates, the tile cladding (facade) is subjected to severe thermal shock. This may be slow, seasonal changes or rapid day-to-night changes.

Rapid thermal shock occurs after exposure to the sun which heats the ceramic facade or plaza. A western exposure can raise the thin ceramic skin to 60°C. The same tile can then be chilled 15-18°C by a rain shower. The heavy concrete support structure remains at a steady 18-20°C. The thermal movement

and shock of the tile facade must be absorbed by a flexible adhesive.

The latex-modified Portland cement adhesives provide this flexibility. They also provide the high adhesive strength and weather-resistance needed for long-lasting insta- llations.

At the top pf the Tele Diffusion Tower in Paris, France, are three stories of studios, living quarters and administrative offices.

What have adhesives contributed to the Ceramic Market?

The architects and designers of the Telediffusion Tower (top) wanted a gleaming, white tower clad with ceramic tile over slip-formed concrete. After extensive testing, they chose latex Portland cement adhesive mortar because of its durability, adhesive strength and ability to accommodate the structural movement. The building now stands as a gleaming white monument to the use of ceramic tile. Such an application would never have been possible if traditional cement mortar had been the only option.

Adhesive technology has made it possible to fix large ceramic tiles, from 300x300 mm, 400x400 mm, up to 600x600 mm on building facades in climates from the Arctic to the Tropics. This new market for ceramic tile has been opened by the development of adhesives.

We now have adhesives that can be used to fix ceramic tiles in a wide variety of compositions and sizes. These adhesives accommodate buildings that move in the wind, floors that flex under loading, plazas subjected to vehicles and heavy traffic, and shopping-mall floors subjected to heavy foot traffic and abuse and metro stations subject to vibration.

Limitations

Modern ceramic tile and adhesive technology is limited by the quality of workmanship in making the installation. That workmanship is dependent upon training the new generation of tile installers.

Installers must ensure the concrete or masonry surface is clean and free from contamination that would inhibit or prevent the adhesive from bonding. Years ago, traditional

methods, utilizing Portland cement and sand, were used for installing floors. Lime was added for making wall mortars. Very little knowledge was required by a ceramic installer to select mixtures. There were only two or three mixtures to choose from. Now,they must also match the adhesive to the surface and the use.

Unless the ceramic installers understand current technology and techniques, they will not have the knowledge necessary to make high quality, permanent, maintenance-free ceramic installations. Trade education, formerly provided by a father or older person is not adequate when technology is constantly changing.

In Germany, there is an excellent system for training young people through work and school in a formal program spanning three years. This program gives them all of the knowledge as well as the practical information to make the sound judgments.

This tower in Zaire was clad in ceramic tile using LATICRETE installacion materials over 20 years ago.

In the United States, England, Australia, and many other countries, there are no formal training programs for tile installers.

The governments do not support such training programs so we have young people working with an older tile installer, and then going off on their own, claiming to be a qualified tile fixer. Unfortunately they are not getting the education necessary to learn the many types and varieties of ceramic tile and types of adhesives. They do not adequately learn product limitations and appropriate applications. Currently, the weakest link in the system is the workman installing the tile.

In the United States, Canada, Australia and in the Far East our company has a strong program to educate installers in
place. We have also encouraged this program in other countries. We believe that in order for the ceramic industry to prosper and grow, ceramic installations must be attractive, long-lasting and free of problems. To accomplish this it is necessary to hire well trained installers.

Conclusion

• Adhesives now exist to fix ceramic tile with a wide variety of compositions and sizes both in interior and exterior settings.

• The introduction of adhesives has made ceramic tile competitive with alternate flooring materials. Limited by traditional mortar installation methods, ceramic tile was often not a construction option.

• Adhesives reduce weight, time and labor cost for ceramic installations. Years ago, there was a limited range of ceramic tiles available. Construction was simple - heavy, low buildings of two to five stories, built primarily of concrete and masonry. These buildings were massive, moved very little with changes in temperature, and certainly would not move at all under wind loading. Adhesives have made ceramic installations simpler by reducing weight.

• Adhesives give ceramic manufacturers unlimited freedom in designing size and materials.

• Adhesives also give architects and owners great flexibility in selection and use of ceramics.

• Ceramic tiles have changed dramatically with new technology, sizes and quality. Adhesive technology has kept pace with these changes.