INTERNATIONAL

# REALTÁ MAPEI

Towering achievements in the golden triangle

The miracle of Assisi

Boston to Boston

Eurostar, you're a star

A bridge to the future

Mapei in the land of the tigers

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**GRAPHIC DESIGN AND ART DIRECTION**/PROGETTO GRAFICO - IMPAGINAZIONE — Magazine - Milan (Italy)
**COLOUR SEPARATIONS AND LAYOUTS**/FOTOLITO — Overscan - Milan (Italy)
**PRINTING**/STAMPA — Arti Grafiche Beta - Milan (Italy)

**Published and edited by**/Direzione e redazione — MAPEI S.p.A.
Via Cafiero, 22 - 20158 Milan (Italy)
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**EDITOR**/EDITORE — MAPEI S.p.A.

Realtà Mapei - Bimonthly magazine - Registered by the Tribunal of Milan n. 363/20.5.1991
Realtà Mapei International is published 4 times per year

Cover main photo: an image of the Petronas Twin Towers of Kuala Lumpur

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# THE MIRACLE OF ASSISI

*by Alberto Balsamo, Umberto Battista, Natasha Calandrino and Renato Soffi*

Friday, September 26, 1997, dozens of earthquakes devastated Umbria and the Marches, two regions in the very heart of Italy, killing 11 people and injuring 126. The tremors caused incalculable damage to the area's art treasures, including frescoes by Giotto in the Basilica of St. Francis in Assisi. Now that the fear and pain of those days have subsided, thoughts have turned to rebuilding and restoration: rebuilding houses, schools, churches and entire villages, so the people who live there can resume their normal lives as soon as possible, and restoring this rich artistic heritage to its former beauty for all of us to enjoy.

PHOTO 1

Photo Agenzia Scala

**From Hell to Heaven**

There was a story already going around in the twelfth century that St. Francis himself had pointed out the exact spot where he wanted to be buried. It was there that the church housing his remains would eventually be built, along with a monastery for his fellow monks. Situated "in quondam voragine", on the high cliff that now, as then, forms the northwest side of the hill-town of Assisi, the Franciscan complex is built on a site whose distinct topography is determined by the steep incline of the slope.
The place was notorious because from time immemorial criminals were tortured and put to death on the gallows there, earning it the name of "The Hill of Hell". Erected in the first half of the 13th century, the monumental complex of St. Francis consists of the two Basilicas, oriented on an east - west axis, and the Monastery which encloses the body of the church for almost its whole length (Photo 1).

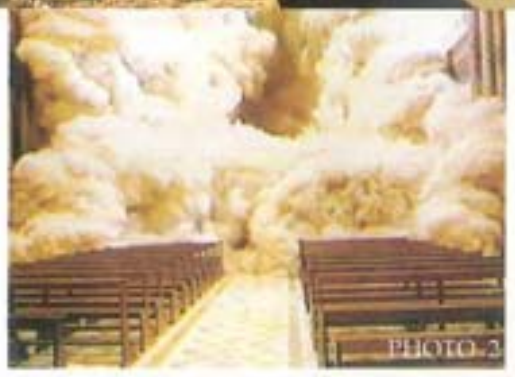
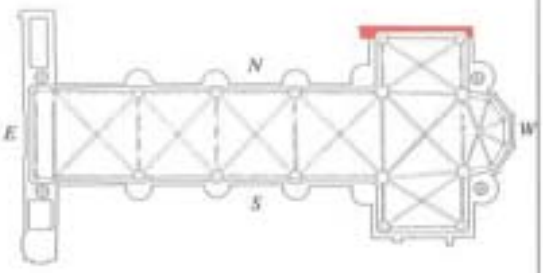


PHOTO 2

The church of St. Francis in Assisi is a marvelous example of Italian Gothic that contains frescoes by the greatest painters of the thirteenth and fourteenth centuries. The architect, Friar Elia, took advantage of the topography of the site (re-baptized "Hill of Heaven" because there lies the body of St. Francis) to create a soaring two-level structure with both levels laid




out on an identical plan: the Lower Basilica, to be used as a mausoleum, and the Upper Basilica, that was expressly designed to receive crowds of pilgrims. The most important artists of the time were enlisted to paint works in the Basilica complex: Cimabue, Giotto, Simone Martini, the Lorenzetti brothers... a priceless heritage that was severely damaged by the deadly earthquakes of September 26th. We were able to see live on television not only the tragedy of those left homeless by the quakes but also the collapse of the vaulting in the Upper Basilica (Photo 2), making it once again the Hill of Hell.

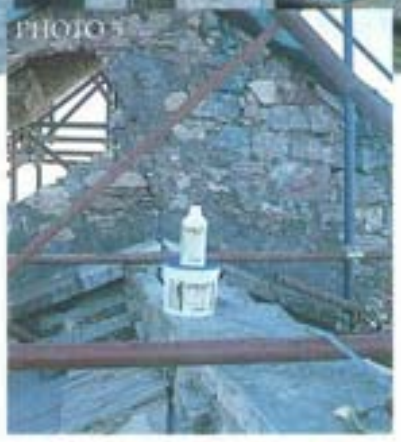
Government Commissioner Antonio Paolucci implemented a plan for assessing the damage caused by the earthquake so that immediate action could be taken to eliminate hazardous conditions and prevent further destruction of the artistic heritage.

To do so he needed the help of the latest and most sophisticated technology in a perilous race against time.

Ongoing sussultory and undulatory vibrations continued to traumatize many areas of the Franciscan complex, severely weakening its stability. With the clock ticking and fearing more after-shocks, technicians began the most pressing work needed to prevent the collapse of the gable of the left transept and the vaulting of the Upper Basilica, with its frescoes by Giotto and Cimabue.

PHOTO 4

PHOTO 3



**The race to save the gable**

The first problem to be tackled was preventing the collapse of the gable at all costs.

Since it weighed between 70 and 100 tons, the consequences could have been deadly if the gable had fallen through the roof of the Basilica.

This triangular piece of stone was by now little more than a shell, with certain sections that had previously measured 80 cm reduced to a mere 20 cm, and pockmarked and eroded from the recent pelting rain (Photo 3).

At this point the gable could not have withstood further shocks and might have collapsed with the slightest movement.

On October 14 at 11:40 a.m. the desperately needed repairs were begun.

The crew knew that the gable could not be shored up from below without risking lives, so with the help of a crane with an arm 50 meters long, they placed an enormous steel-skeleton frame of mesh and tubing over the gable to prevent it from collapsing (Photo 4).

The operation was not successful,

PHOTO 6

however, because the stone was by now ready to crumble.
The remaining sections had to be reinforced before installing the counter-gables which would have to support the structure.
The technology needed had to provide excellent bonding to the substrate, hardness, and high resistance to abrasion.
The solution was achieved using Mapei products (Photo 5).
With PRIMER EP, an epoxy primer with very high bonding strength, a preliminary waterproofing was applied to the stone and the mortar bed. The monolithic repair of the damaged structure was done with a spray application of EPOJET, a fluid epoxy resin (viscosity lower than 380 cP) that has excellent dielectric properties and high mechanical strength (Photo 6). At 12:30 a.m. the mission was accomplished: the gable of the basilica was safe.
"This extraordinary achievement," declared Commissioner Paolucci, "is proof that the Italian technical genius, know-how and craftsmanship exemplified by those who built this Basilica lives on in these men." It was an all-important step in safeguarding the house of St. Francis, but the emergency was not yet over.
Another aftershock on October 7th was the coup de grâce for many structures that had already been seriously weakened. On September 26th the dome-vault over the apse of the Upper Basilica collapsed, taking with it all trace of the "St. Matthew in Jerusalem" fresco by Cimabue. The dome- vault of the first bay and the sub-arch connecting the vaulting with the counter-façade also gave way, partially obliterating the work that Giotto had painted at the age of 25. (From 1290 to 1295 Giotto painted several frescoes of biblical scenes in the Upper Basilica.) The fresco of Saint Jerome and the Scribe that was part of the "Four Doctors of the Latin Church" series (Photo 7) was pulverized, causing the death of two friars and two technicians from the Superintendency who were assessing the nature of the damage and checking the structure's stability (Photos 8 and 9).

Many repairs were performed on areas that were in imminent danger because the static balance of the vaulting was seriously weakened.
The most urgent task was securing the groin of the collapsed vaulting in the first bay which jutted out dangerously several meters into space without being anchored.
The fresco underneath had to be completely protected from any debris that might be dislodged during the salvage work, despite the fact that the groin had many cracks and in some places was split clear through.
These cracks could have allowed adhesive to bleed into the extrados. In addition to that, the entire vaulting system had to be repaired. It had broken away from the side walls of the basilica and was very badly damaged along its whole length. These cracks would only get worse with time.
The repair work had to be done in such a way that no added weight would be put on the structures in question because they were no longer anchored at any point. Putting any more stress on them would have made the rest of the vaulting collapse, along with the fresco underneath. Moreover, an immediate decision had to be made as to the type of repairs that were needed. Work would have to get started within a few days because without eliminating this hazard, the job of shoring up the rest of the Upper Basilica from below would be impossible.

PHOTO 12

PHOTO 11

**A catwalk built for two**

A hanging catwalk made of metal pipe was anchored to the roof, running the length of the center of the Upper Basilica, so that the extrados of the vaulting could be repaired from above. The catwalk could be reached through a rose window, called the "eye", which is cut high up into the front wall of the gable (Photo 10). This catwalk was of vital importance to the outcome of the operation and made it easy to inspect not only the vaulting but the whole Upper Basilica (Photo 11).

PHOTO 10

The working platform then had to be widened by suspending metal scaffolding from it. This enabled the extrados to be repaired from above, with the men working lying face-down, in a not very comfortable position.

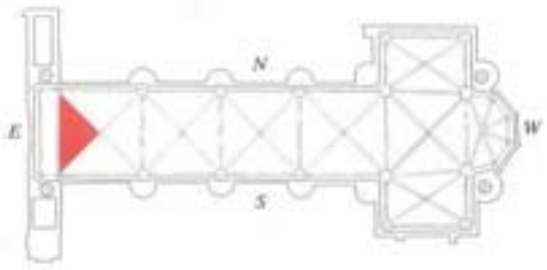
The repair operation proposed by S.A.C.E.N. S.p.A. and MAPEI was given enthusiastic approval. This involved using a modern technique combined with composite materials instead of cement based materials. Resins were used for integral structural bonding along with sheets of composite material, FRP (fiber reinforced plastic), that had to be artfully placed along the pattern of cracks. This technique allowed more than 15 sq. m. of Giotto frescoes to be anchored, along with the rest of the vaulting system. Using resins made wetting the substrate (the extrados of the vault) unnecessary, along with the undesirable consequences it might have caused, e.g. washout, re-activating stable chemical phenomena, endangering the fresco underneath, etc.).

**A delicate operation**

The job of cleaning the extrados of the vaulting was begun on schedule on October 22. This extremely delicate stage involved removing dust and loose material with painstaking care in order to prepare a solid substrate for the next phase (Photo 12). The work had to be done lying down on the platform, since walking on the vaulting was out of the question, making the cleaning difficult. It was also dangerous because the area being repaired was itself so precarious. Yet it was indispensable, as it made deeper evaluation of the actual condition of the area possible. A blueprint could then be drawn up of the cracks, so that reinforcing sheets of FRP could be made to the proper weight and size and applied where needed. To anchor the protruding fragments, EPOJET primer was brushed on first, so that the residual dust particles continually forming on the substrate could be contained (Photo 13). ADESILEX PG1, a thixotropic epoxy adhesive for structural bonding, was then trowelled on (Photo 14). Carmine, Pasquale, Gennaro

PHOTO 13

PHOTO 14



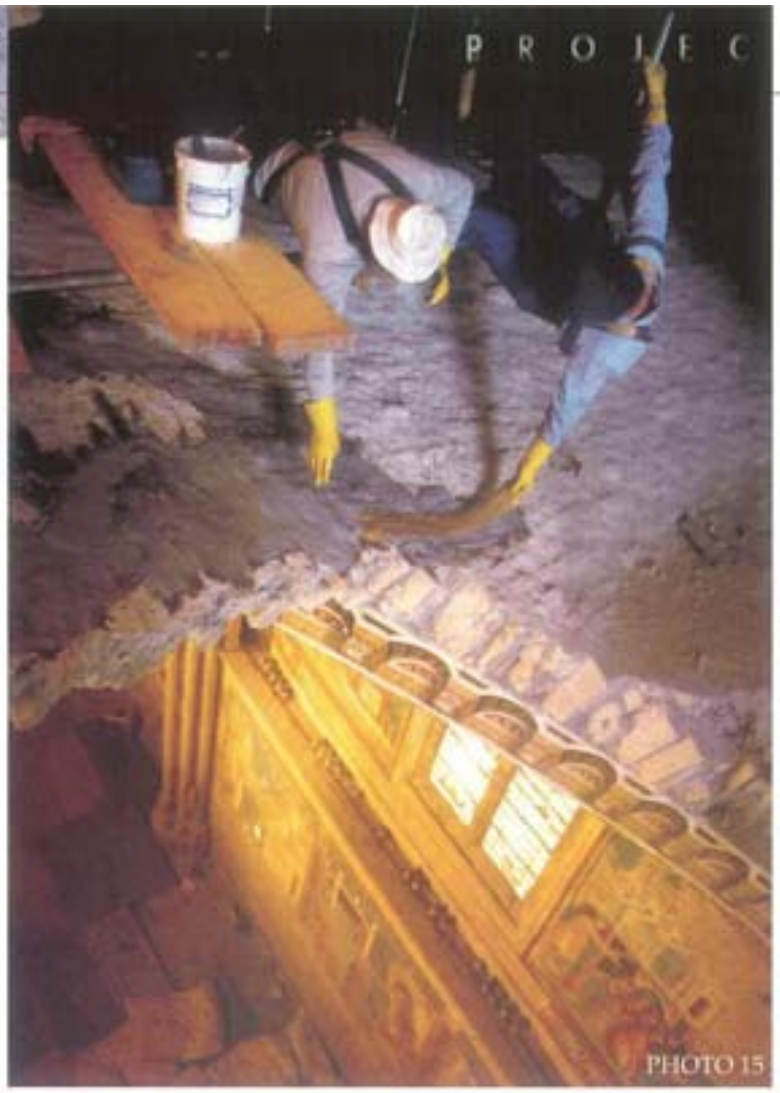


PHOTO 15


PHOTO 16

and Franco, with their backs attached by hooks to the hanging platform, worked with the care and delicacy of fresco painters. Once the surface had been made sufficiently solid and smooth, applying the FRP reinforcing sheets to it required precision and skill. Exerting too much pressure with the tools would have caused debris to fall, particularly bricks that had come almost completely loose on the edge of the surviving vaulting. Excess pressure would also cause the adhesive to penetrate too deeply, damaging the fresco underneath. The repair plan involved first the edges of the collapsed areas and the areas behind these in a preliminary holding operation so that the bonding operation could be performed safely later. Pieces of FRP between 20 and 30 cm wide were then quickly applied over the previously treated areas (Photo 15). The placement and strength of this fabric was carefully calculated to cover the fracture pattern, and the basic weight of each one was determined by specific technical considerations. (Photo 16).

**Repairing the vaulting**

The third and last stage of repair work on the Franciscan church involved the entire system of vaulting which had almost completely detached from the side walls during the earthquakes, with cracks up to 8/10 cm wide along the whole length of the Basilica.
In the opinion of Giorgio Croci and Paolo Rocchi, the two professors who were appointed project managers by the Committee for the Restoration of the Basilica Complex of St. Francis in Assisi, the collapse of the vaulting was caused for the most part by the enormous amount of filler material that had accumulated over the centuries at the juncture of the springers and reins of the vaults, i.e. along the side walls. During the earthquake this loose material exerted very high pressure alternately on either side of the vaulting, causing it to bend tremendously, while making the vaulting and the ribs which support it lose their curvature. To prevent the collapse of the entire structure this accumulated material, weighing 1000 tons, had to be removed. Then the cracks along the entire length of the vaulting had to be repaired, using a binder that had high mechanical strength, yet was similar to mortars used at the time the Basilica was built.
Repair of the "period" lime mortar that had been pulverized was done with MAPE-ANTIQUE MC, a light colored dehumidifying mortar for period buildings that possesses the same physio-mechanical characteristics of porosity and vapor permeability as antique mortars based on lime and pozzolan (Photos 17 and 18). Based on special hydraulic binders and natural sand, MAPE-

PHOTO 17

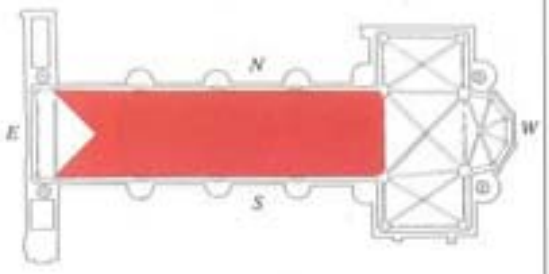



PHOTO 18

PHOTO 19

PHOTO 20

PHOTO 21

PHOTO 22

ANTIQUE MC is especially resistant to sulphate salts, which are one of the major causes of deterioration in period buildings. Moreover, the formulation's low salt content makes this mortar resistant to chemical and physical agents, preventing damage to the frescoes underneath. Once the whole vaulting system was stabilized, a decision was made to suspend the most critical areas of the vaults from the masonry arches that support the roof by using a series of tension wires. These were designed with two springs (Photo 19) to provide constant tension regardless of thermal effects or other deformations. They were anchored to the top of the masonry arches (that date from the 15th century) and to the base of special "connectors" made on site. The same technique was used to make these connectors as was used on the groin: after applying an epoxy system of EPOJET resin (Photo 20) and ADESILEX PG1 (Photo 21) sheets of FRP were made and placed in position by specialists (Photo 22), then cut to the measurements

PHOTO 23

PHOTO 24

of the section, and molded perfectly to the texture of the surface. Dozens of these connectors of different shapes and sizes (Photo 23) tied the critical areas of the vaulting to the arches and to the roof itself (which had been recovered in the 15th century with tiles) (Photo 24, 25 ). Professors Croci and Rocchi

PHOTO 25

maintain that even if the vaulting should break free of the side walls during another earthquake, it would remain suspended from the arches by this system of wires.
A Mapei solution for preserving tradition! ❑

*Our thanks to Paolo Lombardi and Renato Cucchiarini for their invaluable collaboration.*

*Our thanks for permission to print Photos 2, 8, and 9, from "The Vaulting of the Upper Basilica of St. Francis in Assisi" by Giorgio Bonsanti, published by Franco Cosimo Panini.*

*The technical sheets of the products mentioned in this article are contained in Mapei binder N. 3 "Building line".*

## TECHNICAL DATA

**THE BASILICA AND MONASTERY OF ST. FRANCIS IN ASSISI**

**Year of construction:** first half of the XIII century
Restored after the earthquakes of September-October 1997

**Project Manager:**
Dott. Antonio Paolucci, Artistic and historic adviser (coordinator)
Dott. Arch. Costantino Cetroni, BB.AA.AA.AA.SS. Superintendent of Umbria (interior design)
Prof. Ing. Giorgio Croci (exterior design)
Prof. Arch. Paolo Rocchi (exterior design)
Central Restoration Institute (fresco consultant)

**Job-site Supervisor:** Dott. Arch. Costantino Centroni
**Collaborator:** Geom. Raoul Paggetta

**Project associates:**
Dott. Eng. Giuseppe Carluccio
Dott. Eng. Mario Biritognolo
Dott. Arch. Aymen Herzalla
Dott. Arch. Rosalba Lombardo
Dott. Eng. Michele Tataseo
Dott. Arch. Anna Rita Turlò
Dott. Eng. Alberto Viskovic

**Restoration of the groin:**
S.A.C.E.N., Naples
Consulting Engineers for S.A.C.E.N.:
Eng. Alberto Balsamo and Umberto Battista

**Restoration of the vaulting:**
Lunghi, S. Maria degli Angeli (PG)

**Technical Supervisor for Lunghi:**
Eng. Luca Lunghi

**Mapei products used:**
PRIMER EP
EPOJET
ADESILEX PG1
MAPE-ANTIQUE MC

The Mapei products mentioned are part of Mapei's European product lines

# FROM THE BASILICA TO THE CONFERENCE AND BACK


*"Damage caused by the earthquake of September 26, 1997: Criteria for restoration and preventive action for our architectural heritage"* was the title of the seminar held on Feb. 26-27 of this year in the conference room of the Monastery of Assisi. The conference was organized by the Ministry of Cultural and Environmental Resources, the Monastery of Assisi, International ICOMOS (Scientific Committee for Analysis and Restoration of Structures of Architectural Heritage) and the Pro Basilica of St. Francis Commission, with the contribution of Mapei, sponsor of the initiative. The seminar featured the participation of experts from all over the world.

Opening statements were made by Father Berrettoni, representing the Franciscan community, the Mayor of Assisi, Dr. Giorgio Bartolini, the President of the Umbria Region, Prof. Bruno Bracalente and the Director of the Ministry for Cultural and Environmental Resources, Dr. Mario Serio, after which Professors Giorgio Crochi, engineer, and Paolo Ronchi, architect, of La Sapienza University in Rome described the urgent steps already taken and those still needed to restore buildings damaged in the earthquake. These reports were followed by a visit to the damaged areas of the Basilica: over 100 attendees donned hard hats to see for themselves the severe damage the earthquake wrought on the gable and the vaulting. The seminar continued in the afternoon with analyses of historical and artistic concerns described by the architect Costantino Centroni, Superintendent for Umbria, Dr. Antonio Paolucci, artistic coordinator, and by Dr. Giuseppe Basile of the Italian Institute of Restoration. Pasquale Zaffaroni of Mapei then described in detail the restoration work done up to that point. A round table discussion followed on structural analysis and reinforcement criteria for the vaulting, chaired by Prof. David Yeomans.

The next day the seminar discussed the post-earthquake reconstruction of the artistic heritage of Umbria and the Marche. Maria Luisa Polichetti, architect, and Luciano Marchetti, engineer, ministry coordinators for the Marches and Umbria, respectively, together with architects Renco Mancini and Costantino Centroni, Superintendents for the Marches and Umbria, described the enormous damage caused by the quake, which is illustrated in detail in "After the Earthquake", a volume published in English and Italian that was given to those in the audience. Analysis of the damage was later the subject of a round table chaired by Prof. Fritz Wenzel. Discussions continued in the afternoon with talks on prevention criteria given by Dr. Mario Serio, Dr. Jose Maria Ballaster, Director of the Cultural Department, Dr. Marc Laenen and Dr. Alessandro Bianchi, followed by a round table on prevention strategy chaired by Dr. Jean-Louis Luxen. The importance of formulating policy to prevent natural disasters is the subject of an official document drawn up by the speakers at the end of the conference, entitled "The Assisi Declaration", which urges the development of a series of effective measures that should be taken by all countries to prevent or limit the effects of natural disasters.

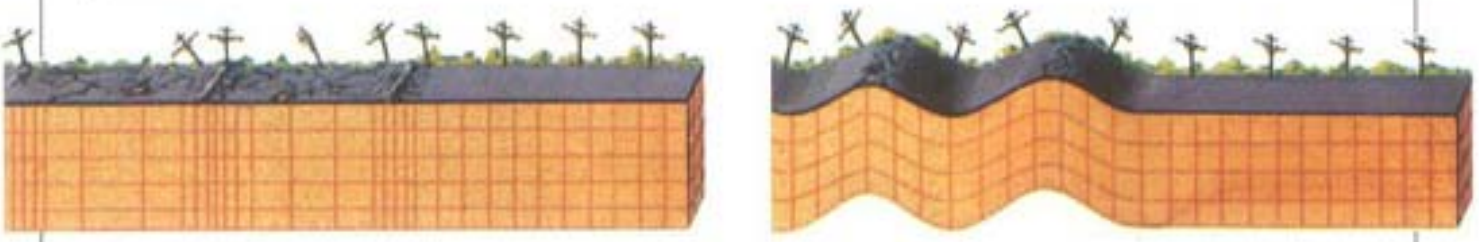
Three stages should be taken into consideration: the time preceding the event for evaluation and prevention, the actual emergency itself, and the post-disaster stage involving restoration and rebuilding. The declaration signed in Assisi should be taken as a synthesis of recommendations and conclusions already put forth in other documents that up till now have not been heeded: the 1993 Recommendation of the Council of Europe "The Protection of Architectural Treasures from Natural Disasters", the Conventions and Recommendations of UNESCO, the ICCROM Training Programs, E.C. Code 8, and many other initiatives.

We hope that this time the recommendations are accepted and put into practice. ❑

# STATIC REINFORCEMENT

Using fiber-reinforced plastic (FPR) for repair work in earthquake zones.

