RESTORING THE

Diagnostics, Materials Preservation and Restoration Strategies.

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The Pirelli Building was erected between 1956 and 1960 under the leadership of architect Gio Ponti, who relied on Pierluigi Nervi, Arturo Danusso and Piero Locatelli to design the structures. Mapei participated actively in the construction of the building, which immediately became the symbol of modern Milan. Eighty thousand square metres of linoleum and Pirelli rubber floors were laid on masonite panels with ADESILEX 3.

Designed by Gio Ponti, it was the first example of floating floor in Italy. Now, as then, Mapei is a leader in the restoration work of the Pirelli Building, started in 2002 after the well known accident (a light aircraft crashed against the 26th floor of the building). This work was based on the awareness that the Pirelli Building is a monument of contemporary architecture; from this initial assumption stemmed the intention of preserving, as far as possible, the architectural and technical value of the building. The preservation work included the repair of the façade, the installation of new floors (both inside and outside the building) and the static consolidation of the concrete structures damaged as a result of the aircraft impact. The building was reopened on 18 April 2004. In the same time frame, two conferences were held on the subject: one at the Restoration Exhibition of Ferrara, on 27 March ("Modern Technologies and Restoration: the Pirelli Case") and the other at Milan Polytechnic on June 1st ("Restoring the Pirelli Building").

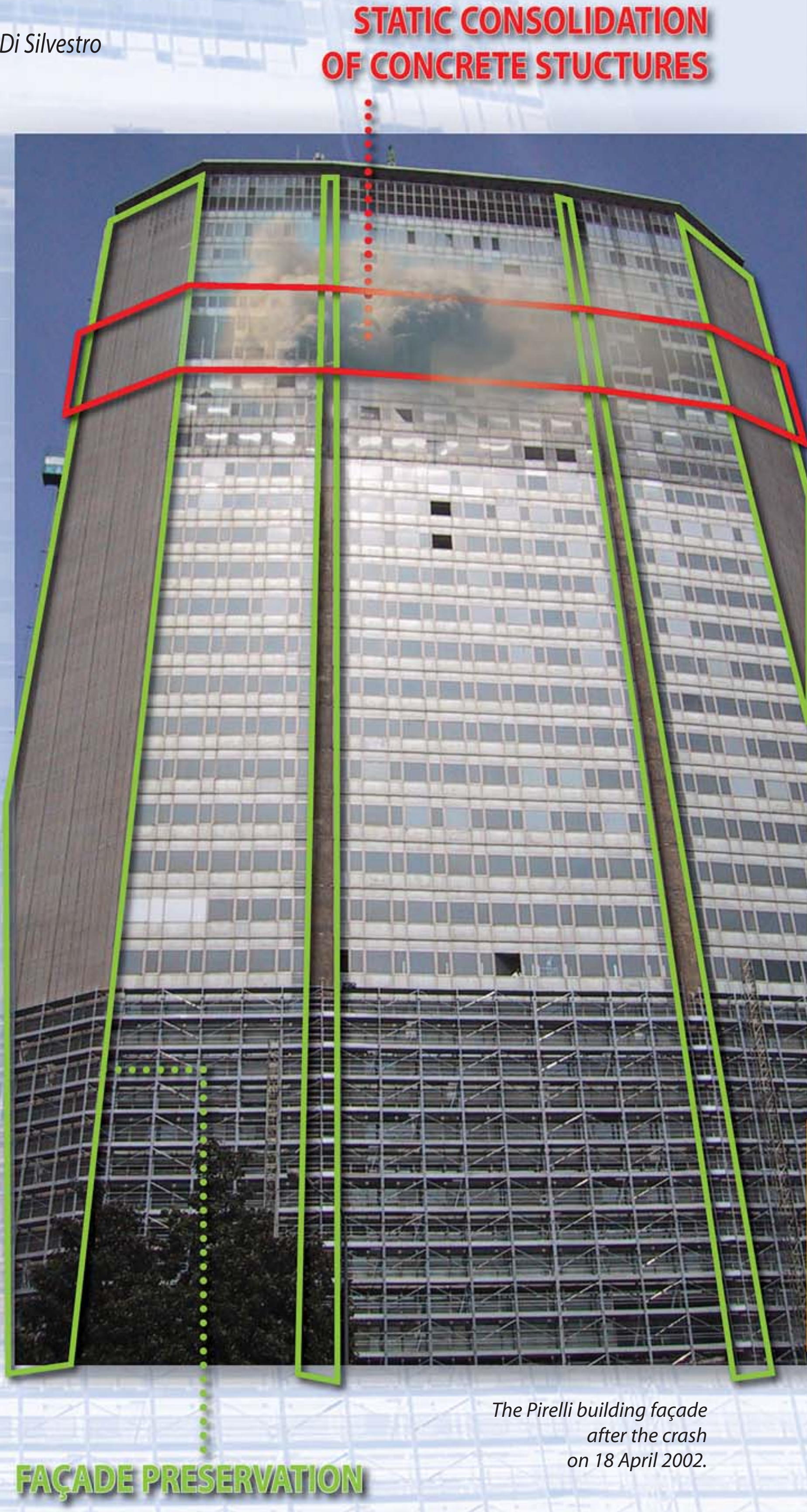
The Works

Within the Pirelli Building restoration project, two essential activities can be distinguished:

1) preserving the façades, with the definition of the scopes and procedures for the work aimed at preserving the existing authentic parts;

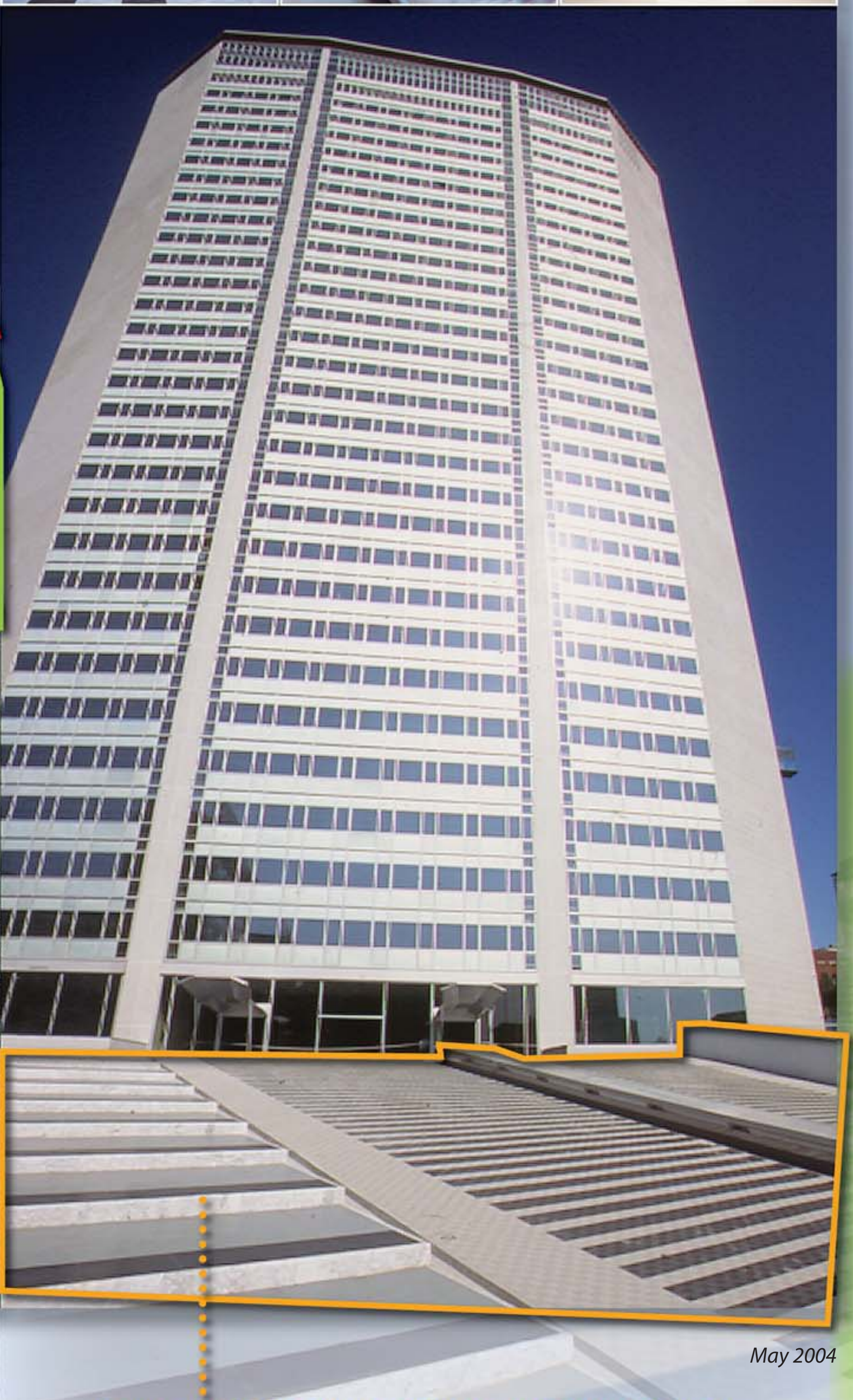
2) the functional restoration, with the definition of the work aimed at restoring deficient parts and to return the building to its full formal aspect and functionality.