*by Alberto Balsamo **



Sometimes structural engineers can seem a lot like doctors: especially when they're restoring "patients" to health, repairing the damage and getting them to stand on their own again. After a careful examination of the skeletal structure's pathology, a wealth of accumulated knowledge and experience, coupled with keeping abreast of professional developments, enables the expert to make an exact diagnosis and to prescribe remedies designed to put new life back into those "old bones".
Static reinforcement of period masonry structures can be especially rewarding in Italy, which has so many buildings prized for their remarkable historic, environmental, cultural and architectural significance.
This important yet delicate work takes on an even more special meaning when carried out as a preventive measure in Italian cities and towns located in earthquake zones where, naturally, saving lives takes precedence over cultural considerations. We can never forget the painful and dramatic loss of life that occurs with distressing regularity every time we have a seismic event of some magnitude, along with the damage to our architectural heritage.
Static reinforcement, especially for masonry, is an object of continual concern to researchers and architects.
This article deals with static reinforcement for masonry using fiber reinforced plastic (or FRP) and does not go into a detailed review of "classic" treatments of old buildings regarding various components of the bearing structure (foundations, masonry, columns, floors, vaulting, attics, roofs, stairways and overhangs) which are widely documented in the literature.
However, it would be useful to discuss briefly the typical static behavior of masonry buildings and the most frequently occurring pathologies in masonry systems. The static behavior of masonry buildings can be compared to boxes: they consist of a series of continuous interconnected vertical elements, separated by floors which act as diaphragms and bearers of the vertical loads directly applied to them.
In general, period buildings were basically designed to bear vertical loads, and are not strong enough to withstand horizontal movement.
This deficiency must be carefully studied and corrected when making a building earthquake proof. Floors play a fundamental role in resisting horizontal movement. They distribute that movement to the vertical walls (in proportion to their relative rigidity) and also ensure that the transverse sections do not suffer deformation in their plane, helping to simplify the behavior of the whole structural system.
In light of the above, it is not only critical to ensure that horizontal sections are "sufficiently" rigid and effectively attached to the vertical walls, but that they are also in sufficient number, and rigid enough for the directions of the acceleration components, the intersecting walls, so that the distribution of rigidity does not cause unwanted torsion.
Unfortunately, static reinforcement of masonry buildings must frequently compensate for the (often congenital) lack of integration of the various elements that make up the structural system.
There are several cures for fighting these ills and they have been constantly improved upon. "Binding" has always

*The enormous energy released by an earthquake travels around the globe in three types of seismic waves. The fastest, called primary, or P waves, compress the surrounding rock and elongate it, while hammering the Earth at a speed of approx. 6.4 km a second. Secondary waves, called S waves, move at half the speed of P waves because they move in an undulatory rather than straight direction, making the rock move up and down as well as back and forth. Lastly, surface seismic waves are caused by the impact of P and S waves on the Earth's surface, moving vertically like the waves of the ocean and zigzagging horizontally at the same time. They often cause the most serious damage to buildings and the landscape. Adapted from "Great Disasters", a selection from the Reader's Digest.*

been effective and this has been borne out in the course of subsequent earthquakes. This technique can be remarkably improved by using FRP, fiber-reinforced plastic, as an alternative

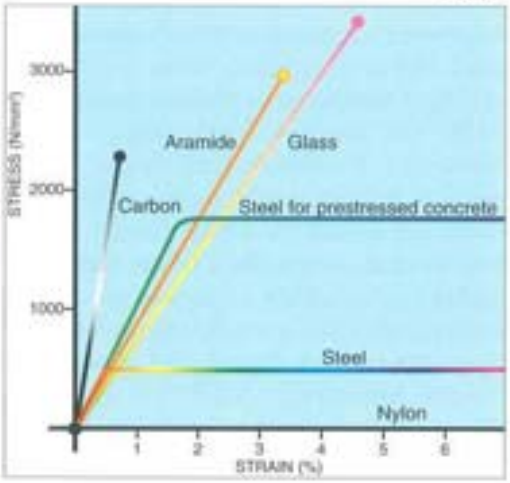
FIG. 1

| Fiber/Material | Density | E (Gpa) Elastic modules | σ (Mpa) Tensile strength | ε % Ultimate elongation |
|---|---|---|---|---|
| Carbon fiber | 1,7 - 1,9 | 200 - 600 | 2000 - 3000 | ≤ 1 |
| Fiber glass | 2,5 | 70 - 85 | 3000 - 4500 | 4 - 5 |
| Aramide fiber | 1,45 | 60 - 130 | 2700 - 3000 | 2 - 3 |
| Steel | 7,8 | 200 - 210 | 500 - 2000 | 2 - 10 |
| Aluminium | 2,8 | 75 | 500 | 10 |
| Titanium | 4,5 | 110 | 1200 | 14 |

to steel. Fiber-reinforced plastic is widely used in the aeronautics industry, ship-building and mechanics, wherever strength has to be combined with lightness and durability. The new generation of FRP is composed of high strength continuous fibers of carbon, aramide and glass, in polymer matrices. Figure 1 compares various types of fibers and metals.
From a technological standpoint, the advantages of using FRP for reinforcement, renovation, restoration, or retrofitting masonry buildings for earthquake-proofing spring from its high mechanical strength, resistance to chemical agents and impermeability to water. Steel, on the other hand, has several disadvantages, such as reduced durability caused by its vulnerability to chemical agents (against which masonry is no protection) and corrosion by water.

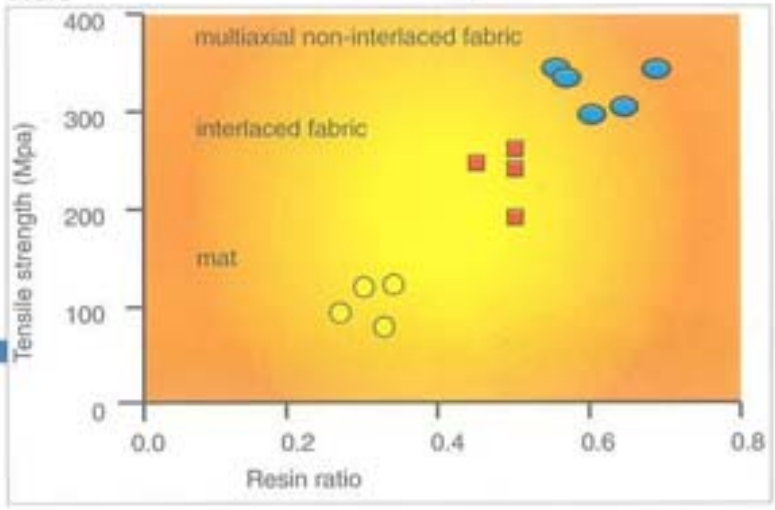
Moreover, steel has little reversibility. FRP is completely reversible since adhesive materials that transmit stresses can be removed. This advantage is particularly interesting architecturally for buildings of historic significance because using FRP is non-invasive.
In general FRP possesses high residual strength and responds well to the application of cyclical loads.

FIG. 2




Its viscous deformation is characterized by a rather high coefficient of viscosity. Raising the temperature beyond a critical threshold causes progressive deterioration in the polymer matrix, resulting in deterioration of the FRP. This effect can be mitigated by taking protective measures, as in the case of metal. In any case, it seems unlikely that the FRP would be exposed to both fire and extreme mechanical stresses simultaneously.
This consideration becomes even more important when the FRP comes into play as static protection during earthquakes. Any effects caused by viscous deformation under extremely heavy loads would be negligible. FRP made with aramide fibers and epoxy resins (aramide fibers are impregnated with epoxy resin, in an average ratio of 50% fiber to 50% epoxy resin) achieved the

FIG. 3




best results in studies conducted on the choice of fiber for reinforcing masonry with FRP. Figure 2 contains σ–ε diagrams for steel and the fibers most widely used in the manufacture of FRP. They show that aramide fibers have a lower modulus of elasticity than steel and appreciably higher final strength. Having a lower modulus of elasticity than steel is far from being a limitation because it is much closer to the modulus of elasticity of the material to be reinforced, i.e. the masonry, than that of steel. FRP with aramide fibers also has excellent resistance to alkaline agents, unlike FRP made with fiberglass.
Aramide is a synthetic long chain polyamide fiber in which at least 85% of the amide bonds are linked directly to two aromatic rings, like a linear chain synthetic polyamide. Generally an aramide fiber has a tensile strength five times greater than that of steel of equal weight. Moreover, it has 50% more elastic strength, greater flexibility in size variations in adverse atmospheric conditions, and is extremely resistant to high temperatures. The raw materials used in manufacturing aramide fibers are basically derived from petroleum and natural gas that contain the essential chemical elements, i.e. hydrogen, nitrogen, oxygen and carbon. When these are combined they form a macromolecular polymer that is extruded as an aromatic polyamide filament. Changing the molecular composition during the process forms different types of aramides (high modulus, intermediate modulus, etc.)
Aramide fiber reinforced plastic is manufactured in round-section bars and rectangular-section sheets.
These elements can be treated with quartz powder to facilitate bonding. The bars are generally used to make reinforcements to be inserted into masonry walls, then securely sealed by injecting grout. The sheets are used for plating vaulting and arches and for making binders and wrappings for partition walls. However, wrapping walls using pre-impregnated sheets is limited by the standard sizes sold commercially. These are rather small and not versatile enough to fit complex shapes. Those limitations can be overcome by making these plastic binder sheets on site, using fabric made of fiber impregnated with epoxy resin.
The plastic sheets can be made up to 130 cm wide and as long as needed. They are very easy to shape and mold to difficult contours. The plastic sheets of fabric made from fiber impregnated with epoxy resin are used for plating vaults and arches. They are also used for binding and wrapping wall panels (consolidating and reinforcing hammer beams and corners in masonry).
They can even be used for wrapping the entire masonry exterior, placing the sheets along lines at various levels around the sides of the building. Depending on the building's state of preservation, this peripheral binding can be connected to vertical strips to form a chain formation as an alternative to conventional chains. Installing the latter


*Source: Mapei R&D Laboratories*

FIG. 4

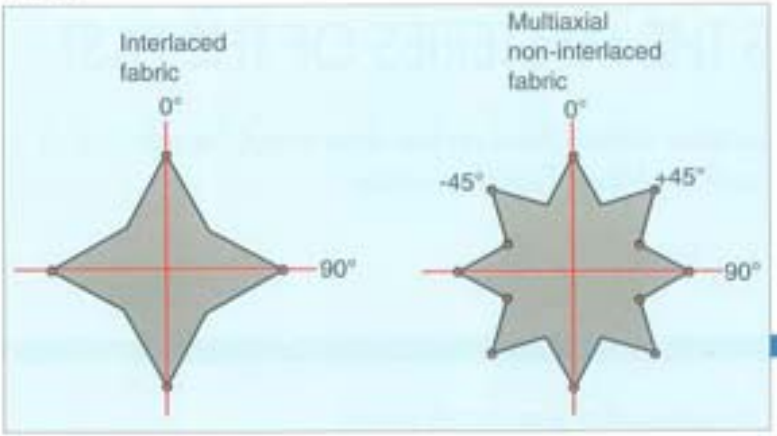
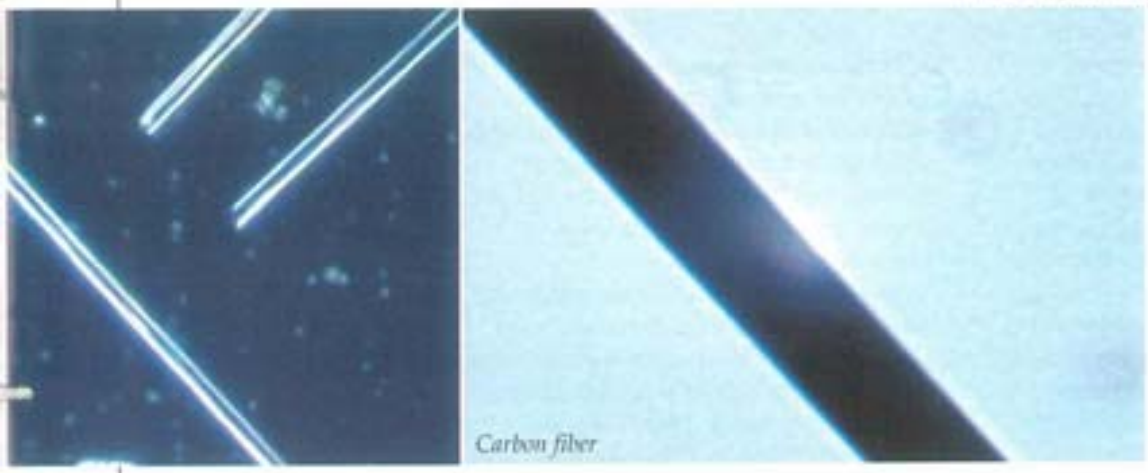



FIG. 5

| Reinforced plastic/ Materials | Density | E (Gpa) Elastic modulus | σr (Mpa) Tensile strength |
|---|---|---|---|
| Carbon fiber composites | 1.5 | 195 | 1125 |
| Fiberglass materials | 2.0 | 34 | 1300 |
| Aramide fiber composites | 1.40 | 77 | 1750 |
| Steel | 7.8 | 200 - 210 | 500 - 2000 |
| Aluminium | 2.8 | 75 | 500 |
| Titanium | 4.5 | 110 | 1200 |

is always invasive since holes have to be drilled through the wall panels, damaging the stone.
Reinforcing sections of wall with FPR must always be done in conjunction with conventional repair and renovation treatments for deteriorated masonry (injecting grout, etc.). Studies show that multi-axial fabrics make the ideal reinforcement for this type of FRP.
Lab tests have proven that multi-axial fabrics perform better because their fibers are not woven but spun in several directions. These one-directional fibers are arranged in layers at different angles, (0°, 90°, +45°, -45°) and with varying weights, in a tricot or chain pattern with a very thin polyester thread. In this way the fibers are not strained by knots, as they are in woven fabrics, so their strength remains unchanged.
When a load is transmitted along knotted fibers in woven fabric, a concentration of stresses is automatically caused by the resin and the knots themselves, so the cyclical application of loads will cause a rapid disintegration of the final laminate. The diagram in Figure 3 illustrates how a multi-axial non-woven fabric has greater tensile strength than woven fabric or mat. Because the fibers are arranged in straight lines with the matrix, they are under tension along with the matrix itself. Figure 4 also shows the almost isotropic nature of the quadri-axial, non-woven fabric which makes it perform better in every direction, increasing both mechanical strength and resiliency. Multi-axial fabrics need to be impregnated with less polymer and yet perform better because there are no voids where the polymer can lodge, unlike the woven fabrics. Figure 5 shows comparisons of various types of FRP and metal. The table refers to one-directional fabrics. Using a multi-axial fabric improves results by 30%. ❑

** Alberto Balsamo is a technical consultant with S.A.CE.N. SpA, Viale Colli Aminei, 279 80131 Naples (Italy), tel.081/7413062*



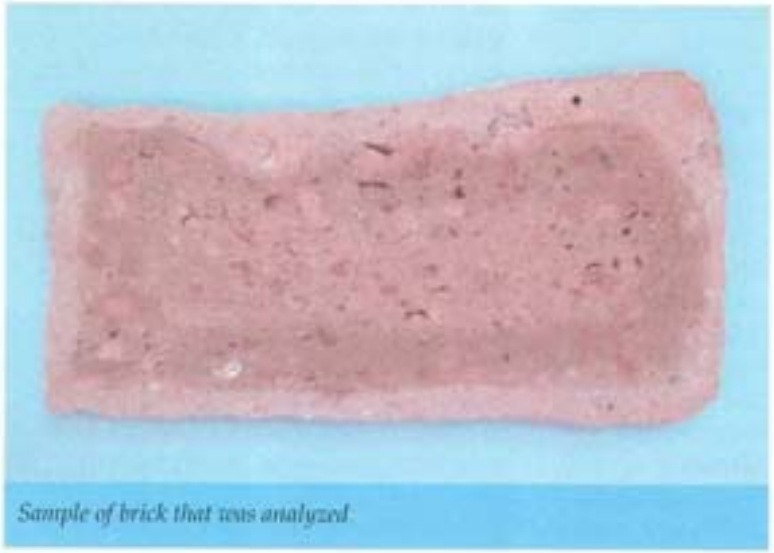
*Carbon fiber*

# TECHNOLOGY REVEALS THE MYSTERIES OF THE PAST

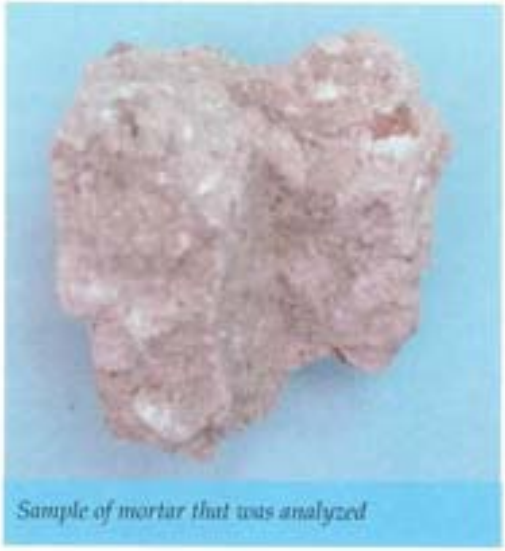
Physio-chemical tests on brick and mortar samples yielded the data that determined the selection of the products used in the restoration of the Basilica of Saint Francis in Assisi.

*by Tiziano Cerulli, Mariarosa Gulfo and Davide Salvioni*

"Antique" building materials were studied to find the best products for restoring the walls of the Basilica of Saint Francis in Assisi. Samples of brick and mortar were submitted to the Mapei laboratories for testing to determine their state of preservation.
The samples were also subjected to chemical analysis which enabled the researchers to study the materials in depth, so they could then give precise indications as to the choice of products to be used in the restoration.
The tests conducted on the brick showed that the samples were in a good state of preservation. Apparently the time that had passed since they were used in building was not a factor in their deterioration.
Chemical tests on their composition revealed the raw materials that were chosen centuries ago to make them.
A particular kind of soil (reactive clay) mixed with limestone marl is the "secret" to their composition. Firing at high temperatures, although certainly lower than 1000°C, is the secret to their mechanical properties. Modern day science has revealed these "secrets", transforming into "scientific" knowledge what was once empirical knowledge wrapped in the mysterious aura of alchemy. The mortar bed in which the bricks were set reflects the knowledge and techniques current at the time the Basilica was built. Analysis revealed its original chemical composition.
The mortar was mostly composed of common lime mixed with reactive materials such as clay. Let's take a closer look at what was found through morphological analysis performed on the brick and mortar with optical and electron microscopes.



*Sample of brick that was analyzed*



*Sample of mortar that was analyzed*

**Morphological analysis of the brick**

Morphological analysis of the brick under the optical microscope shows a compact structure containing variously shaped cavities evenly distributed throughout the thickness of the brick. These macro-pores do not seem interconnected.
In the large photo, white deposits of calcium carbonate can be easily seen. On the exterior surface of the brick is a layer of color, lighter than the middle section of the brick, that is rich in calcium carbonate. This may have been

*All the pictures for this article were taken in the Mapei R&D Laboratories*


*Detail of the surface layer of the brick*

*Detail of clay particle found within a calcareous aggregate*

*Detail of discontinuous area in an island of calcium carbonate*

*In the large photo: detail of mortar with clay component. Inside the mortar well-formed crystals alternate with vitreous areas*

caused by calcium hydroxide penetrating from the mortar bed and its subsequent carbonation.

**Morphological analysis of the mortar**

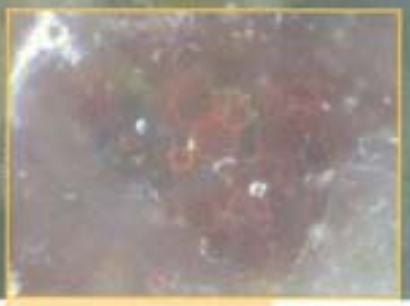
Pictures taken of the mortar sample through the optical microscope show a rather homogeneous and continuous structure of vitreous calcium carbonate without visible macro-porosities, inside which there are areas where the calcium carbonate is well crystallized.
Beyond this, darker areas appear that are probably clay, which would indicate that the mortar had a common lime base, mixed with compounds having pozzolanic properties, such as clay, for example.

**X-rays of brick and mortar**

The same brick and mortar samples were then analyzed under the electron microscope. Morphological analysis with the electron microscope confirmed what the optical microscope showed.
As was already pointed out, the light colored layer on the outside of the brick is clearly visible in the upper part of the

*Micrograph showing the mortar with a clayey inclusion. Well shaped crystalline stuctures, alternating with amorphous areas, are found in the mortar*

*Micrograph showing the central area of the mortar; one can notice a "cavity" inside the carbonate amorphous matrix*

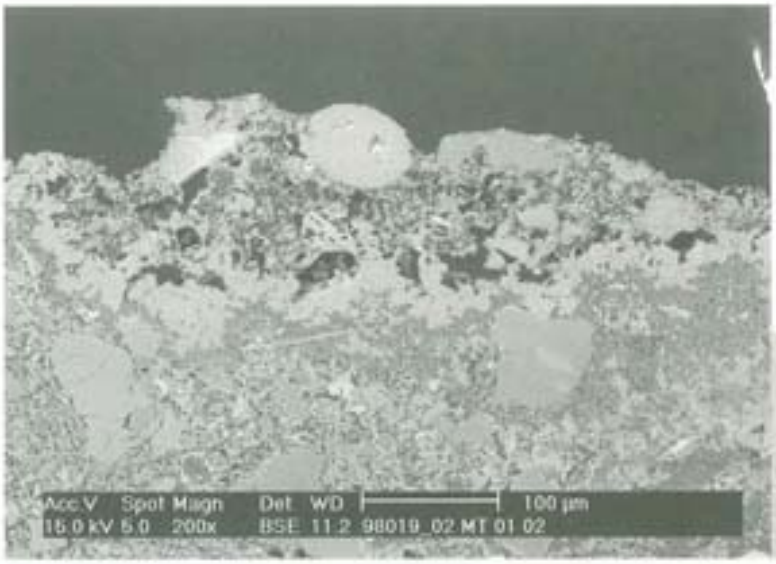


*Micrograph showing the central area of the mortar, clayey inclusion; one can notice areas of regular spherical shape (particles of pyrogenic origin?) which may have been caused by using brick dust to mix the mortar*



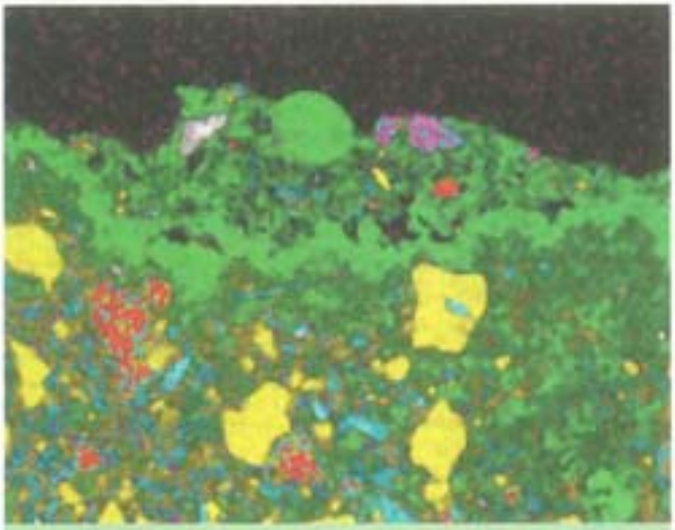
brick sample. This layer is full of cavities and chemical analysis shows it to be mostly calcium carbonate.
The inside of the brick appears to be homogeneous with porosity concentrated in macro-pores rather than widely distributed in micro-pores.
The action of the mortar bed on the surface of the brick is very visible.
The layer of calcium 0.5 to 1 mm deep shows that over the years calcium hydroxide penetrated the surface of the brick where it later carbonized. The carbonation caused the surface layer of

*The picture shows some areas of crystallisation of the carbonate alternating with areas of amorphous carbonate. Siliceous inclusions are present in the carbonatic matrix. The picture was taken assembling nine pictures magnified 100 x*



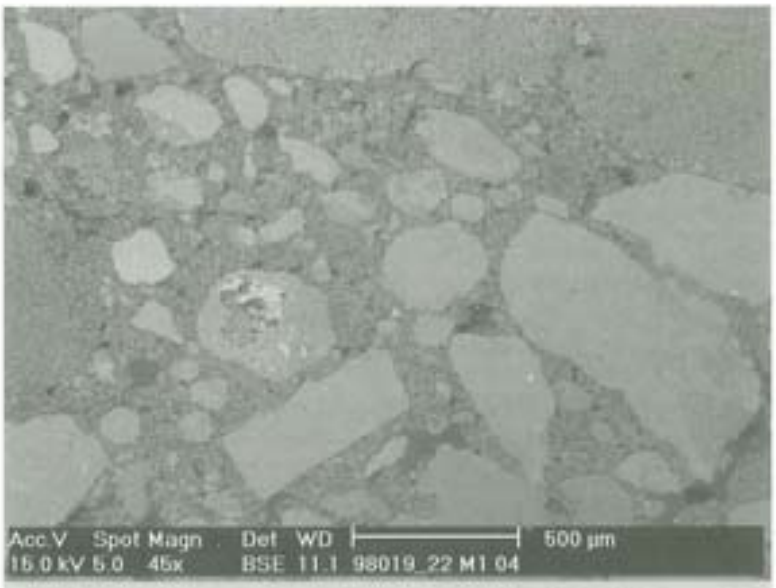

*The SEM micrograph shows the upper surface area of the brick*

potassium
calcium
aluminium
silicon
iron
sodium

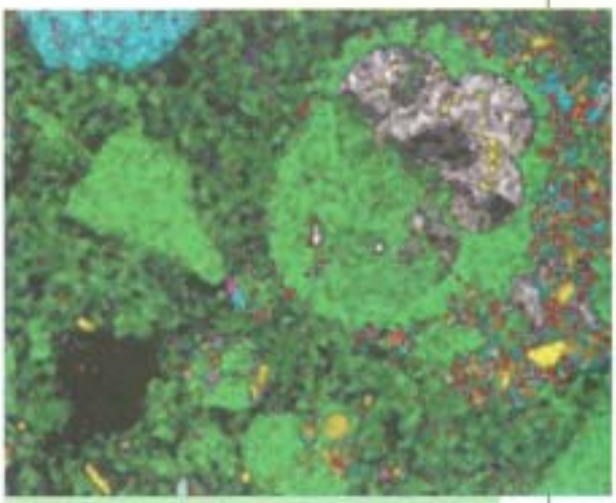


*X-Ray distribution map (see color table in the legend)*

the brick to weaken and decay. Morphological analysis under the election microscope showed that the mortar was composed of a mixture of common lime and silicious material, probably clay, that through the years had surely contributed to its good state of preservation. No soluble salts were found in the mortar, either, so its physio-chemical properties were not compromised by the phenomena that usually occur when these salts are present. ❑




*From the SEM micrograph one can notice "islands" of crystalline material (apparently without porosities, probably due to the presence of fillers in the binder) surrounded by a binder with an amorphous structure, in which microporosities, homogeneously distributed, are present*



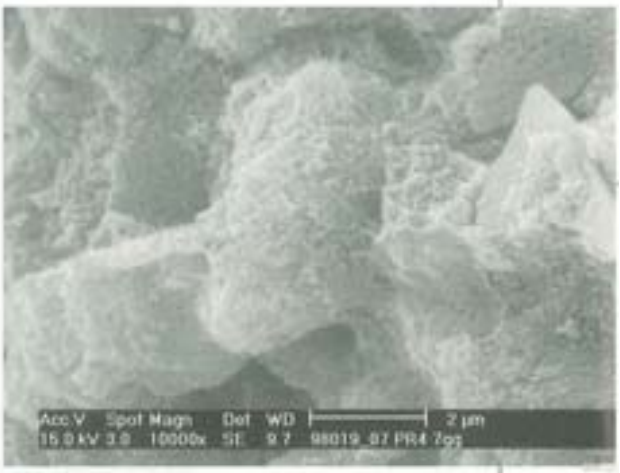
*Close up of picture on the left. X-Ray map of the distribution of the main elements*

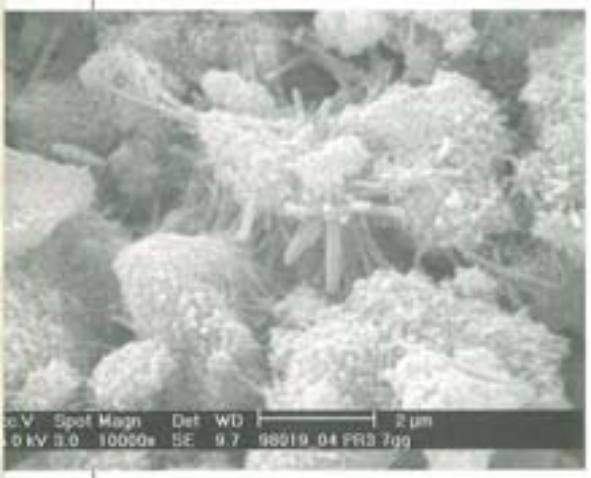
# WHY MAPE-ANTIQUE ?

Comparing different binder systems shows that the products of the MAPE-ANTIQUE line have a micro-structure with properties very similar to those of "period" mortars.

*At left, electron microscope micrograph of the "period" mortar showing the completely carbonated amorphous matrix*

*At right, electron microscope micrograph of MAPE-ANTIQUE after 8 days of curing, showing the rounded structure of an already stabilized system*

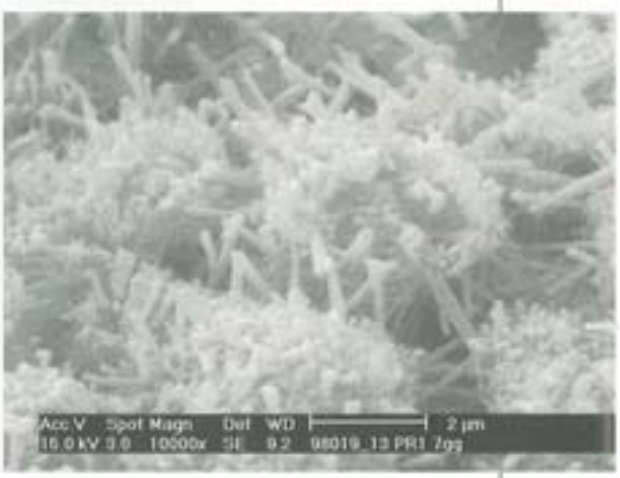




*At left, SEM micrograph of hydraulic lime showing the needles of the C-S-H polymer that are typically found in hydraulic binders*

*At right, micrograph of portland cement, showing here, too, the needles of the C-S-H polymer*

*Source: Mapei R&D Laboratories*



After analyzing the samples of brick and "period" mortar, we decided to make a physio-mechanical and chemical analysis of several different binder systems. This way we could compare characteristics and performance data in evaluating their use for restoration of period buildings (plastering, mortar systems, etc.).
We also focused our attention on morphological analysis of the binders. Other than the binders in the MAPE-ANTIQUE line, we also compared a portland cement binder and a hydraulic lime binder. They were then compared with the results of the analysis of the period mortar used in building the Basilica of St. Francis. The results show that the hydraulic lime and the portland cement have very similar micro-structures but that these differ greatly from the microstructure of the binder of the period mortar. Pictures taken with the SEM electron microscope show the needles of the C-S-H polymer that are typically found in hydraulic binders in both the hydraulic lime and the portland cement. The binder in the MAPE-ANTIQUE line, however, reveals a micro-structure very similar to that of the binder in the period mortar. The micrograph shows the rounded structure characteristic of a system that is already stabilized. These properties were also confirmed by chemical and physio-mechanical analyses performed on the samples.

**A high-strength binder**

The MAPE-ANTIQUE line features products that:
- resist sulphates
- reach dimensional stability after very short cure time
- resist efflorescence

These characteristics are a direct result of the low lime content in the system. After one week the concentration of lime is already insignificant, unlike normal binders whose lime content stays highs even after years. ❑

The Mapei products mentioned are part of Mapei's European product lines

# CLINKER FAÇADES

Clinker cladding is still widely used for its strength and beauty.

*by Roberto Orlando*

"**Clinker**: *material produced by firing a mixture of limestone and clay at a temperature of 1500° C. When ground up, it is a component of artificial cement. Used for making tile and brick." (Encyclopedia Zanichelli)*

Clinker is still widely used even today in new building façades. This material has maintained its popularity because it is versatile, attractive, and especially resistant even under the most adverse weather conditions. Using clinker, which is available in many sizes and colors, polished or unpolished, allows an architect to bring out accents and textures in a building's structure. With technologically advanced setting materials developed in the Mapei research laboratories, clinker can be bonded to all conventional substrates.

For cladding to withstand the test of time, extreme care must be taken during installation. The substrate must be smooth and free of dust or anything that might weaken the bonding of the adhesive. Sufficient curing time must also be allowed: three months for concrete, and one week per each centimeter of thickness for normal rendering. Since exterior surfaces are exposed to various weather conditions and constant temperature variations, both the clinker and the substrate are subject to expansion and contraction in different degrees, due to the nature of the two materials.

For this reason flexible adhesives such as KERABOND mixed with ISOLASTIC must be used, because their elasticity allows for contraction or expansion as needed. Depending on the size of the clinker used and the type of substrate, ISOLASTIC can be substituted for water, either completely, or diluted by 50%.

Enough adhesive must be applied when installing the clinker to cover the tile-back completely. For large modular or strip-tiles with high lugs and ribs, back-buttering is required to make sure there are no voids between the clinker and the substrate.

This is the ideal place for rainwater to penetrate and accumulate, creating dangerous stresses that can cause the clinker to debond when ice forms. ❑

The Mapei products mentioned are part of Mapei's European product lines






The photos feature clinker cladding on buildings completed in the 80's and 90's, using SIRE clinker installed with Mapei KERABOND + ISOLASTIC adhesives.

**1.** Light gray and white polished clinker, size 24.5 x 12 cm, totaling 4,500 sq.m.
**2.** Moss green polished clinker, size 24.5 x 12 cm, totaling 2,800 sq.m.
**3.** Ivory and blue polished clinker, size 24.5 x 12 cm, totaling 14,000 sq.m.
**4.** White unpolished clinker, size 24.5 x 12 cm, totaling 2,400 sq. m.
**5.** Gray and pink polished clinker, size 12x 12 cm, totaling 3,200 sq. m.
**6.** Custom colored clinker with semi-gloss finish, size 12 x 24 cm, totaling 4,500 sq. m.
**7.** Light gray and gray polished clinker, size 12 x 12 cm, totaling 800 sq.m.

Our thanks to Sire Klinker and especially to Dr. Maria Bossolasco, Marketing Director


# FACE-LIFT

An old clinker façade with debonding problems was beautifully renovated in record time.

*by Stefano Pizzorno*

To specialists, renovating a building façade may seem like a routine operation, but when speed and high-quality workmanship are required, things can get complicated. Rush jobs often mean problems, but at the same time, they can be a source of great satisfaction when they are done well, and completed on schedule for the (understandably) demanding customer.

This project called for the renovation of the facade of a prestigious building on Corso Europa in Milan. The polished clinker facade had developed debonding problems caused by water that had seeped in between the substrate and the tiles. Joints had not been grouted when the building was constructed, allowing rainwater to penetrate for forty years, causing serious damage. Once the damaged pieces of clinker were removed, those sections of the substrate that seemed unlikely to guarantee bonding of new materials were demolished.

The substrate was then subjected to analysis. The sections that were removed shows signs of prolonged, deleterious contact with water (Photo 1).

Along the stringcourses and around the blind windows that had been incorporated into the design of the façade, symptoms of carbonation had appeared in the concrete (Photo 2). The reinforcing bars were stripped down to white metal and subsequently treated with MAPEFER, Mapei's two-part cementitious mortar for anti-corrosive protection of reinforcing bars (Photo 3).

The rebars were then coated with MAPEGROUT THIXOTROPIC, the shrinkage compensated fiber-strengthened thixotropic grout for concrete repair, in an average thickness of 25 mm. GRANIRAPID, Mapei's two-part fast-setting mortar system with rapid hydration, was then applied to the previously treated sections of the façade (Photos 4 and 5). This product was ideal for the job because it is shrinkage-free, fast-setting, bonds perfectly to the substrate, and is resistant to temperature variations and aging.

PHOTO 1

GRANIRAPID was applied in a thickness of several millimeters. After a few hours, 12 x 24 cm Laria clinker cladding was installed, using GRANIRAPID and a no. 5 trowel (Photo 6).

PHOTO 2

Only three hours after being installed, the clinker was ready for the first phase of grouting with KERACOLOR White fine-grain ready-mixed cement mortar, taking care to use clean water for mixing. After approximately twenty minutes of letting the mix set in the joints, a preliminary cleaning was done with a hard, just barely wet sponge. This first clean up is very important because it makes the second, final one much more effective, using clean, dry cloths.

Traces of cement, lime, and other job-site materials were removed from the finished facade with KERANET liquid, an acidic cleaner for ceramic surfaces, used with abrasive scotch-brite type sponges.

PHOTO 3

PHOTO 4

PHOTO 5

PHOTO 6


KERANET, a special buffered acid, does not damage surfaces, yet unlike more aggressive acids (muratic, sulfuric, etc.), it actually eliminates the efflorescence which can sometimes develop on them. It probably took longer to erect and dismantle the scaffolding than do the actual renovation using Mapei products. The architect's thanks were reward enough for Mapei, along with his promise to call us on his next project. ❑

*The Technical Data Sheets for the products mentioned in this article can be found in Mapei Binders N. 1 "Ceramic Tile Line" and in N. 3 "Building Specialty Line".*

*We thank Laria Klinker for their co-operation.*

## TECHNICAL DATA

**Installation:** The Gabbiano Building in Corso Europa, Milan, Italy.

**Year built:** 1960

**Year renovated:** 1996-7

**Contractor:** Vetrocemento s.r.l. Milano

**Mapei products used in renovation:**
MAPEFER
MAPEGROUT THIXOTROPIC

**Mapei products for installation of clinker:**
GRANIRAPID
KERACOLOR
KERANET LIQUID

The Mapei products mentioned are part of Mapei's European product lines

# SAFETY UP FRONT

The popularity of ceramic tiles on building façades brings up the aspect of safety once again. This topic was discussed at a recent conference.

*by Adelmo Bovio*

THE THIRTEENTH ATE (ASSOCIATION FOR CONSTRUCTION TECHNOLOGY) CONFERENCE WAS RECENTLY HELD AT THE ARCHITECTURE FACULTY OF THE MILAN POLYTECHNIC TO DISCUSS "SAFETY IN FAÇADES: RESEARCH, DIAGNOSIS, MATERIALS AND SYSTEMS". IN RECENT YEARS, IN FACT, PROBLEMS HAVE SURFACED ONCE AGAIN REGARDING SAFETY AND QUALITY OF MATERIALS AND CONSTRUCTION TECHNIQUES, ESPECIALLY THOSE INVOLVING THE HAZARDS OF CLADDING COMPONENTS ON FACADES. DEBONDING OF SURFACE ELEMENTS IS CAUSED BY A COMPLEX SERIES OF CONTRIBUTING FACTORS. THE MOST SIGNIFICANT OF THESE ARE PERIODIC THERMAL CYCLES OF CONTRACTION AND EXPANSION THAT DIFFER GREATLY FROM THOSE OF THE UNDERLYING WALL SUBSTRATES AND THE PHYSIO-CHEMICAL DETERIORATION OF ANCHORHING SYSTEMS. THE CONFERENCE WAS CONCEIVED CONCURRENTLY WITH THE "SAFETY PROJECT" PROMOTED BY ANFIDES, A RESEARCH PROGRAM ON SAFETY MEASURES FOR STONE FAÇADES. THE MORNING SESSION WAS DEVOTED TO SEMINARS ON DIAGNOSING DEBONDING IN CLADDING, WHILE THE AFTERNOON FEATURED TALKS ON TREATMENTS FOR REPAIRING DETERIORATED BUILDINGS. AMONG THE SPEAKERS WAS ADELMO BOVIO OF THE MAPEI TECHNICAL SERVICE DEPARTMENT WHO DEVELOPED AN INTERESTING ARGUMENT ON THE SUBJECT OF: "INSTALLING EXTERIOR CLADDING WITH ADHESIVE: THE EUROPEAN EXPERIENCE". THE TEXT FOLLOWS HERE IN ITS ENTIRETY:

Exterior cladding, especially in ceramic tiles, has become very common practice in Europe. In Italy, for example, where the total consumption of ceramic tiles for 1994 was 225 million sq. m., 65 million sq. m. were used for walls and more than 5% of this was installed on exteriors.
We can therefore estimate exterior ceramic tile installations in Italy as amounting to about 3,500,000 sq. m., to which natural stone or agglomerates must be added.

**EU standards**

In the past, national standards were published regarding the design and installation of exterior facings in ceramic tiles or natural stone (see following table).

Table 1

| European standards for exterior installations | |
|---|---|
| **France** | C.P.T.-April 1988<br>External istallation with cementitious adhesive |
| **Germany** | DIN 18157<br>Ceramic tile installations with thin-set cementitious mortar<br>DIN 18515<br>External installations in natural stone, conrete and ceramic tile: code of procedure |
| **Great Britain** | BS 5385. Part 2 - 1991<br>Code of procedures for planning and installation of ceramic and mosaic tiles on exteriors |
| **Austria** | Ö - Norm B2207 |
| **Spain** | NTE - 15 - 25 May, 1973 |

The process of integration of EC countries into a single community not only on the economic but also on the legislative level has accelerated the work of the CEN, the organization responsible for formulating new European standards applicable in all EC countries.
For that which expressly concerns ceramic tiles, the TC67

1

2

3

4

committee was created in 1978, chaired at the time by Laurence Burton (GB) and today by Carlo Palmonari (I) . Between 1981 and 1985 the committee elaborated a series of EC regulations for ceramic tiles. In 1989 the WG3 work group operating inside the TC67 began work on formulating standards for ceramic tile installation products e.g. cementitious, organic adhesives in water dispersion, chemical reaction adhesives, and grouts. This committee was assigned to Italy and was chaired by Dr. Giorgio Squinzi. The committee was made up of approximately 15 members of the most important countries, and has concluded its work concerning cementitious adhesives, both organic and latex based. Their conclusions are currently pending public review in the various member countries before being implemented. WG3 activities are continuing with cement and latex based grouting products. At the beginning of 1993 the TC67 created a new work group, the WG4 (headed by Mr. Spencer Ford - GB) which was charged with formulating EC regulations for ceramic tile installation procedures.
This work group is composed of a large number of national delegations and almost every delegation includes representatives from tile setters associations, ceramic tile manufacturers, manufacturers of setting materials, and official testing institutes. After the first four meetings it was obvious that a lot of hard work was going to be needed before obtaining a consensus on EC regulations and codes of procedure.

**Installing ceramic tiles on building façades**

Returning to the subject of EC standards for exterior installations of ceramic tiles, it would be impossible to discuss every problem here, but we'll try to cover the most salient points. In all the standards, special attention is paid to the differential movement between the cladding and the substrate, resulting from temperature variations which can affect the cladding in various ways depending on its exposure to the sun, geographical position and the color of the tiles. The size of the tile is also very important because larger tiles require wider joints and a flexible adhesive. In Europe the most common substrates found in exterior installations are cement rendering and cast concrete. Cement rendering, which is the most widely used, must be well anchored to the wall, solid, without cracks and with a curing time of at least three weeks. Addition of lime to the cement binder can sometimes cause the formation of efflorescence. The substrate surface must be plumb and true, so that when a 2 m-long straight-edge is placed on any part of the surface, it should not show any gap exceeding 5 mm between contact points. If the gap exceeds 5 mm, the substrate should be levelled. Poured concrete is considered an unstable substrate for ceramic tile installations because of delayed shrinkage movement which can occur in the first two years. At least three months of curing are recommended before cladding with ceramic tiles. Using a flexible adhesive (liquid-added latex portland cement mortar or a two-part organic) is an

5

absolute must. A very detailed, interesting description is contained in the French regulations (tables 2 and 3).

**Ceramic tile and setting materials**

With the improvement of ceramic technology, remarkable changes have taken place in the last 20 years in exterior tile installations. Frost-resistant tiles, both vitreous and non-vitreous have become common: this means that their water absorption has been drastically reduced. Moreover they have reached sizes of 60x60 cm. Porcelain tiles are now available with extremely low porosity (less than 0.05% by weight) and in a great variety of colors both polished and unpolished. Special new technology has made it possible to manufacture 80x120 cm non-vitreous tiles. Manufacturers of setting materials have responded to these technological advances in ceramics with new products that work perfectly with the new ceramic materials. In Table 5 we present a list of those most widely available on the world market. The data reported here clearly show how much importance the new types of adhesives place on the flexibility that exterior installations require. Consider the differential movement capability of various types of cement-based mortars, as follows:

- 0.1 mm for non-modified dry set mortars
- 0.1 -0.2 mm for dry polymer-modified mortars
- 0.2 -0.3 mm for normal latex-added mortars
- 0.7 -0.8 mm for elastic latex-added mortars

Comparing this differential movement data with the linear change in the size of ceramic tiles, calculated on the basis of a temperature variation of 100°C (from -20° C to +80°C), which can easily occur in dark colored tiles in Italy, with a coefficient of thermal expansion in tiles of $8x10^{-6}$ x°C$^{-1}$, we obtain the data contained in the following table.

Considering the almost infinite number of freeze/thaw cycles and stresses to which a façade is exposed, the use of a two-part liquid-added latex portland cement mortar is highly recommended for 10x10 cm and 20x20 cm tiles. Using a two-part elastic latex portland cement mortar is recommended for larger size tiles, making sure that the original latex is not diluted on the site.

Table 2

| FRENCH CPT 1988 - Part one | | | | |
|---|---|---|---|---|
| Substrate | Concrete | Cement rendering | Concrete | Cement rendering |
| Adhesives | | Cement adhesives (fine grain) for thicknesses of 1.5 to 5 mm | | Cement adhesives (fine grain) for thicknesses of 1.5 to 8 mm |
| | Cement adhesives (1.5 to 5 mm) + liquid resin | | Cement adhesives (1.5 to 8 mm) + liquid resin | |
| | Cement adhesives (1.5 to 5 mm) with incorporated resins | | Cement adhesives (1.5 to 8 mm) with incorporated resins | |
| Floating | S ≤ 100 cm² | | S ≤ 100 cm² | |
| Floating and back - buttering | 100 < S ≤ 300 cm² | | 100 < S ≤ 900 cm² | |

Table 3

| FRENCH CPT 1988 - Part two | | | | | | |
|---|---|---|---|---|---|---|
| Tile surface cm² | S≤100 | | 100<S≤300 | | 300<S≤900 | |
| Tile weight (Kg/m²) | W≤30 | 30<W≤40 | W≤30 | 30<W≤40 | W≤30 | 30<W≤40 |
| Maximum height | no limit | | to 28 m | | | |
| Floating | yes | yes | NO | NO | NO | NO |
| Floating and Back-buttering | yes | yes | yes | yes | yes | yes |

Table 4

| Tile size | | | | Linear variations |
|---|---|---|---|---|
| 60 x 60 cm | = | $8 \cdot 10^{-6} \cdot 100$ °C $\cdot$ 600 mm | = | 0,48 mm |
| 40 x 40 cm | = | $8 \cdot 10^{-6} \cdot 100$ °C $\cdot$ 400 mm | = | 0,32 mm |
| 30 x 30 cm | = | $8 \cdot 10^{-6} \cdot 100$ °C $\cdot$ 300 mm | = | 0,24 mm |
| 20 x 20 cm | = | $8 \cdot 10^{-6} \cdot 100$ °C $\cdot$ 200 mm | = | 0,16 mm |
| 10 x 10 cm | = | $8 \cdot 10^{-6} \cdot 100$ °C $\cdot$ 100 mm | = | 0,08 mm |

6

Table 5

**TYPES OF ADHESIVES FOR SETTING FLOOR AND WALL TILES**

| | N. of parts | Flexibility | Developed in USA | Developed in Europe |
|---|---|---|---|---|
| **Fast setting cement adhesives** | | | | |
| Cement based (5 to 7 mm. thick) | 1 | NO | 1955 | |
| Cement based + incorporated resins | 1 | NO | | 1960 |
| Cement based to 15/20 MM | 1 | NO | | 1980 |
| Special cement based, fast-hardening (1-2 hours) | 1 | NO | | 1975 |
| Cement based + resin based latex | 2 | NO | 1960 | |
| Cement based + flexible resin latex | 2 | YES | | 1975 |
| **Resin based adhesives in water dispersion (ready to use organic adhesives.)** | | | | |
| High flexibility | 1 | YES | | 1970 |
| Moderate flexibility | 1 | YES | | 1970 |
| **Chemical reaction adhesives** | | | | |
| Polyurethane (one part) | 1 | YES | | 1980 |
| Polyurethane (two part) | 2 | YES | | 1975 |
| Epoxy resin based | 2 | NO | 1965 | |

7

**Rules of thumb for proper setting**

From the previous examples it is very easy to understand the importance of selecting the right mortar for exterior installations. However, this is not enough if the other rules of preparation and installation are not followed. Let's look at the most important:

1. The ceramic tiles must be set on a wet mortar bed, staying within the open time in order to ensure thorough transfer of the adhesive to the back of the tile.
2. All tiles with a surface larger that 100 cm must be installed using the back-butter and float method, spreading the adhesive both on the substrate and on the back of the tile to prevent gaps from forming.
3. Joint width must be calculated keeping in mind weather conditions and freeze/thaw cycles and in any case must be no less than:
a) 2 to 8 mm for both vitreous and non-vitreous tile
b) more than 10 mm for clinker and porcelain tiles
c) 2 to 8 mm for small clinker tiles
4. Dimensions and position of all structural joints must be carefully planned.
5. Movement joints must be provided for every 12 square meters and at the meeting lines between two substrates of different nature and composition .
6. Peripheral elastomeric movement joints must be provided for in all corners and near windows, balconies, etc.
These joints must be at least 6 mm. wide and must be filled with a flexible sealant or equivalent system. When all of the above instructions are followed, it is practically impossible for breaks to occur and only human error during installation or serious structural defects can cause debonding of the ceramic tiles. ❑

*The photos accompanying this article show various examples of European projects:*

*1) Prostejou Revenue Office, Czech Republic*
*2) La Part Dieu Railway Station, Lyons, France*
*3) Office Building, Prato, Italy*
*4) Telecom Offices, Toulouse, France*
*5) Hotel Plaza, Perugia, Italy*
*6) Convention Center, St. Petersburg, Russia*
*7) Esmalglass Research Center, Sassuolo, Italy*

# BOSTON to BOSTON

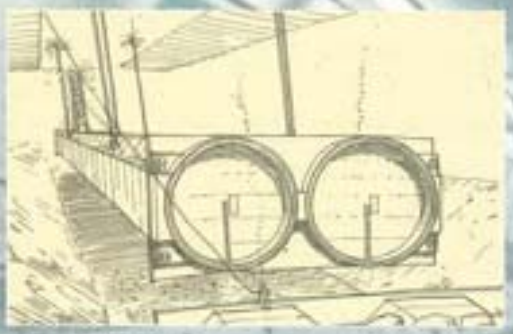
A million and a [illegible] were invested in the Boston Third Harbor Tunnel.

by Natasha Calandria and Ed [illegible]

*Drawing 1*
*The total cost of the Boston Tunnel was $258 million. $30 million were awarded in contracts to local construction firms. The drawing illustrates the amount of funds allotted to the each section of the project.*

*Drawing 2*
*Positioning tunnel sections on a bed of gravel. Once they were lowered into the water, the sections were then connected by specially trained divers.*


DRAWING 1



DRAWING 2

PHOTO 1

Built to increase the capacity of the Central Artery expressway that runs through the heart of Boston, the Third Harbor Tunnel was designed to relieve traffic congestion by connecting South Boston directly with East Boston and Logan Airport. The tunnel is dedicated to Ted Williams, one of the past glories of the legendary Boston Red Sox baseball team. Work began in 1992 on digging a trench 1300 meters long, 30 m. wide, and 15 m. deep, on the bottom of the port of Boston. In two years the "Super Scoop", a dredging machine brought in specially from California, removed 700 cubic meters of soil and sediment from the bottom, despite some inconvenience experienced during lobster and herring migrations.

**The dredging operation**

To reduce the risk of rock fractures that are often the cause of water leaks in tunnels, the architects decided to employ a submerged structure consisting of two parallel tunnels to accommodate four lanes of automobile traffic. At its shallowest point the tunnel is 2.5 meters beneath the surface of the old port, so the longest section of the tunnel is protected by the surrounding rock. Several environmental measures were adopted during dredging to keep loosened sediments from contaminating the waters of the harbor: special rubber protection devices were fitted to the edges of the dredging bucket to prevent the release of contaminated material. While the "Super Scoop" proceeded with dredging, a second machine deposited a bed of gravel on which the tunnel sections would be placed. Each section is 100 meters long, weighs 7.5 tons and is outfitted with shafts for the ventilation system (see Drawing 2). The segments, whose interiors had been cast with horizontally and vertically curved profiles to house the roadways, were encapsulated in concrete and connected to each other

PHOTO 2

*Photo 1*
*10 meters below sea level…a two-story scaffolding is erected to install ceramic tiles on the tunnel walls*

*Photo 2*
*Section after section, ceramic tile walls surround the four traffic lanes*

under water with hydraulic joints. The tunnels rest on uneven terrain, being 25 m. deep at either end and 30 m. deep in the center. These differences in grade made it necessary to use materials with a high modulus of elasticity to compensate for ground settling of the structure. Specifications are stricter for tunnel tile than floor tile due to the environmental conditions to which a tunnel is exposed: constant moisture, continuous vibration, extreme temperature differences, and shock waves caused by the backfiring of internal combustion engines.