With respect to façade preservation, restoration work was preceded by a diagnostic phase comprising tests conducted on site and laboratory analyses, which enabled the stratgraphy of the covering to be determined. The survey thus highlighted that the weak point of the system was represented, in nearly all cases, by the interface between mortar and concrete used for levelling off.



The Pirelli building façade after the crash on 18 April 2002.

PIRELLI BUILDING



May 2004

REMAKE OF THE EXTERNAL PAVEMENTS

To determine the restoration technique to eliminate this pathology, on site tests were performed, which established that the best solution was injection of an epoxy system with very low viscosity into the irregularities between the mortar and the concrete.

In some points of the façade, where the mosaic tiles were completely detached, a new glass mosaic, which was a perfect reproduction of the original, was laid using high performance cementitious adhesives.

The building restoration project also included the reconstruction of the pavement: of the square in front of the building with porcelain tiles and "cement bonding" rubber; at the ground floor, of the conference hall and the lobby (made of Carrara marble, a material that is easily prone to staining, which required specific care); in all remaining stories of the building, with rubber, linoleum and wood .

Lastly, the structural restoration of the building as a result of the accident in April 2002, consisted of re-aligning the frames of the 26th and 27th floors and restoring the original load-bearing capacity for permanent and accidental loads by strengthening with post-tensioned cables - external to the girders - as well as static strengthening of the girders and the bottom face of the impacted beams by plating with carbon fibre reinforced plastic (CFRP).

1. Preserving the Façade

The "Pirellone", as the Milanese call the building, is a unique image and an unmistakable icon on the skyline of the city.

Situated in a strategic area in Milan, facing the Central Railway Station, it is about 125 m tall, and features two fully glazed main façades marked by the presence of two transverse "divides" in Piazza Duca D'Aosta, by the divides and by spaces for machinery in via Fabio Filzi, and joined at the ends by the two reinforced concrete "tips". All reinforced concrete structures on the façades, and the two end tips, are covered with glass mosaic tiles. In 2000, the Lombardy Region had already ordered a "monitoring" of the state of preservation of the façade and a general report on degradation pathologies, as a result of which a bold decision was made: to preserve the aluminium sections of the continuous façades and the glass tile mosaic, abandoning the more rough-and-ready replacement solutions, originally put forward.

1.1 The Glass Mosaic Covering.

1.1.1 Existing Mosaic.

For the purposes of the chemical-physical characterisation of the covering, X-ray diffraction (XRD) tests and X-ray fluorescence (XRF) tests were conducted on the existing mosaic, and many thin sections of the drawn samples were obtained (photo 1).

These investigations confirmed that the tiles, sized 2x2 cm and 4 mm thick, are fundamentally constituted of two layers (photo 2): both are made of silica (SiO_2), alumina and some alkaline oxides (Na_2, K_2O, MgO, CaO, PbO) which confirm the mainly vitreous nature of the covering. In addition to the above elements, the surface layer also includes zinc oxide (ZnO) and zirconium oxide (ZrO_2) and other oxides which cause the colouring (variable from off-white to gray-blue) and the superficial hardness of the tile.

These analyses were also useful during the second phase of the works, when it became necessary to replace some of the tiles in the covering and integrate them with new ones that exactly reproduced the original ones.

1.1.2 New Mosaic.

The size and colour of the newly produced tiles were found to be similar to the original ones of the Pirelli Building, described in the previous paragraph. From a chemical point of view, the main elements which make up their composition (silico-aluminate) are very similar but they differ in the concentration of some minor elements. As shown in photo 3, the new tiles have a higher zirconium (Zr) content than the original ones and they do not contain any lead (Pb). Both types of tile (the original and the new ones) comprise of two main parts: the surface layer and the body. The surface layer of the new tiles is totally vitreous, whereas the body, for both sets of tiles, is characterised by the vitreous fraction and by the crystalline fraction.