**1,400,000 tiles**

The project called for installation of ceramic tiles on the tunnel walls: 630,000 sq. ft. of 8x8 inch (25x25 cm.) tiles specially designed to enhance their bonding strength, for a total of 1,400,000 tiles! Such a large and highly specialized installation required the technical assistance of an experienced setting materials manufacturer. Design professionals for the project selected the world's largest and most experienced, Mapei Corp. with headquarters in Garland, Texas and four plants in the USA.
Mapei products passed fatigue strength tests and proved they could guarantee the high quality necessary for a tile installation in such extreme conditions. The walls were first given a slurry bond coat of cementitious mortar mixed with Mapei PLANICRETE 50* admixture, a synthetic rubber latex for better bonding and increased strength, followed by the installation of a scratch and float coat. Choosing the adhesive required careful evaluation.
This difficult project was made possible by using Mapei KERASET* thin set mortar, a cementitious adhesive that hardens without shrinkage, and bonds perfectly to all substrates normally used in construction, mixed

PHOTO 3

PHOTO 4

with KERAPLY* latex admixture.
Another product developed in the Mapei laboratories was selected for grouting a surface equivalent to that of 4,600 family bathrooms: ULTRACOLOR, a latex-modified, hydraulic cement grout that is fast drying, hardens without shrinkage and prevents formation of surface efflorescence.
*"Mapei products have been selected for the tile installation in the Third Harbor Tunnel project. Mapei technical representatives have been on site on several occasions to ensure that their products were installed properly. The quality and performance of MAPEI products have far exceeded their competitors. From the spreadability of their KERASET, to the ease of clean up of their ULTRACOLOR* grout.*
We are confident that we made the right decision in selecting Mapei products for this project," declared Bob Vesey, Project Manager.
We at Mapei couldn't be more pleased. ❑

PHOTO 5

PHOTO 6

PHOTO 7

*Photos 3 and 4*
*The back-buttering and float system is used for setting the tiles. KERASET* is first applied with a trowel to walls that have been given a slurry bond coat of cementitious mortar mixed with PLANICRETE 50* admixture (photo 3). Then KERASET* is spread on the back of tiles mounted on panels of 25*

*Photo 5*
*Setting the tiles after applying the adhesive*

*Photo 6*
*4,600 bathrooms could have been grouted with the amount of ULTRACOLOR* used in the tunnel.*

*Photos 7 and 8*
*The "Central Artery" is ready to receive the thousands of vehicles that will pass...underwater!*


*Technical data sheets for the products mentioned in this article are contained in Mapei's "Resilient and Ceramic" Binder available from Mapei Corp. (USA) and Mapei Inc. (Canada).*

PHOTO 8

## TECHNICAL DATA SHEET

**Project:** "Third Harbor Tunnel", Boston

**Executed:** 1992-1997

**Project Manager:** Bob Vesey

**Cladding:** 8x8 inch (25x25 cm.) ceramic tiles

**Products used for tile installation*:**
PLANICRETE
KERASET
KERAPLY
ULTRACOLOR
* these products are manufactured by Mapei Corp. (USA)

# EUROSTAR, YOU'RE A STAR

Working at full throttle to build the railway station of the 21st Century, the Eurostar Terminal of the Gare du Midi Station in Brussels

*by Francesco Stronati and Aristide Mariotti*

PHOTO 1

PHOTO 2

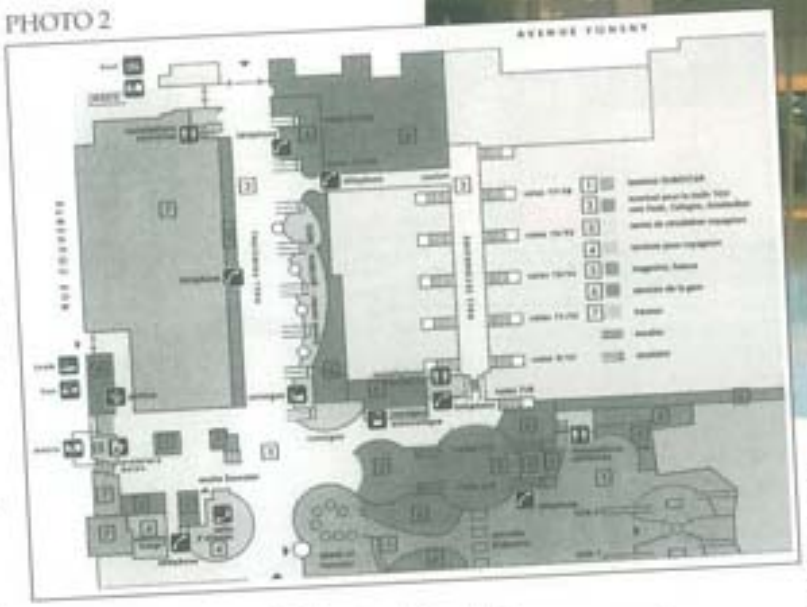


*Photo 1*
*The Eurostar Terminal*

*Photo 2*
*Plan of the new terminal*

The new Eurostar train which links London and Brussels, hurtling through the Channel Tunnel, sparked the impetus to begin work on the renovation of the Gare du Midi railway station in Brussels.The Eurostar project became a reality in 1990 when the Belgian government gave the go-ahead to build a high-speed rail line, the TGV (Train à Grande Vitesse). That same year the Belgian State Railways and a group of private investors founded Eurostation S.A. to plan the rebuilding of the Brussels Midi station, which is used by 400 million passengers a year. Work began in 1992 and is scheduled for completion in the year 2000, by which time the entire station will have been renovated and ready to receive 270,000 passengers a day. In charge of construction are Ing. Persoons and the architectural firm of De Vreese and Parijs.

**Maximum security for Eurostar**

Situated at a right angle to the Main Concourse of the old station, the new TGV Terminal is completely self-contained. It houses Tracks 1 and 2 which are reserved exclusively for Eurostar trains. The Eurostar must follow very strict security procedures and therefore this part of the station must be completely closed off.

## STAGES OF CONSTRUCTION

| | |
|---|---|
| 1992 | Start of demolition work on the Tower of the old station. Tracks 1 and 2 are readied for Eurostar London -Brussels trains; new floors, ceilings and lighting are installed in the main connecting corridor; new escalators leading to the train platforms are designed; the Travel Center is completed; the catering operation is installed in the Salik Building and a tunnel with escalators is built from the catering company to the TGV platforms. |
| 1994 | The TGV Eurostar Terminal is officially opened to receive passengers in November. |
| 1995 | The last section of the TGV Terminal (tracks 3 to 6) is completed and temporarily used for international trains, to be gradually replaced by TGV trains; waiting rooms are completed. |
| 1996 | The Thalys train is inaugurated (the PBKA line: Paris, Brussels, Cologne, Amsterdam). |
| 1997 | The retail space area is opened. |
| 2000 | Planned completion date for the renovation of the entire station. |


*Photo 3*
*Preparing the mix for the MAPECEM screed*

*Photo 4*
*Leveling the MAPECEM screed*

*Photo 5*
*Using a finishing machine for a perfect finish on the surface of the substrate*

*Photo 6*
*Installing the marble agglomerate tiles with GRANIRAPID*

*Photo 7*
*Detail of the floor tiles, set and ready to be grouted with KERACOLOR*

Some sections are reserved for passport control and baggage check, while others are designed for passing time agreeably between connections in bars, boutiques and waiting-rooms. Another TGV Terminal, also known as the PBKA (Paris-Brussels-Cologne-Amsterdam) is located on Tracks 3 to 6. This area has been left open, since it does not require security checks at the entrance. The station is on two floors. Ticket counters and waiting rooms are located on the ground floor and train platforms on the floor above. The project also calls for the eventual construction of retail space for forty shops, hotels and snack bars located on one side of the Main Concourse. On the other side of the Concourse the Travel Center is in its final phase of construction. Here 34 automated ticketing machines will replace the old ticket windows. The entire area surrounding the Brussels Midi Station is slated for change. The renovation of the station is linked to a wider urban renewal project which covers an area of 120,000 sq. m., of which 20,000 are planned for hotels, 10,000 for residences and 2,500 for parking garages.

PHOTO 3

PHOTO 4

PHOTO 5

PHOTO 6

PHOTO 7

PHOTO 8

*Photos 8 and 9*
*Channeling the flow of passengers toward the Eurostar check-in counters and platforms*

**The main challenges: Time and Logistics**

The construction firms working on the Eurostar Terminal had to meet many challenges. One of the most pressing problems was installing the floor quickly. "The time factor has always been our biggest challenge," observed Frans Vandermeersch, Project Manager for CFE Construction. "The station remained open, with over 100,000 passengers transiting each day, so it was impossible to work on more than two platforms at a time. The logistics of the job site presented another major problem: before we could install the new one, we had to demolish the old floor of the main connecting corridor completely, but without entirely blocking off passenger access. The old one had buckled in several places and only risked getting worse over time, so we had to remove it, along with the old substrate."

**Fast products for short deadlines**

To address timing and logistics problems most effectively, the Project Managers required the use of fast-setting products. The ground floor corridor was divided into sections which were closed to traffic only a few days at a time.

**Substrates first**

The first job to be tackled was the removal of the old flooring and substrate right down to the reinforced concrete slab underneath. Then a new substrate was made with MAPECEM, the special hydraulic binder for fast-drying shrinkage compensated screeds. MAPECEM mixed with water and aggregates produces a mix that hardens and cures in an extremely short time, so the MAPECEM screed was ready to be tiled over in only 24 hours.
This way an enormous amount of time was saved on the job-site, avoiding the long cure times required by conventional substrates (at least 28 days) before being able to install ceramic tile or natural stone flooring.
Thanks to the high mechanical strength of the MAPECEM screed it was possible to open the floor to heavy traffic only 24 hours after installation. To anchor the new substrate to the concrete slab, a bonding slurry was applied consisting of one part by water PLANICRETE (synthetic rubber latex for cementitious mortars) and two parts MAPECEM. The mortar for the substrate was poured before the bonding slurry had completely hardened.

**An agglomerated marble floor**

Planning the installation of the flooring required extreme precision since it was a mosaic of marble tiles with colored motifs and many curving designs. The surface of the screed was finished with a finishing machine while the MAPECEM was still fresh. The flooring of agglomerated marble tiles with polyester resins was custom made for this project by Marbra Lys and required the use of a fast-setting and drying adhesive with high adhesion. GRANIRAPID was selected because it meets all these requirements. Only 3 to 4 hours after installing the floor covering with GRANIRAPID it was possible to grout the joints with KERACOLOR FINE GRAIN, a ready-mixed cement mortar for filling joints from 0 to 4 mm. All of these products were used not only for the flooring of the entire first floor of the new terminal, but also on the platforms of

PHOTO 9

ceramic tiles over cement rendering on the walls of the bathrooms in the terminal. The operation took an extremely short time here, too, because this adhesive is ready to use with no mixing needed. ULTRACOLOR, the fast-setting and quick-curing cement grout for joints 2 to 20 mm wide, was used to complete the installation. ❑

*Technical data sheets for the products mentioned in this article are contained in Mapei Binder N° 1 "Ceramic Tile Line".*

Tracks 1 and 2. In addition, the platform of Track 1 had to be waterproofed before installing the flooring. A 2 mm thick coat of MAPELASTIC, the two-part flexible cement mortar for waterproof protection of concrete, was applied over the MAPECEM screed. Waterproofing was easy, using a metal trowel and embedding a fiberglass mesh into the MAPELASTIC. After four days, when the substrate had hardened, it was possible to install the agglomerated marble tiles using, as before, GRANIRAPID.

**Ceramic tile on the walls**

ADESILEX P25, Mapei's ready to use paste adhesive, was used for installing

## TECHNICAL DATA SHEET

**Project:** The Eurostar Railway Station at Brussels-Midi, Brussels, Belgium

**Year of execution:** 1992 to 1998, still under construction

**Contractor:** SCNB, Brussels

**Architects:** Eurostation

**General Contractor for large-scale projects:** AM CDC (Cit-Blaton/De Nul/CEI) CFE, Brussels

**Floor and wall coverings:** marble agglomerate by Marbra Lys, Harelbeke, and ceramic tiles from several manufacturers.

**Mapei products used:**
Installation products: MAPECEM screeds
Slurry mixed with: MAPECEM and PLANICRETE
Adhesives: GRANIRAPID and ADESILEX P25
Grout: KERACOLOR FINE GRAIN and ULTRACOLOR

**Waterproofing products:** MAPELASTIC

The Mapei products mentioned are part of Mapei's European product lines


# A BRIDGE TO THE FUTURE

Mapei products were selected for the East Bridge segment of this grandiose transportation project linking the islands of Denmark with the continent

*by Natasha Calandrino and Pasquale Zaffaroni*

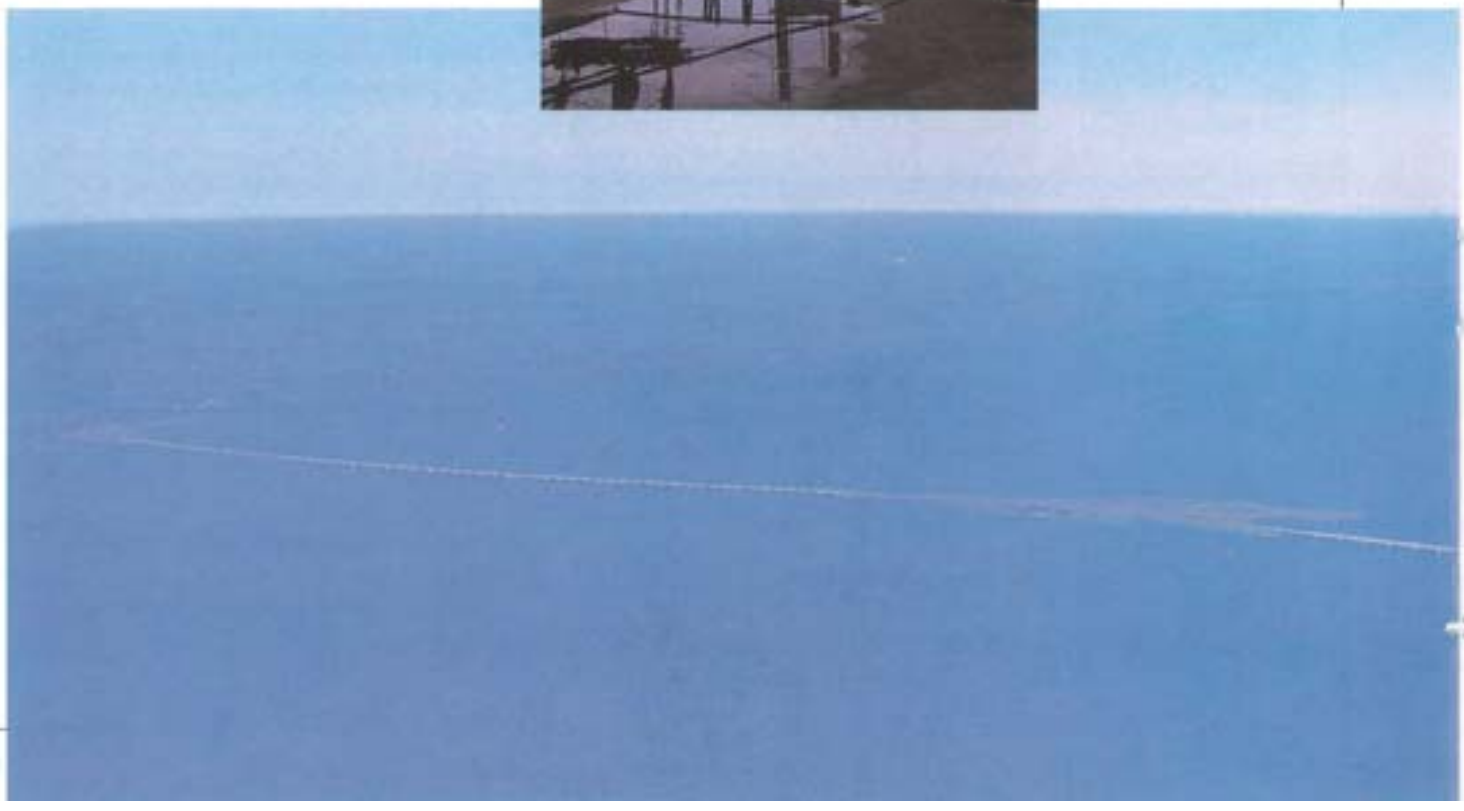
The Great Belt Link connecting the islands of Denmark to the rest of the continent is without a doubt one of the most significant infrastructure projects to be completed in Europe in recent years. The project called for the construction of two bridges carrying three lanes of automobile traffic in each direction (with an estimated 16,000 cars a day!), and an undersea tunnel exclusively for trains: a colossal network 6,790 meters long crossing the Storaebelt Strait between the Danish mainland and the island of Zealand. The two bridges were designed to perform the same function but with different characteristics. The West Bridge covers the first portion of the project between the Danish peninsula and the little island of Sprogo, located approximately at the halfway point of the Great Belt Link. The East Bridge connects Sprogo with the island of Zealand and was inaugurated June 14th of this year. With a central span 1,624 meters long between its two concrete towers, it is the world's second longest suspension bridge.

**The East Bridge**

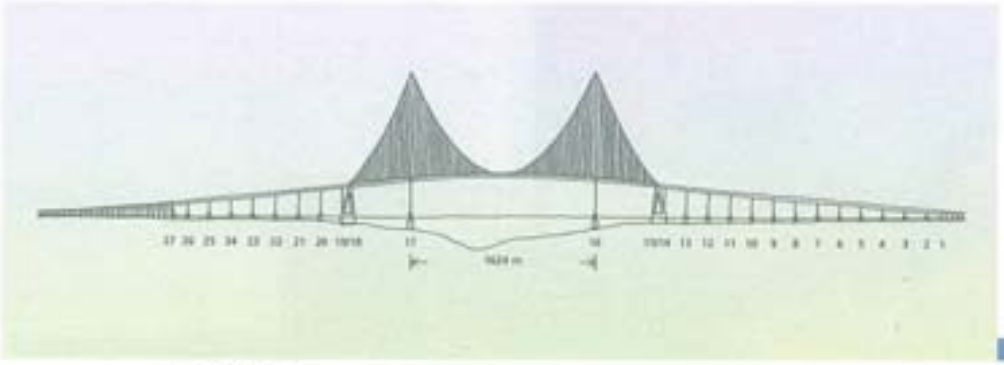
Mapei products were selected to be used

PHOTO 1

*Photo 1*
*"The Great Belt Link" between the North Sea and the Baltic, with two bridges (East Bridge and West Bridge) and a tunnel linking the Danish islands with the continent*



DRAWING 1



*Drawing 1*
*The drawing shows the East Bridge, a suspension bridge 65 meters high with its two lateral access bridges whose steel - supported roadways rest on concrete pylons.*

PHOTO 2

*Photo 2*
*Details of the formwork used in the full scale test for casting the bearings, with the tip of the pylon and the base of the bearing reproduced in the Mapei plant in Mediglia*

*Photo 3*
*One of the first trials of the full scale test*

in building the East Bridge. The project turned out to be especially complex because it had to integrate a transportation system moving cars, trains and ships without having a negative impact on the environment. Each year 20,000 ships pass from the North Sea to the Baltic through the channel separating the islands of Sprogo and Zealand. Having to keep the channel open to heavily trafficked shipping lanes necessitated the building of a suspension bridge 65 m. above the waterline with a long central span. The towers had also to be able to withstand the potential impact of a large ship accidentally colliding into them without the bridge's suffering irreparable damage. The East Bridge is

PHOTO 3

PHOTO 4

*Photo 4*
*The slab produced for the full scale test model to check the performance of the MAPEFILL against the project specifications*

PHOTO 5

*Photo 5*
*MAPEFILL mixed with gravel was used to reduce the heat of hydration caused by the remarkably thick casting*

*Photo 6*
*Detail of the reinforcing bars inside the bearings*

divided into three separate structural elements, the central suspension span and the two bridges approaching it on either side. Although the latter were not suspension bridges, they presented a considerable challenge to the project's architectural and construction firms. For both the central span and the two lateral spans the architects opted for a roadway with a longitudinal center reinforcing beam and with trusses forged entirely in high strength Fe 420 steel.
The roadway rests on concrete pylons 193 m. apart. Its main requirement was resistance to horizontal vibrations caused by wind and vertical vibrations caused by automobile traffic. Most importantly, the mortar used for anchoring the rods connecting the reinforced concrete pylons with the steel bearings supporting the roadway had to possess high flexural and compressive strength.

**Full scale test**

The detailed planning for such a large scale project made it necessary to test the materials to be used. Mapei was able to satisfy this requirement because of the high quality of its products and its very accommodating technical assistance team. A full scale test was conducted at the Mapei plant in Mediglia to guarantee

PHOTO 6

PHOTO 7

PHOTO 8

*Photo 7*
*Checking the porosity on the surface of the MAPEFILL after removing the slab. The photo shows limited porosity*

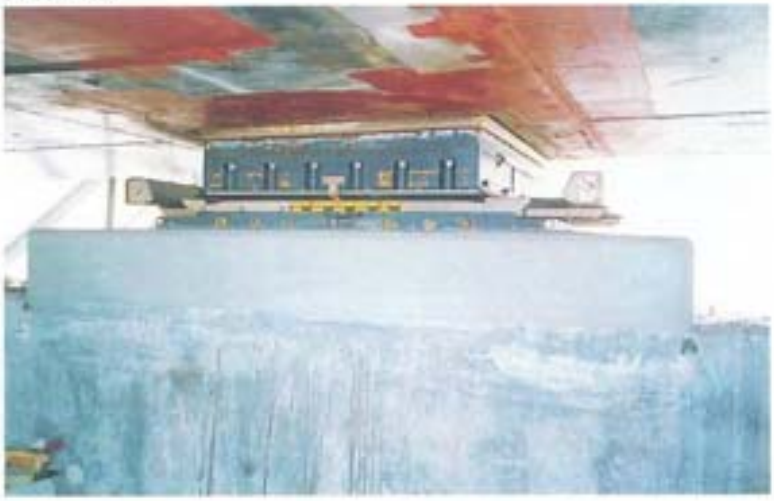
*Photo 8*
*The MAPEFILL bearings are coated with MAPELASTIC to increase protection against atmospheric agents*

*Photo 9*
*Another step in applying the MAPELASTIC*

*Photo 10*
*The finished bearing coated with MAPELASTIC*

PHOTO 9

PHOTO 10



optimum product performance and proper installation on site. Following the pattern of the reinforcing bars, the top of a pylon was reproduced to simulate actual conditions. A slab was then prepared to represent one of the bearings, containing the exact number of the same size Nelson rivets used in the real bearings. An extremely fluid mortar was needed so it could be poured around the thick network of rebars. The ideal product for the task was MAPEFILL mixed with fine gravel to reduce the heat of hydration generated by such thick casting. Once the slab was removed, the surface was examined to check porosity, i.e. the exact number and size of pores. This last test was very important because it ensures that the weight of the beams is evenly distributed over the entire area.

After checking that the modulus of elasticity was in keeping with the requirements of the bearings' manufacturer, tests were made to measure mechanical strength both at normal temperatures and at 5°C over various amounts of time. With the data gathered during the series of full-scale tests at Mediglia, Mapei was able to co-operate actively on site, following casting closely and checking up on the pumpability of the product.

For increased protection from atmospheric agents the MAPEFILL bearings were coated with MAPELASTIC, a mortar that is permanently flexible even at sub-freezing temperatures and

PHOTO 11

*Photo 11*
*The impressive silhouette of the East Bridge under construction. The span was inaugurated June 14, 1998*

impermeable to sulphates and chlorides. A light-colored MAPELASTIC similar to the color of the concrete was requested. Here, too, Mapei was happy to comply. Special importance was placed on maintenance from the very first conceptual analysis of the project. Periodic safety checks will be made to guarantee that the products installed will last for over 100 years, even at gusts of wind up to 25 m/s. ❑

*The technical sheets of the products mentioned in this article are contained in Mapei binder N° 3 "Building specialty line".*

## TECHNICAL DATA

**Project:** "The Great Belt Link"

**Year of Execution:** 1991-1998

**Architects:** Dissing + Weitling Arkitektfirma A/S and Jørgen Vesterholts Tegnestue ApS

**EAST BRIDGE:**
**Construction firm:** Iritecna-CMF Sud, Italia in cooperation with Steinman Boynton Gronquist & Birdsall, USA

**Technical consultants:** Joint Venture CBR:
- COWIconsult A/S, Denmark
- Ramboll, Hannemann & Højlund A/S, Denmark

**Specialists associated with Joint Venture CBR:** Chodai, Japan

**Mapei products used:**
MAPEFILL
MAPELASTIC

The Mapei products mentioned are part of Mapei's European product lines

# HIGH TECH FOR A NEW HEADQUARTERS

Boehringer could count on highly specialized partners and technology to ensure the best outcome possible on this project.

*by Paolo Giglio*

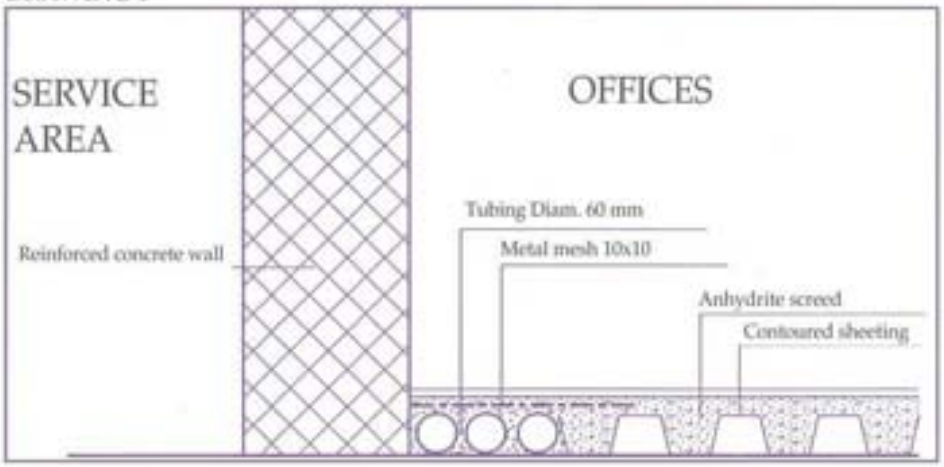
Resilient flooring is ideal for large spaces such as offices, clinics and schools. In Monza, a suburb of Milan, the new headquarters of Boehringer Mannheim Italy, the well-known pharmaceutical corporation and leader in its field, was recently completed. The company took advantage of highly specialized partners and technology to guarantee optimal results. Let's take a closer look at the installation of approximately 14,000 square meters of resilient flooring in their new offices.

**Preparation of the substrate**

Contoured galvanized sheeting was installed and anchored to the finished reinforced concrete slab. This technical solution gave great flexibility for installing the electric system on each floor. We can see in Drawing 1 how the project design found a way of avoiding interference between electric, telephone and computer cables.
An anhydrite screed approximately 4 cm thick was poured over the galvanized sheeting as a substrate for the resilient flooring. The proper installation of materials resulted in a substrate without cracks that features very high mechanical strength. Before preparing the underlayment, a test had to be made with

PHOTO 1

DRAWING 1




*Drawing 1*
*Special design features avoided interference between electric, telephone and computer cables. Contoured sheeting was anchored to the reinforced concrete slab and then embedded in an anhydrite screed*

PHOTO 2

PHOTO 3

PHOTO 4

a carbide hygrometer to make sure that the moisture present in the substrate did not exceed the 0.5% required by present standards.
The underlayment was prepared by abrading the surface of the anhydrite with a sanding machine (Photo 2).
This operation opened the surface pores of the substrate to allow the primer to penetrate into the structure of the screed.
Thorough vacuuming followed (Photo 3).
This step is very simple yet all-important because the underlayment must be free of loose material, dust or laitance.
Then PRIMER G insulating primer was applied with a roller, taking care to spread the product evenly.
This surface treatment between the gypsum substrate and the cementitious leveling compound is indispensable because it prevents a chemical reaction between the sulphates in the gypsum and the alluminates in the cement that can cause the formation of a salt called "ethringite" if moisture is present. One day later PIANODUR R was installed, a fine grain self-leveling cement smoothing compound that hardens in ultra-fast time, ideal for dry areas subject to heavy traffic (Photo 4).

PHOTO 5

PHOTO 6

PHOTO 7

**Installing the flocked flooring**

Once the substrate was prepared, Flotex flocked flooring was installed. This

PHOTO 8

PHOTO 9

hi-tech flooring has a nylon fiber surface heat-anchored to a layer of PVC by means of high-speed electrostatic flocking (that makes the pattern on this type of carpet), with an intermediate stabilizing layer in fiber glass and an sound deadening under-layer of closed cell PVC foam. ROLLCOLL, a fast-setting synthetic polymer based adhesive in water dispersion, was used to install the Flotex (Photo 5).
Photos 6, 7, 8, and 9 show the beautiful finished job which left the customer fully satisfied. ❑

*Technical data sheets for the products mentioned in this article are contained in Mapei Binder N° 2 "Resilient flooring"*

## TECHNICAL DATA

**Project:** Boehringer Mannheim Italia S. p.A., Monza, (MI) Italy

**Year of Project:** 1995

**Construction firm:** Minotti

**Project Manager:** Ing. Minotti

**Flooring:** Flocked Flotex from Bonar & Flotex LTD (UK)

**Gen. Agent for Italy:** Linoleum Italia Srl, Milan

**Flooring installed by:** Self Cart, Monza

**Total area:** 14,000 sq. m.

**Mapei installation products:**
PRIMER G
PIANODUR R
ROLLCOLL

The Mapei products mentioned are part of Mapei's European product lines

# MAPEI IN THE LAND OF THE TIGERS


As one of the most dynamic and economically advanced countries in the world, it was only natural that Singapore was chosen as the site to catapult construction adhesive giant Mapei into the Far East.

In 1989 the first outpost, Mapei Far East, was established in the region in a modest 500 square metre office and warehouse with just five employees.


PHOTO 1

It soon blossomed, however, into a 10,000 square metre operation in a spanking new building situated in the newly established industrial park in Tuas, Singapore.

Over S$10 million has been invested in the new building which houses the company's sales and administrative offices as well as the plant. The facility has a daily production capacity of 120 tonnes of powdered adhesives and five tonnes of liquid polymers.

Establishing a Research and Development laboratory will soon follow.

As Felix Quek, the Managing Director of Mapei Far East, very succinctly puts it, "We need to be here first before we can go elsewhere in Asia."

"The greatest number of projects are located here in the Far East and our success here will give us the most important project references for the Mapei Group," said Quek, referring to the development potential of China, Indochina and India.

"We have to take advantage of the growth here through relationships formed with local businesses. So it's important that we manufacture here in Singapore and be able to offer strong technical support to our customers."

*Photo 1*
*Managing director of Mapei Far East, Felix Quek*
*Photos 2 and 3*
*Two views of the Singapore plant and office*
*Photo 4*
*The liquids plant*
*Photo 5*
*Tubes which feed cement into the silos*
*Photo 6*
*The mixing plant and the conveyor belt*
*Photo 7*
*Detail of Singapore warehouse*

PHOTO 2


PHOTO 3


*Photo 8*
*A training seminar held for Mapei Far East staff by Pasquale Zaffaroni of the Mapei Technical Service (Milan headquarters)*
*Photo 9*
*The staff of Mapei Far East*


**Strong technical support is the key**

One of the main reasons that Mapei has achieved such a huge success in a short period of time is its ability to provide high quality products along with the excellent support of its Technical Service.
Mapei's Technical Service gives every customer pointers on solving problems as well as demonstrating the best installation methods for each project. This close co-operation ensures that Mapei's high quality products receive the best possible handling for obtaining optimum results.
With that in mind, it comes as no surprise that Mapei has been involved in some of the island republic's most prestigious projects, such as the refurbishment and extension of Changi International Airport's Passenger Terminals One and Two.
Mapei also played a part in the extension of the second phase of Nanyang Technological University. Other recent projects include waterproofing the Sumitomo Warehouse and the natural stone and ceramic tile installations in condominium developments like Northvale, Costa Rhu and Taman Nakhoda. Mapei products were selected for the external cladding of the Bishan Community Club and were also used to waterproof the underpasses of the East Coast Parkway.

**Singapore, a commercial bastion**

Already blessed by its pivotal position on world trade routes, Singapore's status as a free port has contributed greatly to its commercial prosperity.
Since gaining independence in 1965 the republic's per capita income has increased several fold. It is now higher than that of several European countries. With a current population of 3.4 million, the remarkable economic growth of this tiny island has made it the world's second most competitive economy for the last couple of years, behind only that of the United States.
Singapore is almost always used as the point of reference for all Asian countries, especially where construction, technology and supply of materials are concerned.
Like Mapei, a vast number of established foreign companies have set-up


subsidiaries in Singapore, using it as a jumping-off point for expanding into other Asian markets. Until recently growth trends for the construction industry in Singapore were at 16% but the economic slowdown currently afflicting the region seems somewhat to have taken the wind out of its sails.
Since Mapei has made a long-term commitment to growth in Asia, it has to be realistic about setting immediate targets while the region rides out the economic storm.

**Mapei in the next millennium**

With the economic slowdown affecting the region and several countries already feeling the full effects of it, a large corporation like Mapei has to reassess its position as a global player in the construction industry. Felix Quek asserts that while the economic downturn in Asia may be misconstrued in some quarters as something totally negative, he would prefer to see it as a silver lining in an otherwise very dark cloud.

*The market covered by Mapei Far East under the management of Felix Quek includes Indonesia, Malaysia, Brunei, the Philippines, Thailand, Taiwan, Hong Kong, China, Japan, Vietnam and South Korea*

## FAR EAST DISTRIBUTORS

**MALAYSIA**
MAPEI (MALAYSIA) SDN BHD
No. 33, Jalan Pengeluaran U1/78
Batu Tiga Light Industrial Park
40150 Shah Alam,
Selangor Darul Ehsan Malaysia
Tel: (03) 5595799
Fax: (03) 5595801
Contact: Mr. David Ma

**BRUNEI**
MEI CHEE ENTERPRISE
Unit 1, 2nd Floor Block C
Bangunan Hj. Abdul Rahman Bin Awg. Hassan
Ban Hjh. Site Ajar Bte Abu Bakar
Dan Anak-Anak
Simpang 88, Kampong Kiulap BE 1518
Bandar Seri Begawan
Negara Brunei Darussalam
Tel: (2) 232023 & 232024
Fax: (2) 232026
Contact: Mr. Michael Lee

**HONG KONG**
BAIN D'OR CO., LTD
Victoria Centre, 6th Floor
15, Watson Road
Hong Kong
Tel: 28079400
Fax: 25129986
Contact: Mr. Adolf Woo/ Mr. Daniel Hui

**INDONESIA**
P T PROPAN RAYA
Construction Chemicals Division
Komplex Roxy Mas Blok D.1 No. 4-7
Jl. K. H. Hasyim Ashari No. 125B
Jakarta Pusat, Indonesia
Tel: (21) 3856030
Fax: (21) 3856031/3862223
Contact: Mr. Yuwono Imanto

**The PHILIPPINES**
DEXTERTON INDUSTRIAL CORP.
208 Rizal Avenue Ext.
1400 Kalookan City,
Metro Manila
The Philippines
Tel: (2) 3616006/7
Fax: (2) 3616940
Contact: Mr. Simpson Ong
**Technical Service in the Philippines:**
Country Technical Service Manager:
Mr. Brian S. Stewart
Tel. (2) 825-0709
Cellular: 9175306321
Concrete admixtures: Mr. Gilbert Cruz
Technical Service Engineer
Tel/fax: (2) 825-0709
Cellular: 0918-816-0635

**TAIWAN**
CHUAN JIH HSIN CO., LTD.
No. 8, Lane 451, Tzu-Chang South Road
Chang Hua, Taiwai
R.O.C.
Tel: (4) 7615521
Fax: (4) 7619241
Contact: Mr. Vincent Lin

ROYAL U-MAN INDUSTRIES CO., LTD
Coral Building, 4FL-3,
No. 129, Chang-Chun Road
Taipei, Taiwan
R.O.C.
Tel: (2) 25515688
Fax: (2) 25419227
Contact: Mr. Danner Tang
**Technical Service in Taiwan:**
Country Technical Service Manager:
Mr. Arno Wang Chih Hung
Cellular: 932-541760

**THAILAND**
BILMAT CO., LTD
1607, Soi Ladphrao 94 (Panjamitr)
Wangthonglang Bangkapi
Bangkok 10310
Tel: (2) 5303963
Fax: (2) 5303964
Contact: Mr. Trakarnchai J

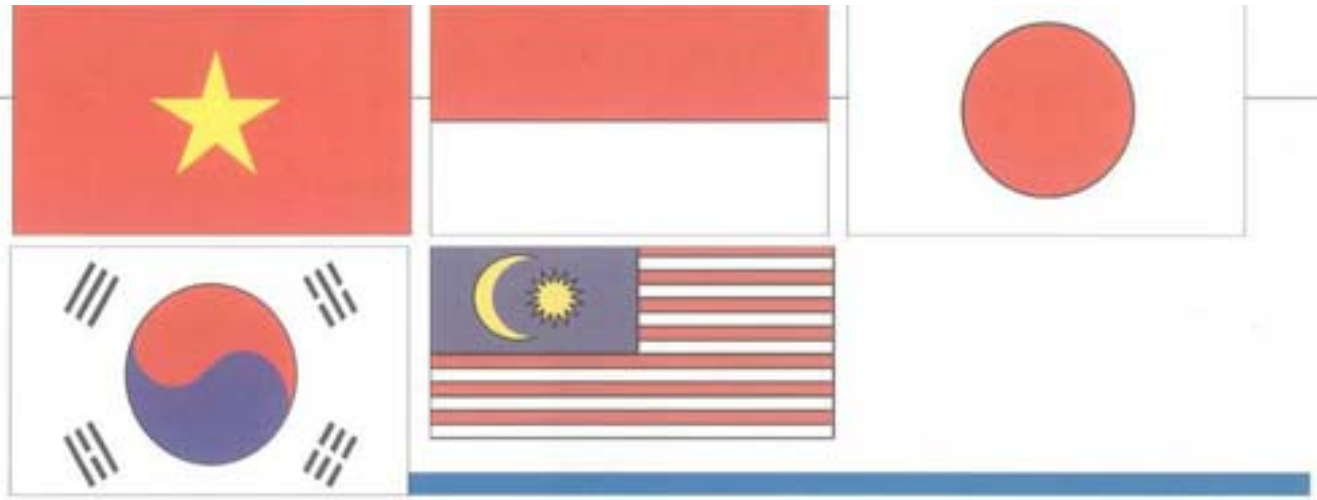


PHOTO 10


*Photo 10*
*The Mapei stand at the Sibex '98 exhibition, Singapore*

"I see this slowdown as something positive, in that we need to realign Mapei's strategy to reconsolidate our position and perhaps look at new and different strategies for the emerging markets."

"I think that the problems affecting the region can be overcome in the next couple of years, although the period of recovery will vary from country to country depending on their individual infrastructures." Among some of the things that Mapei will be looking at is stepping up its marketing strategy and broadening its distribution base as wide as possible. With China's potential for being the site of the next economic boom, the recent establishment of a network there is timely, as Mapei attempts to tap into otherwise unknown territory.

As the Tigers adjust to the changing economic landscape, Mapei, with its well-established reputation and position in Asia, is poised to take advantage of the vast opportunities that will surely open up in the near future.

**Singapore: Mapei's beachhead in Asia**

After establishing the Singapore office as its stable centre of operations in Asia, Mapei has since branched out with distribution points in Hong Kong, Taiwan, Indonesia, Thailand, the Philippines and Japan. Although the network is expanding quickly, Felix Quek believes that the company's next step will depend on where the economy seems to be developing most rapidly. This pragmatic foresight led Mapei to establish an operating branch in nearby Malaysia, which was undergoing a period of rapid development intended to bring the country into the next millennium.

"In 1994, the pace with which Malaysia

Gabriele Missaglia, left, winner of the 1998 Tour of Malaysia cycling race with fellow team member Giuliano Figueras in Kuala Lumpur


Species: Mapei Beetle
Habitat: Singapore

PHOTO 11

*Photo 11*
*Bishan Community Centre, Singapore*
*Photo 12*
*The Sun-Moon Light Exibition Complex in Taipei*
*Photo 13*
*An artist's impression of the Costa Rhu luxury condominium, Singapore*

PHOTO 12

was moving forward through its Multimedia Super-corridor convinced us that we needed a branch in Kuala Lumpur, the nation's capital," explained Felix Quek. "The remarkable growth of its construction industry represents an enormous potential for Mapei's high quality products." With that in mind, Mapei has since been involved in the Kuala Lumpur City Centre (KLCC) project that includes the Petronas Twin Towers, the tallest in the world, and the Suria KLCC shopping centre. And Mapei was not about to miss out on Malaysia's mammoth Kuala Lumpur International Airport (KLIA) project, supplying materials for its VIP Passenger Terminal Building as well as the adjoining Pan Pacific Hotel.

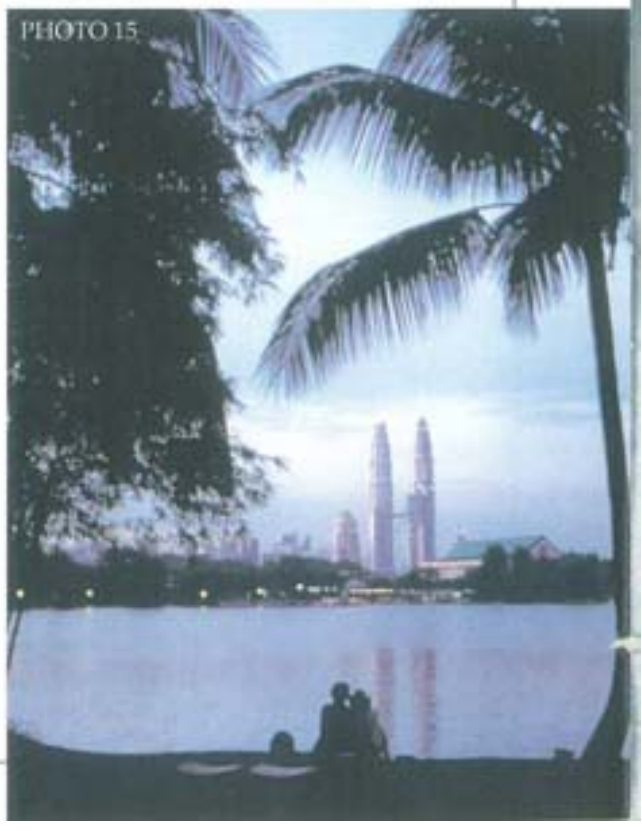
*Photo 14*
*The Northvale Condominium Project, Singapore*
*Photo 15*
*The Petronas Twin Towers, Kuala Lumpur (see following article)*

In the Philippine capital of Manila Mapei supplied the products used to install the external cladding of the Rockwell Center, a condominium project consisting of five residential towers. It is the first high rise in the

PHOTO 13

PHOTO 14

PHOTO 15



country to use exterior mosaic tiles, with a total surface of approximately 42,000 square metres, made possible with the use of Mapei's flexible adhesives. In another part of the city, Mapei took on the development of the Filinvest Festival Supermall, utilising the first floating bed in the Philippines for more than 39,000 square metres of tiles in the public spaces. ❑

# TOWERING ACHIEVEMENTS IN THE GOLDEN TRIANGLE

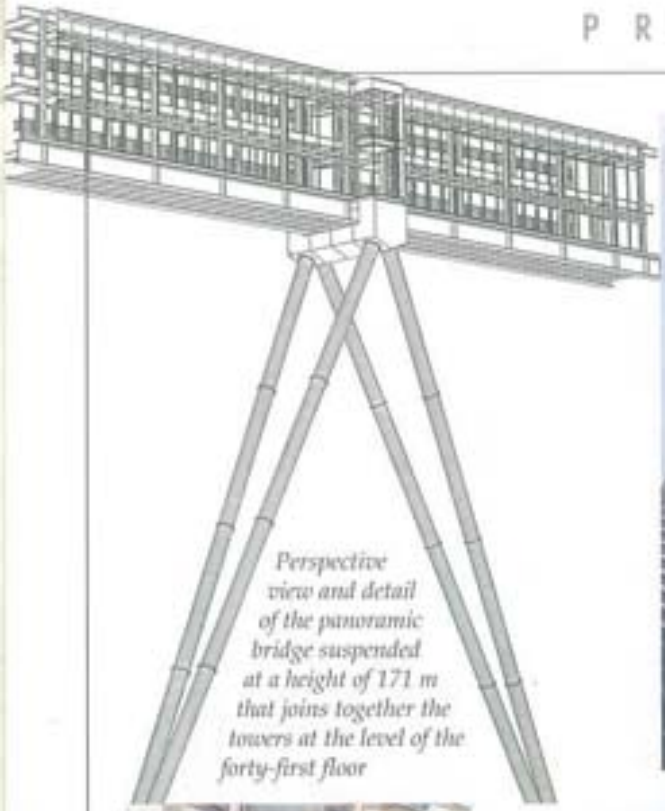
The Petronas Twin Towers and the Suria KLCC shopping centre are spectacular new landmarks in the Kuala Lumpur cityscape

*by Felix Quek*

The Kuala Lumpur City Centre (KLCC) project is Malaysia's most ambitious undertaking to date, a spectacular showcase for this progressive country of 25 million. The rest of the world will agree that Malaysia is moving in the right direction as it enters the new millennium: upward!
The 100-acre KLCC project is located in the Golden Triangle, the pulsating heart of the nation's capital, and its centrepiece is Malaysia's stairway to the skies, the Petronas Twin Towers: at 452 metres, the tallest in the world.
Visible from miles away, the shimmering spires have filled Malaysians with the sense of pride that New Yorkers feel for the Statue of Liberty, or Parisians for the Eiffel Tower.
The complex technical aspects of the project made it without a doubt Mapei's biggest challenge in Asia so far.

**The Petronas Twin Towers**

Mapei's innovative products were essential for the completion of the soaring towers, where the movement of the structure had to be carefully compensated for. Immediately on entering the building one finds Mapei products underfoot in the granite flooring of the lift lobby. Mapei's revolutionary materials were used to install granite in all of the 170 lift lobbies of the towers on a total surface area of more than 4,500 square metres. Due to the nature of the building, the screeds were fortified with PLANICRETE 50, a synthetic rubber latex for greater adhesion, strength and resistance to moisture.
If a conventional system had been used, the flooring would not have been able to withstand the movements in the steel structure. Needless to say, PLANICRETE 50 perfectly satisfied the requirements. The 400 x 400 x 15 mm-granite slabs were then set with KERAFLOOR Grey mixed with ISOLASTIC for added flexibility. The flooring was grouted with ULTRACOLOR for a high-quality colour-coordinated finish.
Mapei products can do wonders under almost any conditions, whatever the specifications of a given project, but it is the technical support Mapei provides that makes it the brand of choice. During construction Mapei technical staff



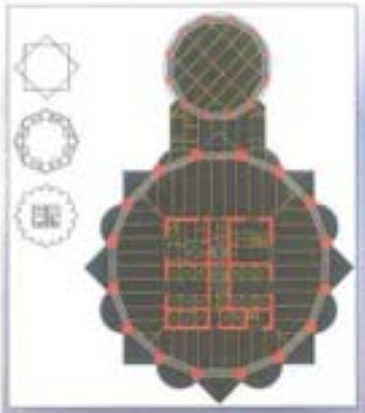
*Perspective view and detail of the panoramic bridge suspended at a height of 171 m that joins together the towers at the level of the forty-first floor*

*Below, drawing of the site plan and outline of the geometrical layout of the various tower levels inspired by the traditional design of Islamic arabesques; the square base represents the earth and the cardinal points and its overall intricacy mirrors the unfathomable nature of God*

provided efficient on-site consultation regarding the best methods of installation. This close cooperation with the client is what makes Mapei unrivalled in its field.

**Suria, the light of the sun**

The podium that anchors the Petronas Twin Towers houses the Suria KLCC shopping and entertainment complex, the like of which had never before been seen in Malaysia. The word Suria means "the light of the sun" in Bahasa Malaysia, and the Suria Centre is dazzling in its design, its size, and the quality of its tenants.
A focal point for fashion, leisure and entertainment, the Suria KLCC rises on six levels above four levels of underground parking, covering a total area of 140,000 square metres, with 94,000 square metres of retail space.
Suria KLCC features more than 250 specialty stores, including a large number of flagship stores as well as international and regional newcomers that add variety to the shopping scene. Other attractions include theme restaurants and two spacious food courts to cater to the tastes of cosmopolitan Kuala Lumpur, population currently 3 million and growing. For it to be truly awe-inspiring, the developers of the project knew that nothing could be left to chance and only the best would do. Mapei materials were selected to be used not only to install the flooring in the huge retail spaces but also for cladding the exterior of the Suria Centre. Mapei's winning combination of high-end products and technical know-how offered the sophisticated technical solutions that the Suria KLCC project called for.



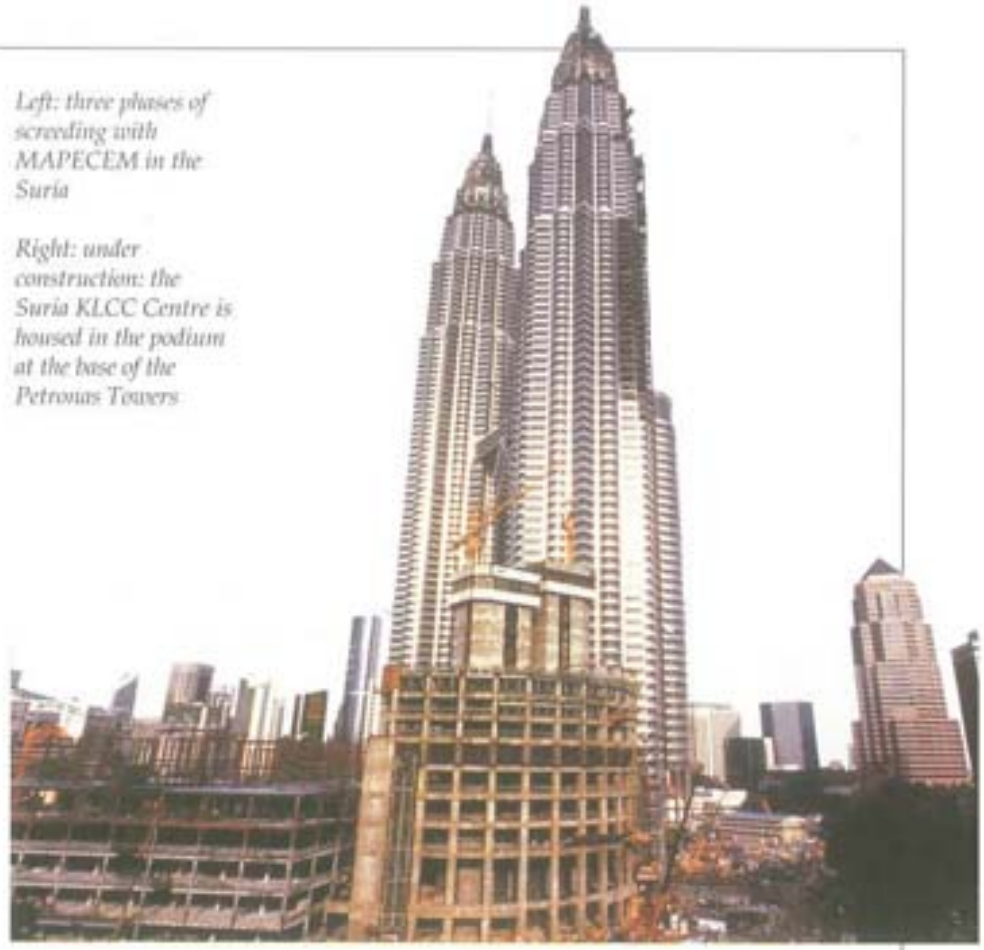


**Marble floors for the Suria KLCC Centre**

To allow for the movement inherent in steel-frame buildings, the floors were

*Left: three phases of screeding with MAPECEM in the Suria*

*Right: under construction: the Suria KLCC Centre is housed in the podium at the base of the Petronas Towers*



designed with floating screeds formed over the structural concrete floor slabs.
MAPECEM special fast-setting hydraulic binder was used for the screeds, over which 20,000 square metres of marble slabs were installed with KERAFLOOR and ISOLASTIC, a flexible adhesive which allows for the movements of the building. The marble flooring was grouted with ULTRACOLOR rapid-setting and hardening cement-based grout.
It was a challenging task to make sure that the screeds could withstand the stress and movement of the building without cracks forming on such a large surface. Movement and expansion joints were sealed with MAPEFLEX PU21, an abrasion-resistant sealant for floors subject to heavy traffic and high movement. Mapei products were also used in the public bathrooms in the Suria KLCC. MAPELASTIC, a two-component flexible cement mortar was used to waterproof the concrete, and PLANICRETE 50 was used to prepare the 4,500 sq. metres of screeds and renders. Homogeneous polished floor tiles were set with KERABOND and ISOLASTIC, which were also used to install homogeneous tiles on the walls. Grouting was done with KERACOLOR.