1.2 Stratigraphy of the Façade Covering.

With respect to façade preservation, the restoration work on existing glass mosaic coverings was preceded by a first diagnostic phase, comprising tests conducted on site and laboratory analyses, which enabled the stratigraphy of the covering to be determined, schematically described as follows:

• load bearing structure of reinforced concrete;

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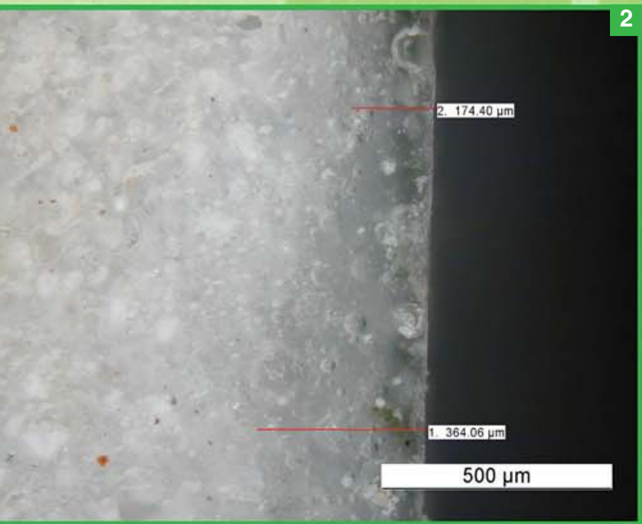

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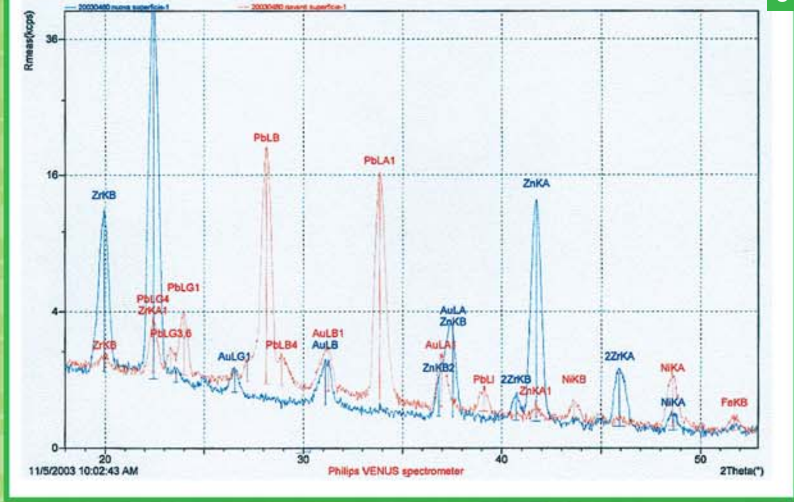

Photo 1.
Macro photo of the covering tiles drawn from the Pirelli Building.

Photo 2.
Section of a tile with measurements of the surface layer thickness: the thickness varies from about 100 to about 400 µm.

Photo 3.
Comparison between the XRF spectra of the surface of an original tile of the Pirelli building (red) and of a Malaysian manufactured one (blue).

Table 1. Mechanical compression strength, volume mass (vm), ultrasound wave propagation velocity (v) and dynamic modulus of elasticity coefficient (E) of the concrete in the reinforced concrete structure.

Core n°	vm (kg/m³)	R_{cil} (h/d=1) (N/mm²)	R_{cil} (h/d=2)* (N/mm²)	R_{cub} ** (N/mm²)	v (m/s)	E (N/mm²)
03-SE-06 75-01	2325	58.3	52.8	66.0	4160	38150
03-SE-07 75-01	2295	35.7	32.3	40.4	4130	37050
10-SS-08 75-01	2210	42.5	38.5	48.0	4240	37530
10-00-12 75-01	2255	33.8	30.6	38.2	4210	37850

*: R_{cil} (h/d=2) = R_{cil} (h/d=1) • 0.905

**: R_{cub} = R_{cil} (h/d = 2) / 0.80

Table 2. Volume mass (vm), water absorption (a), ultrasound wave propagation velocity (v), dynamic modulus of elasticity coefficient (E) and main constituents of the concrete used for levelling off.

Core n°	vm (kg/m³)	a (%)	v (m/s)	E (N/mm²)	Constituents
03-SE-06 75-01	2200	3.8	4000	33375	–
03-SE-07 75-01	2165	4.3	4210	36357	–
03-NO-13 75-01	2202	4.0	4220	37127	–
03-SE-15 75-01	2179	4.1	4120	35053	Quartz, Biotite, Chlorite, Lime
10-SE-06 75-01	2152	4.2	4100	34000	Quartz, Biotite, Chlorite, Lime

The elementary chemical analysis of the specimens was conducted by means of electronic microscopy acquiring the corresponding EDS in the Mapei R&D laboratories.

• layer of concrete with a thickness of a few centimetres, provided to eliminate "out of plumb", defined hereafter as *"levelling concrete"*;
• 1-2 cm thick plaster, provided to enable laying the glass mosaic, hereafter called *"installation mortar"*;
• *"surface paste"*, a few millimetre thick, where the tiles of the glass mosaic were incorporated;
• glass mosaic tiles of the covering.