**Cladding the exterior**

The cladding of the Suria Centre has been Mapei's best work to date in Malaysia. The exterior wall tile installation not only had to withstand the building's movements, it also had to have sufficient adhesion and flexibility to absorb thermal shock. These requirements were met by using KERABOND and ISOLASTIC flexible adhesive to bond more than 10,000 square metres of external cladding composed of factory-applied glazed ceramic tiles on precast concrete panels.
With Mapei products to satisfy special construction requirements, the dream-like Petronas Twin Towers and the Suria KLCC project became a reality.

*Work in progress Right: cladding the exterior of the Suria KLCC Centre (with detail)*

*Left, the finished product: the Suria's cladding completed Above, the intricate roof design of the Suria KLCC Centre Below, the soaring atrium of the Suria KLCC Centre*

**An international effort**

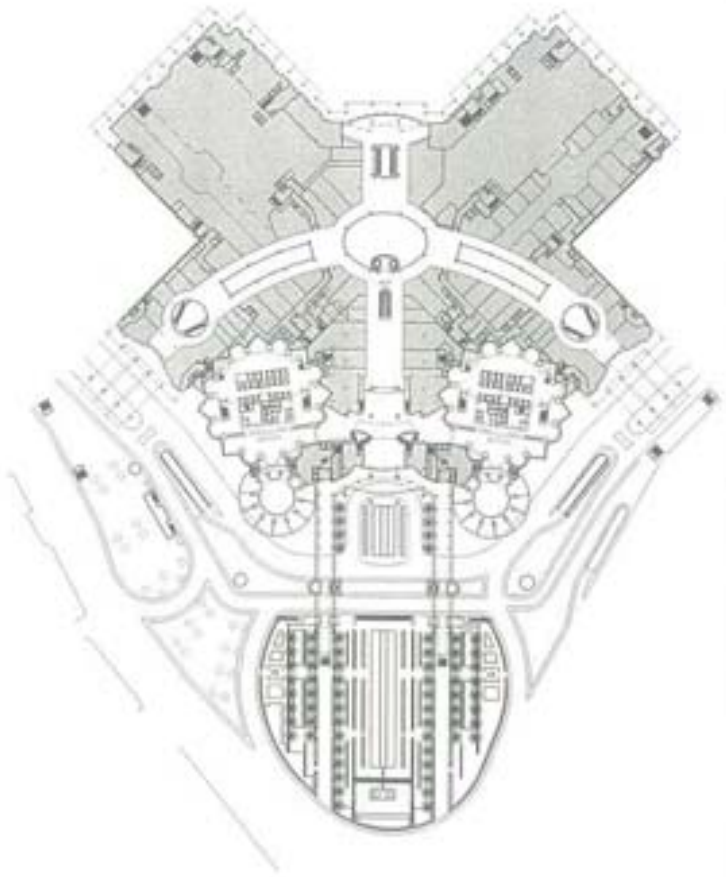
Built as the headquarters of Petronas, the Malaysian state oil company, the Petronas Towers project was from the first an international effort. The American architect Cesar Pelli won the international competition for its design and contractors from many countries worked on various phases of its construction. Mapei's involvement, too, was international, with the combined contributions of material and personnel from Mapei (Malaysia) SDN BHD, Mapei Far East Pte Ltd., Singapore, Mapei Canada Inc. and Mapei S.p.A., Italy. Mapei is proud to be a part of these landmark achievements that are deservedly Malaysia's new pride and joy.

*Riding high in the Petronas Towers: left to right, Adriana Spazzoli, Felix Quek, Giorgio Squinzi and David Ma, Country Manager for Mapei (Malaysia Sdn Bhd)*

*Felix Quek, left, with Louis Couillard of Mapei Inc. (Canada)*

*Left to right: Vittorio Riunno, Guido Trussardi and Luciano Trussardi from Mapei SpA (Italy)*

**CREDITS PROJECT:**
Cesar Pelli & Associates
**Associate Architect:**
Adamson Associates
**Architects of Record:**
KLCC Berhad
Architectural Division
**Structural Consultants:**
Thornton-Tomasetti
Engineers, Ranhill
Bersekutu Sdn. Bhd
**MEP Consultants:**
Flack+Kurtz, KTA Tenaga
Sdn. Bhd.
**Project Management Consultant:**
Lehrer McGovern
Malaysia
**Tenant Interior Consultant:**
Studios
**Landscape Design:**
Balmori Associates
**Curtain Wall Consultant:**
Israel Berger &
Associates
**Lighting Consultant:**
Howard Brandston &
Partners
**Vertical Transportation Consultant:**
Katz Drago Company
**Exterior Maintenance Consultant:**
Lerch Bates & Associates
**Security Consultant:**
Techcord Consulting
Group
**Life Safety Consultant:**
Rolf Jensen & Associates
**Acoustic and Telecommunication:**
Shen, Milsom & Wilke
**Wind Tunnel Testing:**
Rowan Williams Davies
and Irwin
**General Contractors:**
MMC Engineering &
Construction, HO Hup
Construction, Hazama
Corporation/JA Jones
Construction, Mitsubishi
Corporation, Samsung
Engineering &
Construction, Kukdong
Engineering &
Construction, Syarikat
Jasatera
**Client:**
Kuala Lumpur City Centre
(Holdings) Sendirian
Berhad



## TECHNICAL DATA

**Project:** KLCC Petronas Twin Towers

**Year of installation:** 1997-1998

**Materials used:** granite

**Products used:** Screeds prepared with PLANICRETE 50
Granite set with KERAFLOOR+ISOLASTIC and grouted with ULTRACOLOR

**KLCC Suria Centre**
**Materials used:** Marble, homogeneous floor and wall tiles

**Products used:** Retail spaces: screeds prepared with MAPECEM
Marble set with KERAFLOOR + ISOLASTIC and grouted with ULTRACOLOR
Expansion and movement joints sealed with MAPEFLEX PU21
Bathrooms: screeds prepared with PLANICRETE 50
Waterproofing of concrete: MAPELASTIC
Floor and wall tiles set with KERABOND + ISOLASTIC and grouted with KERACOLOR

*The products mentioned are manufactured by Mapei Far East Pte Ltd., Singapore, and Mapei S.p.A., Italy.*

# ADESILEX P4: THE MULTI-PURPOSE ADHESIVE

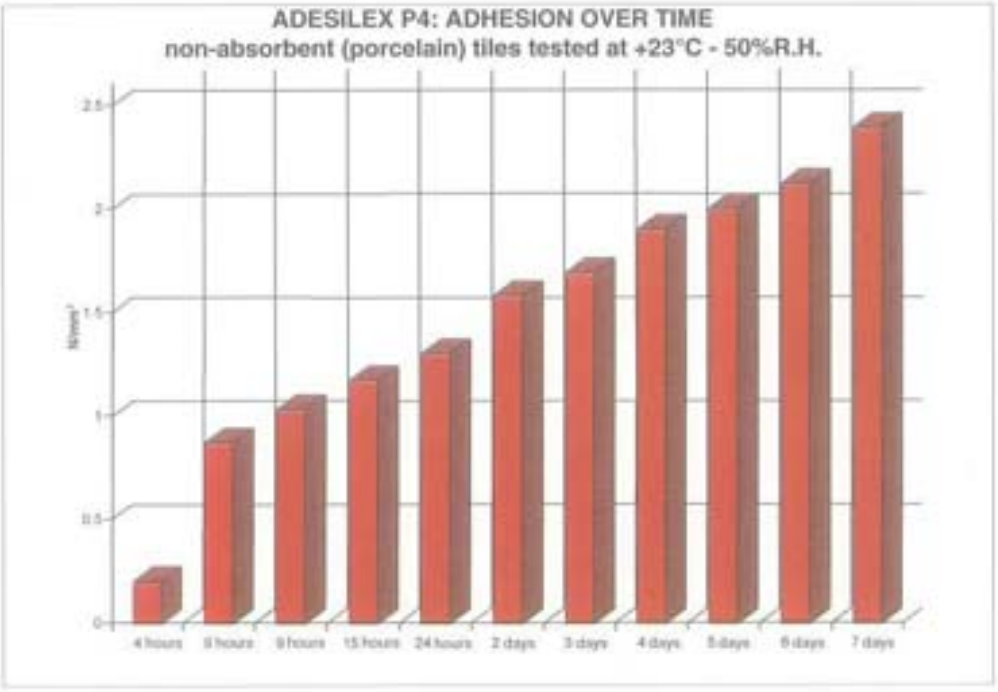
It's installer-friendly, easily spreadable and guarantees 100% self back-buttering of ceramic tiles.

Installing ceramic tile floors in exteriors and in industrial or high-traffic areas requires very careful setting. Voids can form if the adhesive does not completely cover the tile backs, and tiles can crack under heavy loads or loosen in exterior installations if ice forms in these voids. Given the trend toward the production of larger and larger tiles, the tile setter has to use special setting techniques to ensure total transfer of the adhesive. Until recently the setting technique recommended for tiles larger than 30x30 cm. (12x12 inches) was back-buttering, spreading the adhesive both on the back of the tile and on the substrate, setting the tile and then pressing it firmly into place. Obviously this practice is time-consuming and consequently lowers productivity and raises costs. Even when this method is carefully employed, it is practically impossible to tell if the application is performed correctly without removing a tile specimen. The Mapei laboratories, always in the vanguard of research for products that make setting simpler yet ensure total bonding at the same time, have developed a new product, ADESILEX P4.

Let's start with the name, which is synonymous with reliability: ADESILEX harks back to Mapei's first cementitious adhesive for ceramic tiles, i.e. the legendary, inimitable and eternal ADESILEX P9.

The "P4" stands for the product's being formulated specifically for flooring with a high resistance to impact (P4 is the highest UPEC classification).

ADESILEX P4 is a grey powder to be mixed with water in a ratio of 20÷22 % for a mix that becomes much more fluid with just the motion of the trowel. It requires minimum effort on the user's part and at the same time maintains adhesive beds without undulations. To take advantage of ADESILEX P4's special properties and obtain optimum results, selecting the right trowel is very important. The size of the trowel should be chosen according to the size of the tile, remembering that the adhesive can be applied up to




*Source: Mapei R&D Laboratories*

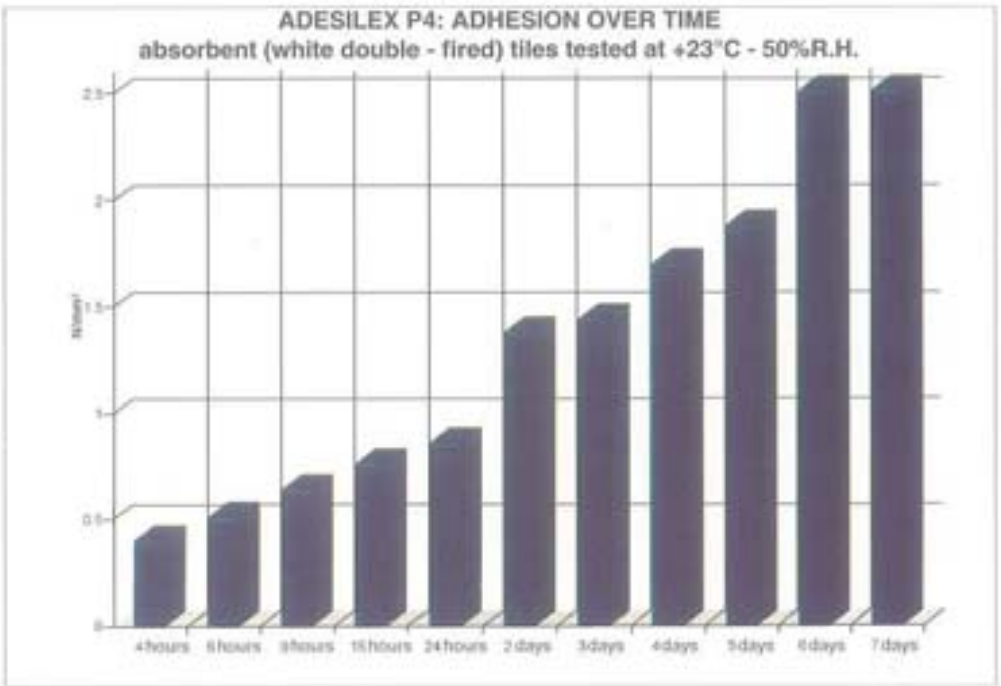

2 cm thick. ADESILEX P4 can be trowelled on without undulations, but when the tile is laid it becomes a semi-fluid paste which self-levels with a light hand adjustment, filling the grooves left by the trowel and ensuring compete transfer of the adhesive to the back of the tile. This allows the flooring to settle perfectly and the distribution of load is even because the adhesive is working on all points of the surface. To illustrate the importance of the distribution of the forces which the tile transmits to the adhesive, let's take for example a 10x10 cm tile (approx. 4x4 inches) set with an adhesive that has a "pull strength" of 10 kg/cm². If the tile is completely covered by the adhesive it will take 1000 kg to cause debonding, but if the tile is only 50% covered the force necessary to loosen it is reduced to only 500 Kg. To have the same guarantee of bonding you would have to use an adhesive with a pull strength of 20 kg/cm². An adhesive than can ensure total coverage of the substrate underneath even a large size tile gives a much greater margin of safety that a normal adhesive with the same mechanical strength.

ADESILEX P4 is also fast-setting: it cures rapidly without significant shrinkage, allowing the installation to be ready for traffic in a very short time. ADESILEX P4 bonds perfectly to all materials generally used in construction and because of its high resin content is able to absorb deformation of the substrate and extremes of temperature.

ADESILEX P4 can also be used as a levelling compound for all substrates used in construction, such as concrete slabs, cement screeds, and existing ceramic tile, terrazzo and natural stone floors.

In addition, brick and concrete block walls can be built in half the usual time when ADESILEX P4 is used as a mortar. Simply dip the bottom of the brick or cement block into the ADESILEX P4 mix, set it into place, and PRESTO! You've found yet one more way to use ADESILEX P4, the multi-purpose adhesive!

The Mapei products mentioned are part of Mapei's European product lines.




*The two graphs show that ADESILEX P4 quickly develops bonding strength with all types of tiles, vitreous and non vitreous*

*The technical data sheet for ADESILEX P4 is contained in Mapei Binder N. 1, "Ceramic Tile Line."*

*Source: Mapei R&D Laboratories*

# FOR A SCREED THAT'S THE TOP

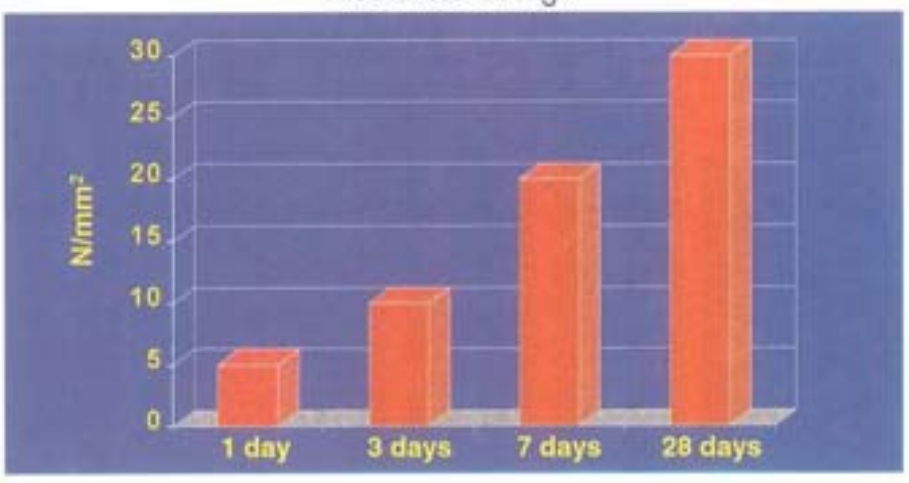
Screeds made with TOPCEM are easy to install, lower costs and, most importantly, cure completely in only 7 days.

*by Francesco Stronati*

Making screeds that are ready to receive any type of flooring within an extremely short time ceased to be a problem years ago. In 1987 the Mapei laboratories formulated MAPECEM, the special hydraulic binder for screeds that are ready for the installation of ceramic tile floors after only 4 to 5 hours of cure time, and only 24 hours for flooring sensitive to moisture (natural stone, parquet, PVC, etc.). MAPECEM, which is now distributed all over the world, made installations possible in many large projects such as airports, train stations, swimming pools, subway stations, etc. Generally on construction sites deadlines are fairly long, but still not long enough for a tile-setter to wait the minimum cure time necessary for normal cement screeds: 28 days in good weather conditions. Installation of ceramic tiles often takes place only a few days after screeding and cracks may appear in the floor due to inevitable hygrometric shrinkage of the mortar. There is a demand for a binder that can produce mortar for screeds that is easy to apply and has a long open time, yet allows materials to be installed within a few days.
To meet this need the Mapei research laboratories have recently formulated TOPCEM, a special hydraulic binder with normal setting and quick drying for forming screeds that are ready to receive ceramic tile installations in 24 hours, natural stone in 3 days, and wood, PVC, linoleum or rubber after 7 days. TOPCEM is a special hydraulic binder which enables mortar to be obtained with a low water-binder ratio. In its plastic state the mortar has these characteristics:

*TOPCEM mix being applied with a pump*

- Long open time of the mix (50 to 60 minutes). This is extremely advantageous because it makes for easy screeding and avoids the formation of the cracks which normally occur between the leveling strips and the screed, if the screed is poured after they have already hardened.
- Easy screeding. TOPCEM has the same consistency as mortar used for traditional ceramic tile installations well known to tile-setters. The mix is easily applied even with a pump and can be compacted easily, reducing tamping with a wooden float to a minimum.
- Floating of the surface can be done with a finishing machine or disk.




*Mechanical strength of a TOPCEM screed with various cure times, measured on mortar samples 4x4x16 cm and cured at an ambient temperature of +20°C and 95% R.H.*

*Source: Mapei R&D Laboratories*

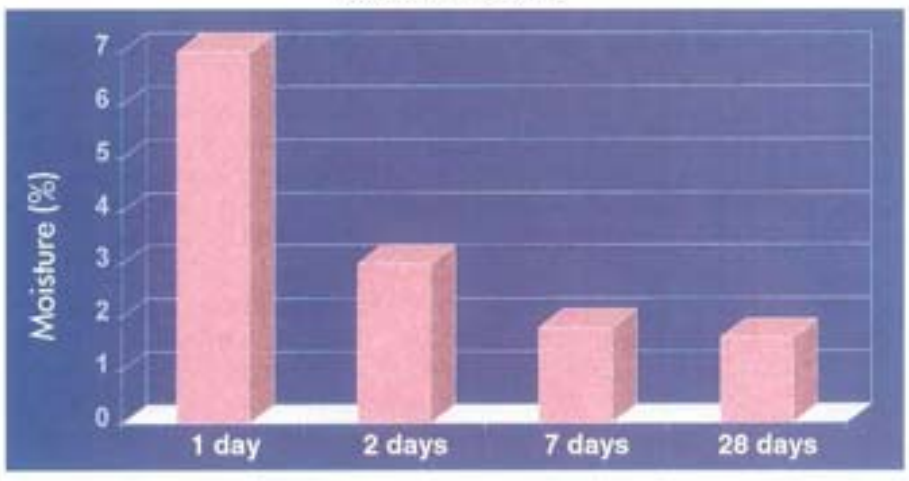
When hardened TOPCEM screeds have the following characteristics:
• Significantly reduced hygrometric shrinkage which occurs with 24 hours of screeding;
• High mechanical strength (30 MPa after 28 days at +23°C and 50% R.H.), ideal for flooring installations subject to heavy traffic;
• After 7 days, a residual moisture content less than 2%, ready to receive any type of moisture-sensitive flooring.

**Directions for use**

TOPCEM is substituted for cement in screeds. It must be used in a dosage of 200 ÷ 250 kg. for every cubic meter of graded aggregate from 0 to 8 mm. in diameter. After dry mixing thoroughly, enough water should be added to obtain a mix with a "damp earth" consistency that with a float finish will produce a smooth, compact surface without bleeding. For screeds more than 4 cm. thick a polyethylene insulating sheet must be laid to create an isolation layer between the screed and the underlying substrate. Around the perimeter of the area and around columns an expansion joint about 1 cm wide should be formed with polyethylene sheeting between the wall and the screed. Special care must be taken in placing the polyethylene sheets which, besides allowing the free movement of the screed on the slab underneath, create a vapor barrier against damp rising from the substrate and allow the screed to dry within the prescribed length of time. The vapor barrier is indispensable even when screeds are formed over existing substrates that are completely cured because it prevents them from absorbing water from the mix of the TOPCEM screed. The absorbed water would subsequently rise and retard curing. For forming screeds less than 4 cm thick this solution is not possible. The screed must be bonded to the underlying substrate, which must have sufficient mechanical strength and be thoroughly clean. To ensure bonding, an anchoring slurry must be applied, mixing water with TOPCEM and PLANICRETE 1:1:3 by weight. The TOPCEM screed should be applied when the anchoring slurry is still fresh. The surface can be floated with a finishing machine. ❑


*Detail of TOPCEM screed with reinforcing*

*The TOPCEM technical data sheet is contained in Mapei Binder n. 3 "Building Specialty Line"*




*Source: Mapei R&D Laboratories*

*The graph illustrates the residual moisture of a TOPCEM screed as measured with a carbide hygrometer. After only 7 days the TOPCEM screed has a moisture content of less than 2%, which enables any type of flooring to be installed rapidly.*

The Mapei products mentioned are part of Mapei's European product lines.

# SURFACE PREPARATION: THE KEY TO A SUCCESSFUL INSTALLATION

*by John Kehoe**

Successful installations of ceramic tile, stone, hardwood, vinyl or resilient tiles all have one thing in common. They all meet the expectations of the customer. The customer expects that floor to be solidly bonded. It should not deflect, crack or degrade. It should not change with respect to the original acceptable appearance over time and it should be installed in a minimum amount of time. In short, what a customer is looking for is value. They want a one-time inconvenience followed by a problem free life of that floor. They want the surface to be slip free. They want straight grout lines and each tile should be no higher than another should. They want quality workmanship.

Clear communication is the best way to avoid the things that may prevent meeting the customer's expectations. The definition of those expectations should be apparent before the work is begun, but sometimes the work is completed long before any dissatisfaction is evident. The level of dissatisfation may require verbal instruction on care and maintenance. It can also require a costly removal of the new floor and installation of another. If the dissatisfation is caused by a lack of proper surface preparation, the latter option is usually favored by the customer and disdained by installers while lawyers on all sides prepare for battle. To dispense with the surface preparation is to invite trouble. Each installation requires that some consideration be given to the existing floor before the installation is started. Whether they are paying for a small kitchen remodeling or accepting bids on a large commercial project, most consumers are concerned about the appearance of the floor *after* the installation is completed. All they know when they decide to renovate is that the existing floor is undesirable. The existing floor may be out of style or it may be failed because it is cracked, loose, faded, dirty or stained.

**What are some of the possible problems that can prevent you from meeting the customers expectations?**

**Concrete leveling, flatness**

Larger porcelain tiles and dimensional stone are becoming the mainstay in installations today. There appears to be no end in sight to the preference for these larger units. When narrow grout lines are ordered for these installations, the flatness of the concrete becomes an important issue. Flat concrete is important to the installer trying to maintain a tight grout line, which is also a more desirable look.

A tolerance of 1/8 inch (3 mm) in 10 feet (3 m) is considered adequate concrete flatness to maintain tight grout lines. This 1/8 inch (3 mm) is often incorporated into specifications for the concrete work in new installations, but this level of flatness is not often found when the flooring installation is ready to start.

When concrete needs to be leveled, there will be some added height to the existing floor. If a mud bed is the method chosen to level the floor, an added height of at least 1 1/4 inches (32 mm) will be needed. This sometimes creates transition difficulties that would be preferably avoided. Thin leveling compounds like self-leveling underlayments can level concrete floors with as little as 1/8 inch (3 mm) added height. The self-leveling underlayment is a fluid consistency that can be used to fill the low levels of a floor before adding height to the high areas.

Generally, these products are fast setting; they can be walked on in less than three hours. They have high strength, usually about twice the compressive strength of the concrete to which they are bonded. In addition, self-leveling underlayments have low shrinkage, allowing the installation of hard flooring products like stone and tile without the usual 28-day cure time for typical concrete.

*Right: hospital, Bolzano, Italy. leveling with ULTRAPLAN MAXI self-leveling compound before installing pvc flooring*
*Opposite page: San Carlo hospital, Milan. Sealing cracks with EPORIP before installing pvc flooring*

**Cracks**
Almost any section of concrete inevitably has existing cracks, or it will form them over time. The stresses created by cracks in concrete build up in rigid materials like grout, stone and mortar. When the stresses become greater than the strength of the grout, stone and mortar, cracks form in these materials.
Often the grout becomes cracked. The tile cracks and in a smaller number of cases, tiles become a tripping hazard from raising or becoming loose. The treatment for cracked concrete where stone and tile are to be installed is to use a crack isolation membrane or use method F111 from the (TCA) Tile Council of America Handbook.
The F111 method will add at least 1 1/4 (32 mm) inches to the existing concrete, but will isolate the new installation from the existing concrete with a cleavage membrane that is placed under the wire-reinforced mud bed. Crack Isolation membranes or (CIM) do not significantly add to the height of the installation. They are usually flexible, high strength bonded materials, applied directly over cracked concrete before the mortar is applied. They work by absorbing the stress caused by the movement of formation of cracks in concrete.

**Moisture**
Water causes some stone to darken and grouts to discolor.
For practical purposes, water cannot be completely removed from an installation. There is always some water in concrete, plywood and other building materials. Water becomes a danger to your installation when certain limits are exceeded.
Water that permeated up through concrete can cause failures in a membrane that is intended to stop water from penetrating down. Stone and tile installations often include a waterproofing membrane to stop water from penetrating through to the lower levels of a building. Stopping water from penetrating to the lower levels is the function of the membrane products. The membrane has the support of the concrete when the force of the water comes from the tile surface to the membrane. When water is forced up through the concrete, there is only the weight of the tile, mortar and grout to support the membrane. The possibility of a problem is likely when the amount of water that passes through the concrete exceeds three pounds (1 kg) per 1000 square feet (93 sq. m) per day. This level of moisture is found more often in below grade situations like basements, but on grade concrete can also have this level of moisture. The only way to be sure of the moisture content is to check it.
Test kits are available from several sources to make accurate determinations of the moisture in concrete. The most accepted method is the calcium chloride test, where results of the tests can be obtained in three to five days.

**Conclusion**
The appearance of any installation is the first and most important factor that a customer notices.
The appearance is also a major reason for choosing a high quality material like stone and ceramic tile.
These durable and beautiful materials are expected to maintain that appearance from installation until replacement.
The replacemement should be many years after the installation for these materials. Any component of the installation that reduces the chances of obtaining the expected appearance should be reconsidered. Knowing the products and practicing the methods to confront the surface preparation issues that are present on nearly all installations will make certain that the customer's expectations are met.

Our thanks to Stone World Magazine for allowing us to reprint this article from their Oct. 1997 issue.

The Mapei products mentioned in the captions are part of Mapei's European product lines.

**John Kehoe (Ceramic Product Manager of Mapei Corp) passed away October 23, 1998 from complications due to Leukemia. John was with Mapei for six years at the West Chicago location before transferring to Garland. He will be deeply missed.*
*(To contribute to the scholarship fund for John's Children, please send contributions to: Jane Kehoe's Children Scholarship Fund, Payable to: Jane Kehoe, C/O American National Bank, 900 75th St., Willowbrook, IL 60521, Attn: Cheryl Jagen, Acct #: 5350031880)*

# PROPER SUBFLOOR PREPARATION CAN PREVENT PROFIT DRAIN

*by Steve Chase**

One of the major preventable profit drains in the floor covering industry, the need for reinstallation following a flawed application, has led to intense focus on the development of proper subfloor preparation techniques and products.

Many floor covering and accessory product manufacturers, as well as others associated with the floor covering industry, have noted that the majority of floor covering problems are installation related.

These errors fall into two categories: Errors made during the preparation work or during the actual application of the product such as:

- Installation over a dirty floor
- Installation over a highly alkaline floor
- Installation over existing cut back adhesive
- Installation over an uneven floor
- Installation directly over incompatible substrates
- Installation over a very porous floor covering causing the adhesive to set up too quickly.

Even floors that have been properly abated ( asbestos removal) may not be properly prepped for the installation of today's floor coverings.

Claims resulting from these problems are very costly to manufacturers, contractors and dealers. No one makes money on a reinstallation. The bottom line is that these claims cut into the profitability of the industry.

The National Association of Home Builders (NAHB) is predicting a 7% growth in remodeling through the year 2000, so the task of dealing with existing substrates and subfloors takes on an added significance.

For this reason, manufacturers must find new solutions to old problems, problems that will increase as more new floors are installed over existing floors.These innovations will need to provide newer and easier ways to do the job correctly and be both cost effective and less labor intensive. There are several efforts under way to address this challenge.

*Applying PRIMER G to improve adhesion before leveling with PLANO 3*

National and regional associations, such as the Floor Covering Installation Contractors Association (FCICA) and the Certified Floor Covering Institute (CFI), are addressing the need for improved installation training and communications to the installation community.

Manufacturers are also addressing problems associated with subfloor preparation by developing products and systems which make it more cost effective and, more importantly, easier to do the job correctly the first time.

Floor covering manufacturers have provided some good recommendations to properly prepare floors, but these recommendations can be labor intensive and costly - it's not always easy to do things correctly. As a result, short cuts are sometimes taken. This is where many problems may occur.

In the recent past, manufacturers and installers have had a difference of opinion in the best materials to use. An increasing number of resilient manufacturers have been recommending portland cement-

*Applying PLANO 3 self-leveling smoothing compound with a pump*

*Portello convention center, Milan, Italy. TOPCEM screed*

based underlayment powder for patching and leveling because of their excellent mold and mildew resistence. But some installers continue to prefer the gypsum-based patching compounds due to their excellent quick setting properties, good sandability and feather edging properties. Therefore, accessory manufacturers have to provide products which meet both needs. For example, already there are fast set portland cement-based patching compounds that meet the needs of both the manufacturers and the installers. These new products cure chemically rather than by the slow evaporation of water into the atmosphere or into the subfloor. Another promising product now entering the marketplace is a cementitious primer that can be used directly over existing glazed ceramic tile to prepare the floor for a new floor covering such as carpeting or ceramic tile. In the past, the glazed surfaces needed to be abraded, then primed and then floated with a latex underlayment system prior to installation of new floor covering. These new products eliminate the need to abrade the existing floor, thus eliminating a labor intensive step in the preparation process and a potential dust hazard. Even though the environmental issue will still be the major challenge affecting the floor covering industry, the need for better subfloor preparation, techniques and products will be an important step in reducing application related complaints and increase the profitability of an industry on the brink of a 7% growth period.

Our thanks to Dimensional Stone Magazine for allowing us to reprint this article from their Nov. 1997 issue.

The Mapei products mentioned in the captions are part of Mapei's European product lines.

**Steve Chase is vice-president of the Floor Covering Adhesives Division Sales for Mapei Corp. (USA)*

# SWAMY SAYS...

*by Mario Collepardi* *

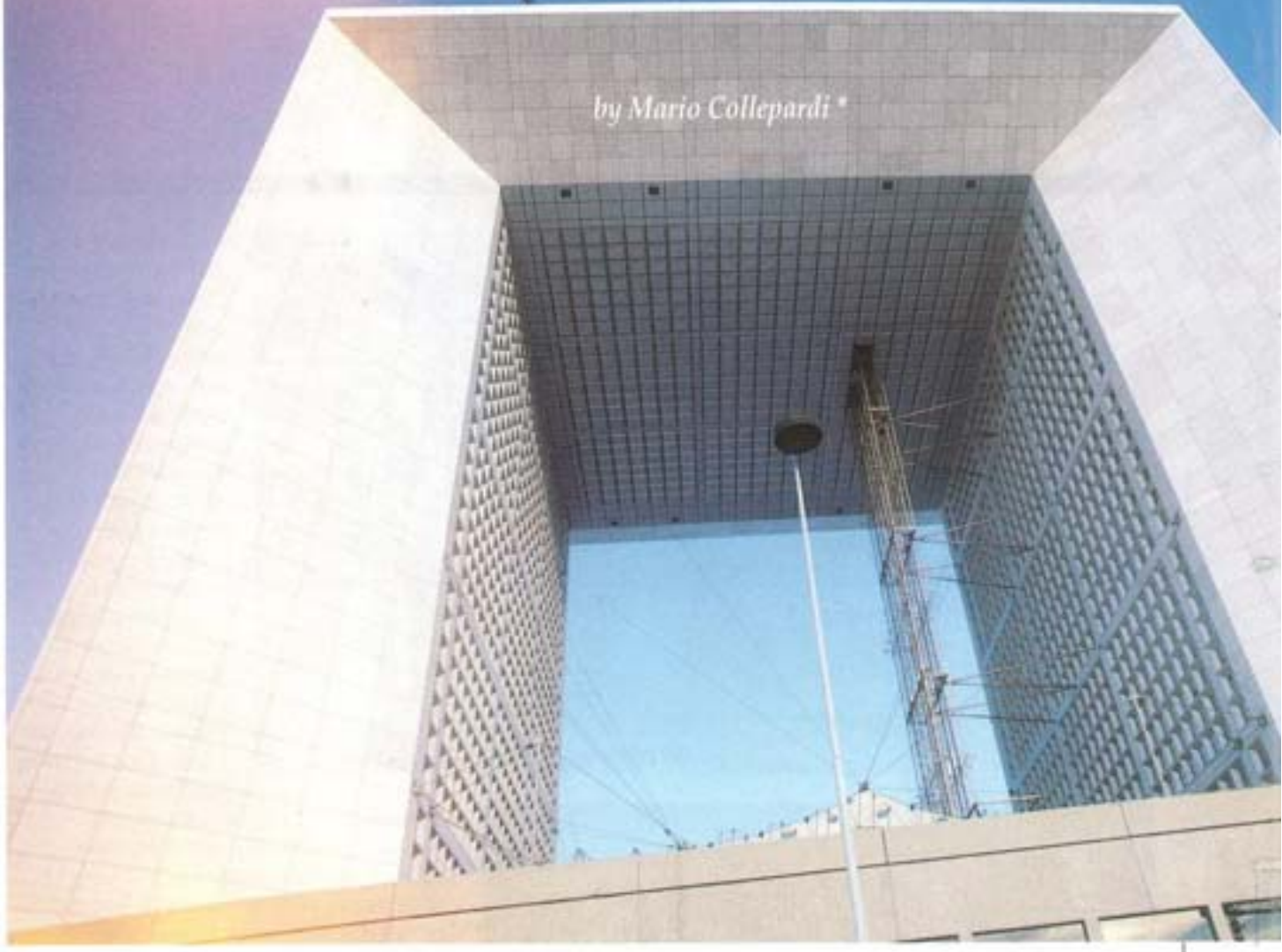


Photo Gianni Dal Maigro

Swamy [1] maintains that even though a material more or less similar to the one we today call concrete has been used for thousands of years, "real" concrete came into use only a hundred and fifty years ago with the advent of cement.
In the meanwhile concrete has become the most widely used construction material in architecture and civil engineering. However, says Swamy, it is only in the last twenty to thirty years that important progress has been made in the study of the microstructure of concrete and the radical changes in its properties when used in various applications.
This writer is in complete agreement with that opinion and believes that, with exceptions, we still continue to specify the "old" concrete without taking advantage of the extraordinary opportunities offered in the meantime through scientific and technological progress in the field.
Among these exceptions it is worth mentioning Pierre Richard. When designing the Grande Arche in Paris [2, 3], Richard took advantage of "new" high performance concrete ($R_{ck}$=70MPa) and was not above adding his own contribution to the progress of concrete science, using Reactive Powder Concretes (RPC), bringing them to performance levels unimaginably high for conventional concrete, with a mechanical and compressive strength of almost 800 MPa (N.B. that's 800, not 80!) and with a ductility that brings its fracture energy to approximately 40000J/m$^2$ [4]. Incidentally, it is noteworthy that in the case of RPC we have gone from the scientific discovery of this material to its practical application in just a few years, as predicted by Bouygues for a bridge in Canada, or for the rebuilding of the ancient lighthouse of Alexandria, the seventh wonder of the world.
In light of this spectacular progress, we

*La Grande Arche, Paris, France,*

must ask ourselves whether to persist in calling such a material "concrete" is to indulge in English understatement or to exhibit serious ignorance. On the other hand, between "fragile" ordinary concrete ($R_{ck}$ 20-30 MPa and fracture energy of barely 120 J/m$^2$ ) and the high point of the above mentioned RPC, a whole range of new materials exists, all of them cement-based, for which new terms continue to be coined in the international literature: suggestive acronyms like HSC, HPC, CCB, DSP, MDF, and SIFCON; etc. that demonstrate the extraordinarily innovative performance of the new materials as compared to conventional "concrete".

And what is the situation like in Italy? With the usual rare exceptions, the situation is disappointing, to say the least, if one stops to think that for most concrete manufacturers, ordinary concrete with $R_{ck}$ of 20-30 MPa still represents a fraction of the market compared to the much higher demand for concrete sold by cement content. It is worth noting that according to Law No.1086/71, ordinary concrete is the only kind permitted in reinforced concrete and prestressed concrete structures, and it would surely be hard to find an architect who doesn't specify the quality of the concrete required for a project. So why do manufacturers of ready-mixed concrete receive such a low number of orders from contractors for ordinary concrete, as opposed to the high number of orders filled for cheap cement-factor concrete, especially when the latter is illegal when used for reinforced concrete and prestressed concrete? At first hearing, the answer to this innocent question may be the word "cheap", if it's true what some people claim, that a product's biggest appeal is price. Actually the situation is more complicated and is a question of accountability, as is well known to almost everyone in this business. Moreover, it must be emphasized that concrete sold by cement-content costs a contractor less for the simple reason that it does NOT offer the same guarantees or performance as higher performance concrete. In fact, if the two materials were equivalent in terms of performance, it would be a wonder if they DIDN'T cost the same. Compliance with performance specifications can be verified by testing samples and obliging the concrete supplier to fulfill his commitment .

On the other hand, specifying by cement factor rather than by performance sometimes presents insurmountable difficulties. It can lead to specifications being ignored, because it favors unfair competition from suppliers who skimp on cement content and offer a low quality, low priced product that appears to be more competitive.

But this aspect aside, how should the cement factor be calculated when a performance specification exists? If it were that easy to find a direct correlation between cement content and performance characteristics, the problem would not even present itself, and the law would allow the use of either type of concrete indifferently. But the mechanical performance of concrete depends also on the water for the mix, in addition to the type of cement, the distribution, size, and stone quality of the aggregate, the use of admixtures, etc. But there would be no reason for this situation to exist if the tests that are mandatory by law were actually carried out, i.e. taking samples during actual casting and checking them against the $R_{ck}$ specified by the architect. I'm not revealing any secrets when I tell you that counterfeit samples are often submitted as substitutes. There is a flourishing market for these fakes that are made up according to the number and performance level required. And it's no scoop to divulge that in some cases, in order to avoid even bothering to make or buy the fakes, certificates have been issued for $R_{ck}$ tests that were never

carried out, on samples never submitted. And what is the role of the client in this situation? Strangely enough, our government specifies and insists on the use of quality concrete for public works. Any manufacturer of ready-mixed concrete can testify, in fact, that the number of orders for quality concrete increases in direct proportion to the amount of government-commissioned construction underway in a given area. Semi-public corporations such as the Italian State Railways, Enel (the Electric Company) and the Società Autostrade (Highway Authority) and certain local administrations would have found it hard to skimp on the quality of concrete and thus risk the stability of a bridge or the safety of a dam. On some occasions the concrete specifications of these public corporations, although perhaps not always easy to interpret, were ahead of present regulations regarding durability of works in reinforced concrete and prestressed concrete, and insisted on the use of innovative criteria or materials, such as silica fume, fiber-reinforced concrete, sulfate-resistant cement, and superplasticisers to improve performance of structures and reduce maintenance costs.

To return to Swamy's thesis in closing, unfortunately I cannot help but mention that much of the responsibility for the present situation concerning specifying, testing and placing of concrete lies with the teaching faculties of the universities: teaching concrete to students of architecture, construction and civil engineering, where it is offered, is still often based on the old notions of the chemistry of cement alone, rather than on the modern principles of the Science of Materials that is centered on the correlation between the microstructure of matter on the one hand, and the engineering macro-properties of construction materials on the other. Only through this modern approach to the study of materials is it possible to impart knowledge that is formative rather than merely superficial, which allows the future architect or engineer to custom design case by case for the properties a structure requires, whether this is based on a conventional concrete or on an innovative cementitious material that is more ductile, more dimensionally stable, and more resistant to dynamic stresses or aggressive environmental stresses. ❑

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*We are grateful to "The Italian Cement Industry" review for allowing us to quote from its issue n. 699 of May 1995, p. 315-317.*

**Mario Collepardi is Professor of the Science and Technology of Materials (Faculty of Engineering) at the University of Ancona (Italy).*

# ELECTROSTATIC CHARGES IN FLOORING

*by Adelmo Bovio **

Wherever flammable or combustible materials are handled, electronic components are manufactured, or where electronic equipment is in use, the presence of electrostatic charges can be dangerous. In physics labs, munitions depots, operating rooms, battery-recharging stations and even places where integrated circuits or calculators are being used, many precautions must be taken to prevent sparks being set off by electrical devices (doorbells, light-switches, electric motors). One of these precautions involves the installation of flooring to eliminate electrostatic charges that can be generated in the surroundings.

*At right, installing conductive linoleum with two-part adhesive over grid of copper wire*

*Below, instrument for measuring insulation used to check conductivity in flooring*

*At right, hospital in Pavia, Italy. Adesilex V4 conductive was used to install pvc flooring*

**The causes of electrostatic charges**

Poor conductors (for example bakelite, glass, wool, synthetic fibers, etc.) are apt to accumulate electrostatic charges when subjected to friction or contact with other bodies. Electrostatic charges are caused by the transfer of oppositely charged electrons from one body to another whenever they make contact. Even the human body is apt to accumulate electrostatic charges produced by clothing when insulated from ground (by rubber soled shoes, etc.). The accumulation of electrostatic charges can reach a potential of several thousand volts, so that when two bodies having opposite electrical charges come near each other or near a grounded object, this generates a short circuit, causing a spark. Fortunately these charges, which are in direct current (DC), are of very low intensity, on the order of thousandths of an ampere (mA) and thus not dangerous. When the potential difference is great enough (around 2500 volts) the discharge causes a shock which can be felt: 2,500 volts marks the threshold of human sensitivity. To state it another way, the phenomenon of electrostatic discharges is similar to that of lightning bolts generated by the approach of oppositely charged thunder clouds with very high electrostatic charges, which discharge their electric potential through the humid air, either into the cloud formations themselves or towards earth.

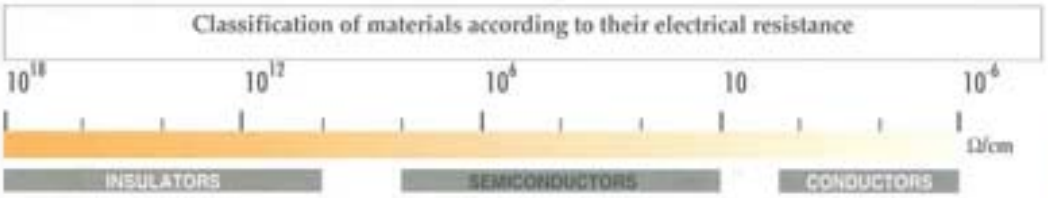
**Dissipation of electrostatic charges**

In locations where electrostatic charges are be dangerous, flooring can be installed to disperse them. Obviously it is imperative that all objects present have good conductivity. A surgeon in an operating room using an anaesthetic like

cyclopropane, which can explode when mixed with air, has to wear shoes that disperse the electrostatic charges of his body and clothing through contact with the floor. In the same way gurneys and all other objects present that are liable to become electrostatically charged must be grounded to a unipotential conductor (ground) or to the floor. Very strict regulations exist to this effect in every country. In Italy, chapter 3.5.03 and Appendix A of the CEI 64-4, which specifies criteria for electrical systems in medical facilities, is devoted to measures for eliminating electrostatic charges. The insulation resistance limits specified for flooring (generally similar to regulations in effect abroad) is 106 Ω (1 M Ω) within one year after installation, not to exceed 108 (100 M Ω) in all subsequent tests.

**Conductive flooring and antistatic flooring**

From an electrotechnical point of view, electric resistance is a specific property of every material. The following graph illustrates their classification accordingly.




The following belong to the family of insulators: amber, teflon, PVC, quartz, ceramic tile, glass, etc. Metals, on the other hand, belong to the family of conductors. The resistivity expressed in Ω relates to a unit measuring surface area ($cm^2$) and a unit measuring length (cm). To illustrate the concept better, a copper wire with a cross section of 1 $cm^2$ and 5.8 km in length generates a resistance of 1 Ω, whereas a cylinder of PVC with a 1 $cm^2$ cross section and 1 cm long produces a resistance of $10^{22}$ Ω. Flooring usually labeled "conductive" "static dissipating" and "antistatic" are not numbered among the conductors but belong to the family of "semiconductors". These are generally identified by their resistance to insulation which is usually pegged at a maximum of $10^{4}$ Ω for so-called conductive flooring, and from $10^{6}$ Ω to $10^{9}$ Ω for static dissipating floors. Excepting flooring classified as antistatic according to specification DIN 5435/2, i.e. not causing accumulation of charges greater than 2,000 volts, it must be remembered that the resistivity specified refers to the whole "package". As far as conductivity is concerned, the "package" goes from the surface of the flooring to the unipotential node, and inevitably the ohmic resistance of the adhesive must also be taken into account. For this reason conductive flooring is usually manufactured with a resistivity much lower than $10^{6}$ Ω.
As an example, paragraph 8.1.2 of the UNI 8273 specification for rubber flooring sets maximum levels for electrical resistance at:
-less than 0.05 M Ω (50,000 Ω) for conductive flooring
-from 0.05 M Ω to 100 M Ω (100 million Ω) for antistatic floors
-over 100 M Ω for insulation flooring.
All organic resin based dissipative flooring and conductive adhesives are manufactured by incorporating electro-conductive substances, which can be organic, for antistatic floors in particular,

*At left, Hospital, Fossano, Italy, conductive porcelain quarry tile installed with KERABOND CONDUCTIVE adhesive*
*Two photos of flooring in the Sandoz factory in Milan. Above: conductive flooring in the blending and packaging lab. Below: detail of anti-static flooring in a service area. Colorex EL and Colorex AS vinyl floor coverings were installed respectively with ADESILEX V4 CONDUCTIVE*

*San Carlo Hospital, Milan, Italy. Pvc flooring installed with ADESILEX V4 CONDUCTIVE adhesive*

*At left, Hewlett-Packard offices, Stezzano, Italy. ADESILEX G19 CONDUCTIVE was used to install pvc flooring*
*At right: conductive cementitious adhesive used to install conductive ceramic tiles*


*At left: installing copper strip with conductive polychloroprene adhesive*
*At right, installing conductive pvc with conductive adhesive in water dispersion*

or mineral, such as graphite and carbon black, especially for conductive flooring and adhesives. In the latter case the color of both adhesive and flooring is black. With special procedures (pressing at high temperature) PVC flooring can be manufactured in light colors, since conductivity is provided by a very thin grid of black PVC throughout the entire thickness that does not noticeably change the basic color.

| INSTALLATIONS | DAMAGE CAUSED BY ELECTROSTATIC CHARGES | RESISTANCE SPECIFIED BY THE SYSTEM (1) |
|---|---|---|
| A) Telephone switching stations | Disturbance of telephone traffic | $10^8 - 10^9\ \Omega$ |
| B) Locations containing electronic calculators | Falsification of calculations and memorized data | $10^5 - 10^9\ \Omega$ * |
| C) Integrated circuit laboratories | Irreparable damage to semiconductor elements | $10^6 - 10^8\ \Omega$ * $10^4 - 10^6\ \Omega$ * |
| D) Battery recharging stations | Ignition of primer mixture | $10^4 - 10^6\ \Omega$ |
| E) Operating rooms | Ignition of explosive mixtures (Air/solvents or anaesthesia) | $10^4 - 10^5\ \Omega$ |

*According to the specifications of the various builders.
(1) System: From the surface of the flooring to ground.

### Conductive adhesives

Conductive floors are usually installed using special resilient materials, but conductive ceramic tiles may also be used. Conductive flooring is usually installed with conductive adhesives such as ADESILEX VZ CONDUCTIVE, ADESILEX G19 CONDUCTIVE, or ADESILEX V4 CONDUCTIVE for resilients, and KERABOND CONDUCTIVE for ceramic tiles. The flooring must be installed over a copper wire grid approx. 1/10 mm. thick and 10 to 15 mm. wide, connected to the unipotential node (earth plate), with a hook-up every 30 m².
The CEI 64-4 standard does not specify the shape of the grid but the wire is usually present under each element of the flooring. The distance between is determined by the size of the tiles or pieces of flooring.
The Mapei research laboratories have recently developed a new formula for ADESILEX V4 CONDUCTIVE using a light colored electro-conductive material that possesses and retains excellent conductivity (from 50,000 to 150,000 Ω) over time.
It goes without saying that this innovation generated great interest among contractors who were thus spared their recurring nightmare of having to clean up stains left by messy black adhesive. The table at left lists the main uses of electro-conductive flooring with the maximum levels of resistivity permitted, along with the possible consequences of failing to observe them (courtesy of Forbo Resilienti srl).

**Key to the electrical resistances quoted**

$10^3\ \Omega = 1\ K\Omega = 1000\ \Omega = 1$ kilohm
$10^4\ \Omega = 10\ K\Omega = 10.000\ \Omega$
$10^5\ \Omega = 100\ K\Omega = 100.000\ \Omega$
$10^6\ \Omega = 1\ M\Omega = 1.000.000\ \Omega = 1$ megaohm
$10^8\ \Omega = 100\ M\Omega = 100.000.000\ \Omega$
$10^{-6}\ \Omega = 0{,}000001\ \Omega$

The Mapei products mentioned are part of Mapei's European Product Lines.