1.2.1 Elasto-mechanical Characterisation of the Layers.

To determine the elasto-mechanical characterisation of the layers, that is the physical-mechanical characteristics of the concrete and mortar in the façade, samples were drawn by coring.

Load bearing structure of reinforced concrete

Because of the low thickness of the various layers, the crush test to determine mechanical compression strength could only be conducted on 4 cores and only for the concrete of the load-bearing reinforced concrete structure. The results in terms of mechanical compression strength and volume mass, along with ultrasound wave propagation velocity and the estimated value for the dynamic modulus of elasticity coefficient are shown in Table 1.

Compression strength (R_{cub}) data indicate a high quality for the conglomerate of the reinforced concrete structure, taking into account that the lowest value was found to be 38.2 N/mm^2 and in one case an R_{CUB} of 66 N/mm^2 was recorded. The excellent quality of the concrete in the structure was also confirmed by the values of the ultrasound wave propagation velocity, all higher than 4000 m/s, limit beyond which the conglomerate is generally assumed to be free of cracks, macro-voids and generally of compacting flaws. Lastly, the dynamic modulus of elasticity coefficient, about 37650 N/mm^2 on average, was consistent with the R_{cub} data.

Levelling concrete layer

No crush test could be instead performed on the layers of levelling concrete because of its low thickness. Therefore, to characterise the conglomerate, X-ray diffraction tests, water absorption tests to evaluate the open porosity of the material, and ultrasound wave propagation velocity tests were conducted (Table 2).

The ultrasound wave propagation velocity data, all higher than 4000 m/s, indicate that the levelling cement, in terms of compactness, absence of cracks and macro-voids due to compacting flaws, can be considered substantially equivalent to the conglomerate of the reinforced concrete structure. The excellent quality in physical and elasto-mechanical terms, and in particular the absence of macro-voids and significant porosities, was indirectly confirmed by the water absorption values. They were all found to be lower than 4.3%, thus indicating that the cement matrix is constituted by a reduced open porosity, considering that water absorption can exceed even 8-10% for poor-quality concrete. Moreover, these excellent properties were confirmed by the absence of on-going chemical degradation phenomena, as supported by the X-ray diffraction tests which excluded the presence of substances deriving from chemical reactions harming the conglomerate.

Installation mortar

X-ray diffraction tests highlighted also in the installation mortar the absence of degrading substances and the presence of physiological constituents only, i.e. quartz, feldspars, biotite and chlorite. The tests also pointed out the presence of calcium carbonate in a proportion of over 30% and the absence of hydrated lime, confirming that the installation mortar is cement lime mortar and is completely carbonated.

Surface paste

This paste was found to be constituted prevalently of cement and lime. Moreover, X-ray diffraction tests demonstrated the absence of gypsum, probably due to a partial "sulphatisation" of the cement material as a result of contact with the atmosphere and in particular with sulphur dioxide.

1.2.2 The Prevalent Damages.

On site surveys showed too that the damages present on the façade covering were in different forms. Among these forms the most widely recurring pertained to:

1) the complete detachment of the installation mortar and, therefore, of the glass covering leaving the levelling concrete visible (photo 4);
2) the detachment of only the mosaic tiles from the surface paste;
3) the partial detachment of the installation mortar from the underlying levelling concrete without the collapse of the glass mosaic covering (photo 5).

In some areas, this last type of damage was found to have gaps in the order of one tenth of a millimetre, while in other situations, instead, the detachment was so accentuated that, even without exhibiting the collapse of the mosaic covering, it had centimetre-thick gaps between the installation mortar and the levelling concrete.

With the exception of some local situations, in no case was the following found:
- the detachment of the levelling concrete from the load-bearing structure;
- the detachment of the paste from the installation mortar. The survey thus highlighted that the weak point of the system was represented, in nearly all cases, by the interface between mortar and levelling concrete.

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Photo 4.
Complete detachment of the installation mortar and, therefore, of the glass covering leaving the levelling concrete visible.

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Photo 5.
Partial detachment of the installation mortar from the underlying levelling concrete without the collapse of the glass mosaic.

1.3 Work Techniques.

1.3.1 Injections: Trials and Tests.

To determine the restoration technique to eliminate the most common type of damage (partial detachment of the installation mortar without the collapse of the glass mosaic covering), on site tests were conducted, entailing the injection of EPOJET LV*, an epoxy system with very low viscosity (140 mPa·s), in two zones called ZONE A and ZONE B.

6

Photo 6.
Injection of Epojet LV epoxy resin. Drilling the injection holes (diameter of the holes: 10 mm; depth: 30 mm) in order to intercept the gap between the installation mortar and the levelling concrete. Cleaning the holes with compressed air. Positioning the injection tube and the monitor tube into the holes. Injecting epoxy resin.