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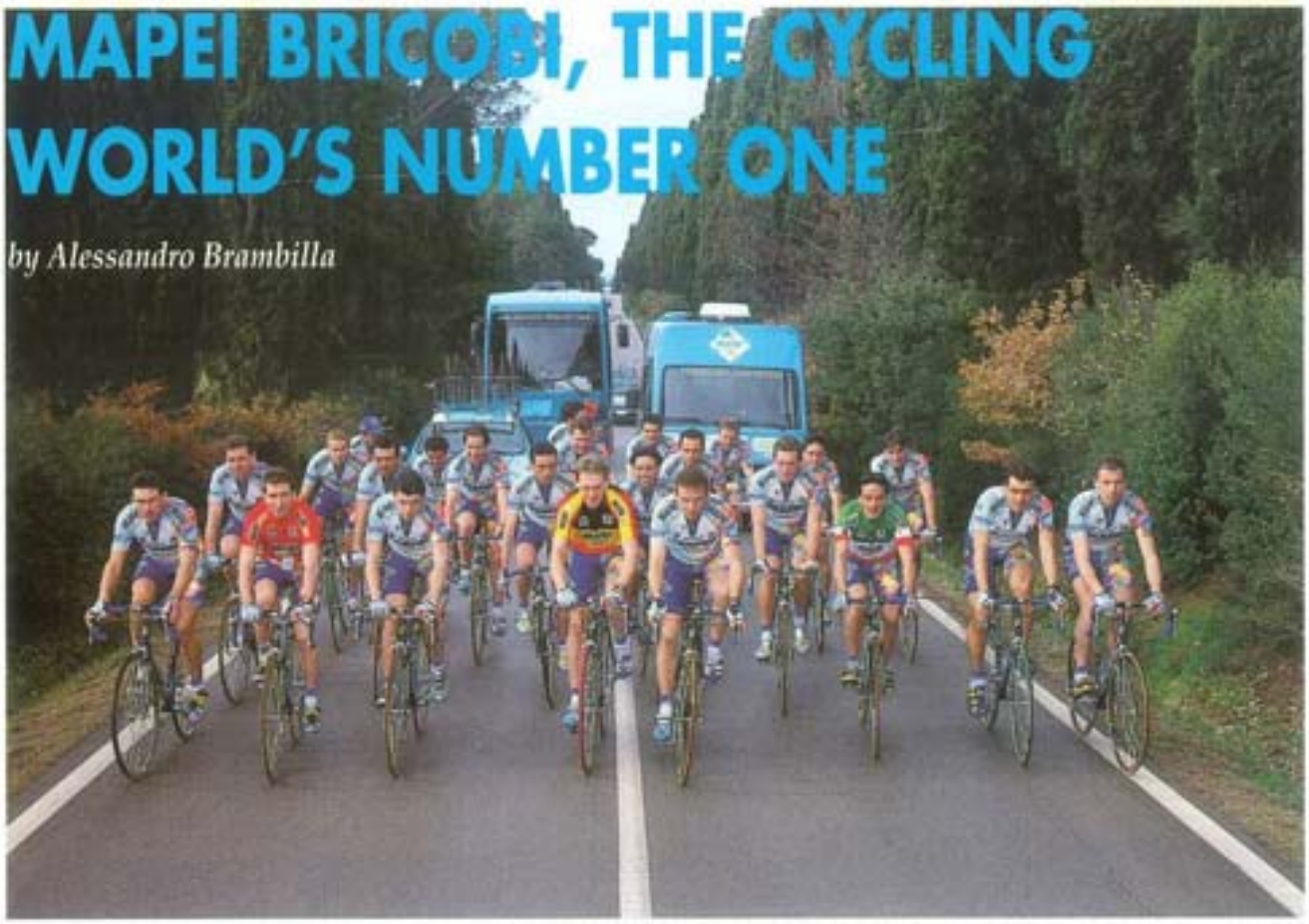
# MAPEI BRICOBI, THE CYCLING WORLD'S NUMBER ONE

*by Alessandro Brambilla*



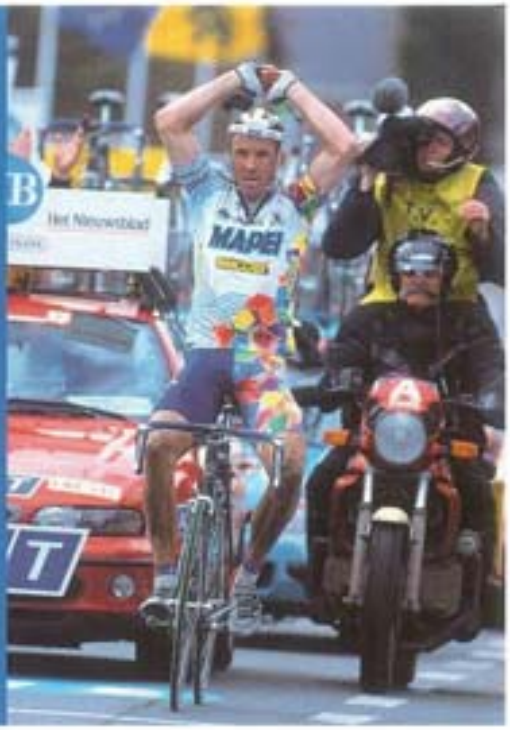
This is the fifth year that Mapei has been the main sponsor of a professional multinational cycling team. The look is revolutionary: all the legendary Mapei building blocks stand out in bold relief on the team jerseys, this year in partnership with Bricobi. And the Mapei Bricobi warriors still pedal on Colnago bikes specially made for them.

The Team Manager is Giuseppe Saronni, winner of 197 races in his professional career. Mapei Bricobi has four Directeurs Sportifs because the team races on several fronts, even on different continents, simultaneously. These are Pietro Algeri, Fabrizio Fabbri, Maurizio Piovani and the Belgian Patrick Lefevere. They coordinate tactics for 24 athletes from 6 countries. In the very first races three new arrivals made their explosive entrance on the scene, all of them first year professionals. Mapei Bricobi signed up the most talked about of the beginners, the Neapolitan Giuliano Figueras, who won the Under-23 World Championship. Giuliano came from the Zalf team, as does 23-year old Matteo Frutti, another new team member for Mapei Bricobi. Last year they won 7 races each. "We also signed Massimo Codol for his pro debut," said Algeri, "after he came to us from the Pagnoncelli team. Massimo is a terrific overall rider and a terrific climber." The 25-year old Codol won 11 races in 1997.

As for the rest, Mapei kept the same strong line-up that enabled it to close 1997 with 95 victories: Jan Svorada (Czech Republic), who had earned himself the title of "The Mapei Cannonball" for his 16 successes, and Tom Steels, Belgian Champion, with 12, have been right out front at the thronged finish lines. Russian rider Pavel Tonkov, Number One in the Giro d'Italia in 1996, gave his all in the big stage races. Last year Tonkov won 10 races. Swiss national champion Oscar Camenzind (8), Daniele Nardello (4), and Giuseppe Di Grande (4), have all made good on the great promise they showed on going into the new season.

In the classic line races the Belgians Johan Museeuw (11) and Frank Vandenbroucke (8), Andrea "The Gladiator" Tafi (5) and Stefano Zanini (3) have been among the most feared adversaries on the team. And let's not forget Gianni Bugno. You can bet that before winding up his career Gianni will leave his mark on several finish lines, as he did by winning a stage of this year's Tour of Spain. Franco Ballerini, king of the pavé, followed up on his past victories by riding to glory once again The other dynamic riders on the team are 1997 Italian champion Gianni Varesi (19), the Belgians Wilfried Peeters (2), Nico Mattan and Bart Leysen, and Polish rider Zbigniew Spruck, in addition to Gianluca Panegonda (1), Gabriele Missaglia (2), Davide Bramati (2) and Paolo Lanfranchi. During the season the team has been evaluated and tested at the Mapei Sports Division Center in Castellanza (Varese). Tom Steels got the new season off to a good start when he won two stages of the Criterium of Maiorca and two stages of the Ruta del Sol in Spain. In the Tour of Malaysia Andrea Tafi won the time trial, Giuliano Figueras a road stage and Gabriele Missaglia triumphed in the general classification.

# CLASSICS, GRAND TOURS, NATIONAL CHAMPIONSHIPS: MAPEI BRICOBI'S A WINNER




*Museeuw triumphant in the Tour of Flanders*

**Museeuw and Vandenbroucke, Flanders Fliers**

Mapei Bricobi, cycling loves you! You're always first in the races for real men. You hold the colossal Classics in awe, like the Tour of Flanders, which is worth more than a World Cup to a Belgian. It's a race with 15 super-steep climbs up the pavé. Museeuw won the race for the third time. Another Mapei Bricobi standard bearer, Stefano Zanini, took second place. Stefano arrived at the finish line 42 seconds behind Johan, ahead of Tchmil, Magnien and all the aristocrats of the Classic. The great, the phenomenal Museeuw won the Flanders in '93 and '95, too. A three-time winner that makes him a Lion of Flanders, like Magni, and the Belgians, Leman and Buysse. Johan turned professional in 1988. For four seasons now he's worn the building-block logo of Mapei Bricobi on his jersey and in his heart, with 82 victories. He's won the most World Cup races of all the riders racing today, with 8 time trials. On top of that, Johan twice won the World Cup and in 1996 he took the World Championship road race title.

The "Golden Boy", Frank Vandenbroucke, took the Gand Wevelgem, the 208 km Belgian classic with its own share of climbs and cobblestones. Fresh from his triumph in the Paris-Nice stage race, "VDB" took off out in front of the group of the best, receiving an ovation from the Flemish spectators. Nico Mattan, who has worn the Mapei Bricobi jersey two years so far, took third place, preceded by the Dane, Michaelsen. Two Mapei Bricobi team members stood on the winner's podium for the second time: the team had already ridden to victory once before at Wevelgem, with Steels in '96.

**BALLERINI AND HIS PARIS-MAPEI-ROUBAIX**

Franco Ballerini and Mapei Bricobi have done it again! Franco won the Paris-Roubaix for the second time. It was the race of his life! Franco won this rocky classic in 1995, too. From the start in Compiègne to the Aremberg Forest the Roubaix seems like a normal race. But beyond the legendary forest, the roads are narrow and paved with cobblestones in

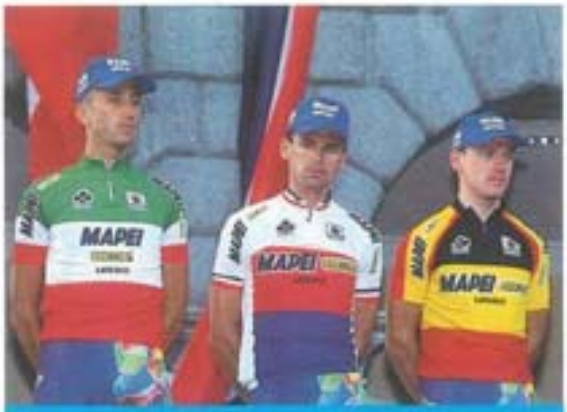

*Ballerini winning his second Paris-Roubaix*


*Mapei monopolizing the podium at the Roubaix. Left to right: Tafi (2nd), Ballerini (1st), Peeters (3rd)*

several stretches that, besides being a tough test for any car suspension, make riders pop into the air like champagne corks. But it can become a nightmare even before that. Ask Ballerini, who suffered many flats and falls, and then found himself in the middle of the forest at km 143 of the 266 km race, a full 7'15" behind Steels, Marichal, Van Heeswihk, Rokia, Govenou, Desbiens, Moreau, and Rich. Ballerini made an incredible comeback and caught up with Desbiens and Govenou, the survivors of the front group at 51 km from the finish. He overtook even them. At Carrefour de l'Arbre, 27 km from the finish, with Ballerini way out front, Andrea Tafi and Wilfried Peters, those Mapei Bricobi building block-logo'd angels, left Van Bon and the others behind in the dust and took over the winner's stand. The French classic ended with Ballerini first, Tafi second with 4'16", and Peeters third with 4'18". The Belgian, Bart Leysen, nicknamed "The Stone-crusher", another Mapei Bricobi stalwart, finished eighth with 6'33".
Mapei Bricobi re-affirmed its reputation as a record-making team, with its third victory in four tries. The team with the building block jersey is the only one in cycling history to have placed three athletes on the winner's podium in two races. Museeuw won in 1986, followed by Gianluca Bortolami and Tafi.
This year "Ballero", Tafi and Peeters raised their winner's bouquets high together. You're more of a legend than ever!

## TONKOV AND MAPEI, THE TOUR OF HEROES

Mapei Bricobi raced with honors in the 81st Giro d'Italia (Tour of Italy), dominating the team classification and setting records, winning second place in the generals, thanks to the Russian Pavel Tonkov. Marco Pantani won the Giro, with 1'33" over Tonkov. Besides the place of honor occupied by Tonkov, Mapei Bricobi won fourth place in the general classification with Swiss rider Oscar Camenzind (12'16" behind the winner) and sixth place with Gianni Faresin (at 18"31). The three men finished among the first six, something that hadn't happened since 1982. This year the Giro started in Nice with 162 riders. Only 92 finished, with 42% of the athletes giving up. Mapei Bricobi was the only team that made it to the end with all nine of its original riders. Tonkov had a beautiful win in Alpe di Pampeago. The Russian proved once again that he's a great stage race champion. For the third year he finished the Giro as one of the top two. Pavel came in first in '96, and second the following two years. Not even the great Indurain was able to come in among the top two for three years in a row. After his victories in the '92 and '93 Giri, the Spaniard only came in third in '94.
In modern times only the great Merckx, winner of five Giri, was greater than Pavel.
The Mapei Bricobi team later took part in several short stage races in Austria and the United States to prepare for the great challenges facing them later on in the summer.




*Tafi, Svorada and Steels, all national champions*

## TAFI, STEELS AND SVORADA, NATIONAL CHAMPIONS

In 1997 Mapei Bricobi won four national


*Mapei Bricobi, first in the team classification in the Tour of Italy*

championships. This year the team had to content itself with only three (!) national titles.
Tom Steels, flying through the Knokke Eist Grand Prix, was declared the winner of the Belgian Championships for the second year in a row. Jan Svorada won the championship title in the Czech Republic, as he had in '96.
For the first time in his career Andrea "The Gladiator" Tafi experienced the joy of winning the Italian national title. Andrea Tafi donned the white, red, and green jersey at the end of the Master Grand Prix in Bergamo. Mapei Bricobi had a double win in the spectacular Bergamo race, with Tafi first and Daniele Nardello second, cheered on by the huge crowd. The excellent Alberto Elli, who had broken away with them in a dash for the finish, was relegated to third place. It was a very tough Italian championship, with 188 riders starting and only 61 finishing. Another real race for real men. And a real test for Mapei Bricobi.

**MAPEI BRICOBI MAKES IT A CAPITAL TOUR**

Mapei Bricobi put on quite a show in the 1998 Tour de France, winning six stages. Daniele Nardello finished the Tour in eighth place, 16'7" after the leader, Marco Pantani, and Giuseppe Di Grande came in ninth, at 17' 35".
The first 180 km-stage started and finished in Dublin, the Irish capital, and Zanini rode down out of the Irish hills wearing the King of the Mountain jersey. Steels ascended the podium wearing the green jersey of the Tour point leader. The hungry Steels raised his arms in victory at the twelfth stage from Tarascon to Cap d'Agde (206 km).
The next day yet another victory for the team in the Frontignan to Carpentras stage (196 km). Tafi, Nardello and four others were in the front group. Nardello won his first stage of the Tour. Tafi finished third. Steels finished out in front again in Switzerland in the eighteenth stage, from Aix-les-Bains to Neuchâtel (218 km).
In the twenty-first, from Melun to the Eiffel Tower (147 km) Steels finished first and Zanini second. Winning the first stage in Dublin and the final stage in Paris, along with four more in between, made the 1998 Tour de France a capital Tour for Mapei Bricobi.

# THE 1998 CYCLING OSCAR

**The number one team with 68 wins!**

Oscar Camenzind wins the third World Championship in four years for Mapei, plus the Tour of Lombardy, and more records are broken

*Camenzind at the finish line of the world championship*

Fans with Mapei Bricobi in their hearts are once again World Champs! Oscar Camenzind, the Swiss rider from the canton of Lucerne, took the title in Valkenburg amidst the windmills of the Dutch province of Limburg. Camenzind, who has been with the Mapei Bricobi team since 1997, sped into the finish line alone, 23 seconds ahead of Van Petegem and 24" ahead of Bartoli. Camenzind's performance was a masterpiece of strength and strategy. Mapei Bricobi riders were part of four national teams: Bugno, Tafi, Zanini, Nardello and Faresin for Italy, Steels, Mattan and Peeters for Belgium, and Spruch for Poland. Eleven kilometers before the finish Camenzind took off, pursued in vain by Van Petegem and Bartoli. Tafi, "The Gladiator", finished eighth, 4' 44" behind Oscar. Camenzind is the third Swiss rider to wear the road race champion's striped jersey. With Camenzind's victory Mapei Bricobi became the first team to win three World Championships in four seasons. Abraham Olano took the title in 1995 and Johan Museeuw in 1996.
Doing honor to the jersey he wears, six days after his triumph in Valkenburg Camenzind lorded it over the Tour of Lombardy, the last of the World Cup trials, coming in 6" ahead of the Dutch champion Boogerd. Tafi won the "Lombardy" for Mapei in 1996.
For the fourth time in five seasons Mapei dominated the Team World Cup. The team closed 1998 with 68 victories in 14 countries, with first-place finishes for 15 of the 25 riders on the team. That's 60% of the team, another record.
Here are the 1998 classifications for the Mapei Bricobi bombers: Steels (15 wins), Vandenbroucke (11), Svorada (10), Tafi (7), Tonkov (5), Zanini (3), Museeuw (3), Bugno (3), Spruch (2), Nardello (2), Camenzind (2), Ballerini (1), Figueras (1), Missaglia (1), and Peeters (1).
The Mapei team has won 384 victories all told since it was formed.
What a team!

*Oscar conquers Lombardy*

*The Mapei team wins the world cup*

# THE QUEST FOR QUALITY

Quality in products, service and the environment, too: our commitment to the environment has been rewarded with ISO 14001 certification for the Environmental Management System at the Mapei plant in Robbiano di Mediglia.

*by Nazario Borghetti and Roberto Leoni*

Quality is a priority goal that Mapei has been pursuing firmly, concretely and effectively for many years in support of its agenda for development and internationalization. However, for Mapei, quality doesn't just mean consistent excellence in product performance and service, but also commitment to the kind of industrial development that will conserve natural resources and protect the environment for future generations.
To demonstrate its determination, Mapei management has established that all Mapei Group companies operate with Quality Management Systems and Environmental Management Systems that comply with internationally accepted standards, and are certified by independently accredited outside organizations.

**Mapei and ISO 9001**

In 1994 Mapei operations in Italy obtained certification of compliance with UNI EN ISO 9001 Quality System standards. This prestigious acknowledgment means that Mapei supervises its research, development, production, sales, marketing and technical assistance operations in ways that guarantee quality products and service as well as customer satisfaction. The program was followed up with ISO 9001 certification of Vinavil in 1995, Mapei Canada in 1996, and Mapei France in 1998. In April of this year Mapei SpA obtained renewal of the company's Quality System certification until the year 2001. ISO 9002 certification is shortly to be awarded to Mapei Kft, Hungary.

**Mapei and ISO 14001**

In 1997 the Mapei Group's main production and distribution center in Robbiano di Mediglia implemented the Environment Management System in compliance with ISO 14001 standards. The experience acquired with the Responsible Care program and the existence of a certified Quality System constituted a solid base on which the Environmental Management System could be built. The two systems have many similarities on such key points as prevention, management commitment to constant improvement, organization, documentation, objective evidence of goals achieved, and employee training.

At the beginning of this year the commitment to the environment was rewarded when the Mediglia plant received certification for complying with ISO 14001 standards. This type of certification is not issued to the company but to the production facility. Mapei is the first company in its field to have obtained this recognition. Receiving the environmental certification at the same time as the renewal of the ISO 9001 certificate is confirmation that it's possible to combine the quest for quality in products and services along with safeguarding the environment.

*Nazario Borghetti, the Mapei Group's Quality System Manager and Roberto Leoni, Health, Safety and Environment Manager*

**What is the 14001 standard?**

At present environmental certification can be awarded by complying with the terms of the ISO 14001 standard, which is recognized internationally, or through Regulation 1836/93 of the EC Council (EMAS).
The ISO 14001 standard is a document that describes the requirements a company must satisfy to control the impact of its operations on the environment and to obtain recognition of environmental


CISQ
CERTIFICAZIONE ITALIANA DEI SISTEMI QUALITÀ AZIENDALI
ITALIAN CERTIFICATION OF COMPANY QUALITY SYSTEMS
CERTICHIM
250/1
MAPEI S.p.A.
Viale Jenner 4
20158 MILANO
ITALIA
20158 MILANO - Viale Jenner 4
20158 MILANO - Via Cafiero 22
MAPEI CENTRO SUD S.p.A.
UNI EN ISO 9001

# 14001

The Mapei Environmental Management System

ISO 14001

Mediglia, Italy plant
CERTIECO No. 1230

compatibility. The most important of these are:

- preliminary analysis to identify all environmental aspects of plant operations;
- evaluation of the effects of operations on the surrounding environment (emissions, waste disposal, noise, energy consumption, etc.)
- definition of goals designed to reduce impact on the environment and development of prevention systems for potentially hazardous situations;
- open internal communication and, more importantly, external communication (public organizations, citizens' groups, etc.) of environmental programs and findings;
- commitment and involvement on the part of management to determine environmental policy and organizational structure, to define roles and responsibilities, and to provide sufficient resources;
- systematic checks of all parameters subject to legal specifications and the recording of findings;
- tests to evaluate compliance with the standard and with internal and legal requirements;
- ongoing employee training to encourage and promote prevention.

**What is ISO 14001 certification?**


CERTIFICAZIONE DEI SISTEMI DI GESTIONE AMBIENTALE DELLE AZIENDE
CERTIFICATION OF COMPANIES ENVIRONMENTAL MANAGEMENT SYSTEMS
CISQ
CERTIECO
SINCERT
MAPEI S.p.A.
Via Cafiero 22
20158 MILANO
UNI EN ISO 14001

Once a company has organized its Environment Management System and has verified by means of internal audits the correct implementation of all specifications detailed in procedures and operational guidelines, it then asks an independently accredited outside organization to evaluate its system's compliance with the specifications of the ISO 14001 standard. When the outcome is positive the outside organization issues a Certificate to the company and conducts periodic checks that the system is being properly enforced. Effective management of the ISO 14001 environmental system means:

- facilitating relations with the surrounding community, the authorities and with employees;
- greater organizational efficiency and awareness of the environmental aspects of operations and products;
- moving with the utmost speed in complying with environmental regulations and legislation;
- reducing environmental hazards to a minimum;
- consolidating the company's image

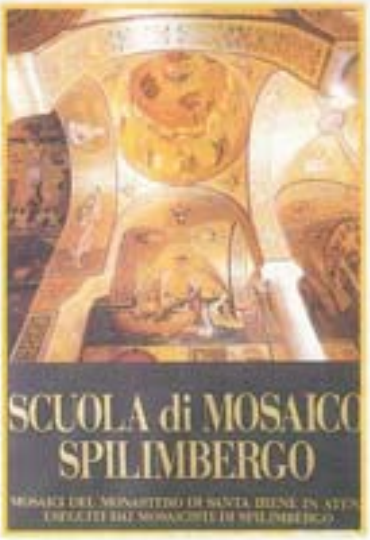
Mapei is specially committed to providing its customers with full and prompt information and assistance regarding environmental questions, and to developing products that are safe for the user with minimum environmental impact. ❑

CERTIECO

The CERTIQUALITY Institute, recognizing the importance of managing environmental concerns and its connection with Quality Management, has instituted the Environmental Certieco, with its special logo and its own Certification Committee. At the beginning of 1994, in cooperation with the Institute of Economics for Energy Sources of Bocconi University in Milan, Certieco inaugurated its first experimental program, one of the few recognized and approved by the EC. Certieco works in cooperation with other Italian organizations that belong to the Italian Quality System Certification board and other organizations around the world that participate in the IQNet, the International Certification Network, both of which are committed to Environmental Certification in their respective fields.

# Tile after tile after...

Mosaics have existed since ancient times. The name of the Italian city of Spilimbergo is inextricably linked with this art form: it's known as the mosaic capital of the world. Spilimbergo was officially enshrined as such when the Mosaic School of Friuli was opened in 1922. This art school is unique in its teaching and production methods, and students from all over the world apply for admission to its courses. The quality and scale of the artworks fashioned in the school's workshops are eloquent testimony to its fame. They decorate public buildings and private residences all over the world. Even in this location you'll find Mapei: on the work tables of the Spilimbergo Mosaic School you'll see KERABOND, a cement based powdered adhesive, and ISOLASTIC, a latex admixture which lends flexibility to cement based adhesives.




The students use these products to execute mosaics using an ancient technique invented by Gian Domenico Facchina in the latter half of the 9th century. To make work easier and more comfortable Facchina decided to work "backwards", gluing the front side of the mosaic tiles first onto paper and then installing the back of the completed design onto fresh cement. The preliminary drawing reverses the image of the cartoon from right to left. Markings are traced on the back that will later serve as a guide to integrate the various sections into a single artwork. First a level layer of fresh mortar approx. 2 cm. thick is applied to the surface to be covered. Using a trowel, the tiles are then grouted with a mix smooth enough to penetrate into the joints of the mosaic. The section is then installed by bonding it to the support, beating it in with a float. One of the school's latest works adorns the floors and walls of the Church of St. Irene in Likivrisi Attikis (Athens), an impressive work covering 1,000 sq. m. depicting religious subjects, conceived and executed with the highest regard for Byzantine traditions. All of the mosaic work was done in Spilimbergo and glued onto paper before being shipped to Athens, where it was installed over cement adhesive that had been applied to the floors and walls. ❑

The Mapei products mentioned are part of Mapei's European product lines.

# MAPEI CLIMBS MOUNT RUSHMORE

Mapei products are an integral part of a breathtaking centerpiece for the lobby of the Radisson Hotel in Rapid City, South Dakota.

As a majestic American national icon and the state's most popular tourist attraction, the Mount Rushmore National Monument was a fitting choice as a decorative element in the lobby of the Radisson Hotel in Rapid City, South Dakota. Mount Rushmore is not only a shrine to the greatness of the four American Presidents, George Washington, Thomas Jefferson, Theodore Roosevelt and Abraham Lincoln, whose massive images are carved out of the living rock, but a monument to the artistic skill and the patience of the sculptor for whom the work was a labor of love that took years to create.
In the hotel a smaller masterpiece pays homage to the genius of the larger. The centerpiece of the stone floor tile design in the lobby features Mount Rushmore in all its color, drama and dignity. Technologically advanced products manufactured by Mapei Corp (USA) were selected by the Creative Edge Corporation to help execute their intricate waterjet design. Mapei PRP 315 Waterproof Membrane provided watertight protection and Ultra/Plan self-leveling underlayment gave the work a firm foundation. Grani/Rapid mortar made for fast, easy installation of the stone floor tiles, which were then grouted with Ultra/Color. A Mapei installation that's truly a work of art!