Photo 7.
Adhesion tests performed with torque meter.

7

The injection work was performed with double membrane pneumatic motor pump, with a maximum pressure of 8 bar and a capacity of 5 litres/min (in small detached areas, injections were made with a syringe), and it comprised the following steps (photo 6):
1. drilling two 10 mm diameter holes to a depth of more than 3 cm, in order to intercept the gap between *installation mortar and levelling concrete*;
2. cleaning the holes with compressed air at the pressure of 7-8 bar;
3. inserting the injection tube and the monitor tube into the holes to a depth of about 1 cm, sealing with EPORIB TURBO*, fast-hardening two-component polyester resin;
4. injection of compressed air at a pressure of 4-5 bar to ascertain whether the injection circuit was fully open between the two holes;
5. mixing the two components of the EPOJET LV*, a low-viscosity epoxy resin and injecting it into the bottom tube until it flowed out of the monitor tube in the top part, at a pressure of 0.5 - 2.5 bar.
After 7 days, with a manual torque meter adhesion tests were performed (photo 7).
Tables 3 and 4 show the results of the rip tests.
The tests showed that the "crisis" takes place almost exclusively either in the adhesive layer that binds the covering to the installation mortar or in the levelling concrete, confirming the effectiveness of the selected epoxy system (EPOJET LV*), which in addition to sealing the gaps, was also able to penetrate into the cement matrix for about 3 mm, contributing to a better restoration of the monolithic nature of the façade elements (photo 8); EPOJET LV* is characterised by the following properties:
- Brookfield viscosity: 140 mPa·s
- adhesion to concrete: >3.5 N/mm²
- flexural strength: 20 N/mm²
- elasticity coefficient: 1100-1800 N/mm²

It is an epoxy system without either charges or solvents, characterised by a markedly lower viscosity than traditional epoxy systems used in the construction industry and, what is more, with fluidity characteristics that are absolutely incomparable with those of cement suspensions. Moreover, another factor providing more assurance in the degree of adhesion between the layers is the tensile strength by flexure of the system (20 N/mm²), far greater than the value (3-10 N/mm² max) that can be guaranteed by any cement system (even a

Table 3. Results of the adhesion tests performed in ZONE A.

Test n°	Max force (KN)	Adhesion (N/mm²)	Type of failure
2A	5,1	2,0	Mosaic "paste" failure
2B	>9	>3,6	Levelling concrete failure
2C	>9	>3,6	Mosaic "paste" failure
2D	7,6	3,0	Levelling concrete failure

Table 4. Results of the adhesion tests performed in ZONE B.

Test n°	Max force (KN)	Adhesion (N/mm²)	Type of failure
3B	>9	>3,6	Levelling concrete failure
3C	7,7	3,1	Mosaic "paste" failure

high performance one).
As a result of these preliminary test, the epoxy resin injection system was selected to restore the entire façade of the building, in those areas where the problem of the detachment of the installation mortar from the levelling concrete was prevalent.

1.3.2 Partial Bonding.

Partial bonding has been made where only the mosaic tiles were detached from the "surface paste" used for laying them. The restoration work consisted of bonding new tiles with ADESILEX P1O* mixed with ISOLASTIC* diluted at a ratio of 1:1 with water, a high performance, deformable cementitious slip-resistant adhesive with extended open time, classified as C2TE according to EN 12004 and as S1 according to EN 12002.

1.3.3 Reconstructing the Render and Laying the New Mosaic.

To solve, on the other hand, the type of façade damage characterised by the complete detachment of the installation mortar from the levelling concrete, the decision was made to obtain a cement coat, using NIVOPLAN* mixed with water and 2 kg of PLANICRETE* per bag, levelling mortar for walls with high adhesion to supports (adhesion values > 2.5 N/mm after 28 days) and high flexural strength (8 N/mm²), to reduce the risk of cracking and modulus of elasticity coefficient approaching that of the coatings normally used in façades.
The new mosaic tiles were then laid using KERAQUICK* mixed with LATEX PLUS* diluted 1:1 with water, high performance slip-resistant improved fast setting, highly deformable, cementitious adhesive, classified as C2FT according to EN 12004 and S2 according to EN 12002.

Photo 8. Section of a consolidated specimen. From right to left: the tiles, the "paste", the plaster and the levelling concrete.

Photo 9. Smoothing the concrete casting with Adesilex P4.

The selection of a different adhesive from the one used to install the individual tiles detached from the surface paste was necessary because this work was performed in winter, when night time temperatures dropped below freezing and there was the risk that, using a normal setting adhesive, the mixture water would freeze at night, thereby compromising the correct hydration of the adhesive.
Consequently, a fast-setting and hydrating adhesive was selected, which is also characterised by high deformability, essential for laying on very tall facades. To overcome the problems described above and to facilitate installation work, moreover, the floors of the scaffolding where work was being performed were hermetically closed by positioning plates of insulating material, and heated by injecting warm air from below, in order to maintain a constant temperature of about 5°C.
Both in the case described in this paragraph and in the one of the previous paragraph, the grouting of the joints between the tiles was done with ULTRACOLOR*, a high performance grout, classified as CG2 according to EN 13888, now substituted by Ultracolor Plus.

2. Installation of External Floors.

Within the scope of the restoration work on the Pirelli Building, the pavement of the square in front of the building was rebuilt.
The new pavement, made of porcelain tile and cement bonding squares, was laid on a concrete support.
After completing local repairs of the base layer using PLANITOP 400*, fast-setting shrinkage compensated thixotropic mortar (compressive strength Rc > 45 N/mm², flexural strength Rf > 7N/mm², dynamic elasticity coefficient E > 24000-28000 N/mm²), the casting was smoothed (photo 9) with ADESILEX P4*, fast-setting adhesive (Rc =14 N/mm², Rf > 5 N/mm²). The porcelain tiles were laid with KERAFLEX*, high performance, slip-resistant cementitious adhesive with extended open time, class C2TE according to EN 12004.
The laying of the cement bonding rubber, on the other hand, was performed with GRANIRAPID*, two-component, high performance fast-setting cementitious adhesive, classified as C2F according to EN 12004, by laying the adhesive both on the support and on the rear of the squares.

3. Installation of Internal Floor and Wall Coverings.

With regard to the floors inside the building, the laying began with the installation of Carrara marble plates in the lobby in front of the conference hall, using KERAQUICK*, a high performance fast-setting slip-resistant cementitious adhesive, classified as C2FT according to EN 12004.
The selection of a fast-setting adhesive was dictated by the awareness that natural and artificial stone materials can undergo considerable warping and/or expansion in the presence of moisture or due to the effect of temperature gradients; moreover, in the presence of water originating from the substrate, they may spot and/or exhibit unsightly efflorescences.
In the specific case of Carrara marble, this material is in fact dimensionally stable, but it has the problem of staining, caused by the presence in the material of substances (mainly ferrous materials) which may be dissolved by the aqueous solution originating from the adhesive or from the sand and cementitious mortar used for laying according to traditional techniques; these substances, carried to the surface of the material, oxidise due to the effect of the action of oxygen and light, thereby causing the disfigurement of the covering.
To solve this problem, the Carrara marble in the

Pirelli building was laid only after verifying the absence of moisture rising from the substrate and determining that the residual moisture of the base is below values where there might be risk of the formation of the unsightly spots and efflorescences. Moreover, the material was laid using a rapid setting adhesive (KERAQUICK*), because

Photo 10.
Laying Carrara marble with white Keraquick.

Photo 11.
Installation of linoleum floors with Ultrabond ECO V4SP

Photo 12.
Detail of the post-tension cables and of the reinforcement of the floor slab with Carboplate E170/50.

Photo13.
Reinforcing the floor slab.

the high rate of hydration of the binder which it contains allows the moisture content in the adhesive to be limited to a value which avoids promoting the formation of spots on the plates of the stone material laid (photo 10).

The floor surface intended to be covered with DLW linoleum and Freudenberg rubber was first carefully analysed. This analysis helped to assess the most suitable technical solutions in order to prepare the laying surfaces correctly, a condition which is indispensable to guarantee functionality, mechanical strength and the absence of cracks.

In the areas which required complete dismantling and rebuilding of the existing substrates, TOPCEM PRONTO* ready-to-use, pre-packed, normal-setting mortar was used to prepare the screeds, which allowed a resilient floor to be obtained after only 4 days with a maximum residual moisture content level of 2%. The surface was then finished off with a layer of ULTRAPLAN* ultra-fast hardening, self-levelling compound to optimise the laying surface. On the surfaces which were still in good condition, the cracks were sealed with EPORIP* two-component epoxy based adhesive for cold joints and monolithic sealing of cracks in screeds. Once prepared, the screeds were then treated with PRIMER G* synthetic resin based primer in water dispersion and, where required, consolidated with PRIMER MF* two-component, solvent-free epoxy primer. These surfaces were also finished off with ULTRAPLAN*. The cork was laid on the ULTRAPLAN* layer using ULTRABOND ECO V4SP* universal adhesive in water dispersion for resilient floor coverings, while the linoleum was laid on the cork using ULTRABOND ECO 540* adhesive in water dispersion with low emission in volatile organic compounds (photo 11). The rubber floor covering, on the other hand, was laid on the ULTRAPLAN* using ULTRABOND ECO V4SP*. Once this phase was completed, a vinyl textile covering, produced by Liuni, was also laid. This operation was carried out using ADESILEX MT32* adhesive in water dispersion for the installation of wall coverings.

4. Static Consolidation of Concrete Structures.

On 18 April 2002, at 5.47 p.m., a single-engine Commander 112 Tc aircraft hit the façade of the Pirelli building in Piazza Duca D'Aosta, between the 26^{th} and the 27^{th} floor, practically on the centreline of the building, penetrating it.

As a result of the impact, the engine of the aircraft detached from the fuselage, exiting from the facade of via Fabio Filzi, and the two fuel tanks, located near the wings, exploded. Consequently, a breach opened in the facade and a fire started, with a highly visible column of smoke billowing from the building. After penetrating the façade of the building in Piazza Duca D'Aosta, the aircraft, which had already slowed down due to the impact against the façade, stopped its motion with the impact of the wings against the machinery spaces. On the floor of the 26^{th} storey, there were no substantial damages. However, the shock wave caused by the overpressure generated inside the building, initiated by the fuel tank explosion, caused highly visible downward deformations in the 26^{th} floor frames and upward deformation in the 27^{th} floor frames.

The restoration project therefore entailed the static repair of the beams of the central area of the 26^{th} and 27^{th} floor frames, damaged as a result of the aircraft impact. Given the sizable deformation, the first step was to realign the frame by "forcing" it, in a controlled manner. Subsequently, after rebuilding the damaged sections and sealing the gaps, the damaged structures were returned to their original load-bearing capacity, by a combined action produced by post-tensioned external cables and plating the bottom face of the girders and of parts of the floor with carbon fibre reinforced plastic CFRP (photo 12).

4.1 Preparing the Substrate.

Plating operations were preceded by repairs to the damaged concrete: cracks were sealed with EPOJET* epoxy resin (Brookfield viscosity 380 mPa·s, adhesion to concrete > 3 N/mm^2) injected at low pressure through small tubes located at the sides of the lesions.

The exposed reinforcements were then subjected to passivation treating the previously sand blasted and cleaned reinforcement rods with MAPEFER*, two-component anti-rust mortar for the protection of reinforcing rods (adhesion to concrete > 2.5 N/mm^2, adhesion to sandblasted steel >

2.5 N/mm^2, excellent resistance to saline fog after 120 h in accordance with DIN 50021).
The degraded concrete sections were reconstructed by casting into formwork, using self-compacting cement with volumetric stability and high mechanical strength, prepared with STABILCEM SCC* and GRAVEL 0-8* (slump flow 71 cm, compressive strength after 28 days Rc > 49, flexural strength after 28 days Rf > 6 N/mm^2, dynamic modulus of elasticity coefficient E=25000 N/mm^2).

4.2 Applying Carbon Fibre Laminas.

After completing repairs on the degraded concrete, the structural strengthening of the girders and of the bottom face of the floor slabs was performed by applying pultruded carbon fibre laminas.
The procedures followed to apply the laminas are as follows:
1. thorough cleaning of the substrate by sandblasting, hydro-blasting or simple brushing, to eliminate every crumbly and incoherent part from the concrete;
2. applying, with brush or roller, MAPEWRAP PRIMER 1*, two-component superfluid solvent-free primer based on epoxy resins (viscosity: 300 mPa·s, adhesion to concrete>3 N/mm^2), with the property of consolidating concrete surfaces before the carbon fibre laminas are applied;
3. applying a uniform, 1-1.5 mm thick, layer of ADESILEX PG1* epoxy adhesive on one side of the pultruded lamina after removing the protective film;
4. laying a further layer of ADESILEX PG1* also on the substrate where the lamina is to be bonded;
5. laying the pultruded carbon fibre laminas CARBOPLATE E170/50* (photo 13) exerting a constant pressure on its whole length with a rigid rubber roller and eliminating excess resin with a spatula;
6. applying medium viscosity epoxy adhesive in uniform thickness on the laminas, to enable sandblasting the surface if it is to be plaster coated.

5. Conclusions.

The restoration of the Pirelli Building involved mainly repairing the facade covering, remaking external pavements and internal floors, and the static strengthening of the girders and floor slabs of the 26th and 27th stories, impacted as a result of the aircraft accident on 18 April, 2002.
This article has described the preliminary diagnostic work aimed at defining the restoration techniques and the materials to be used to preserve and restore the existing authentic parts of the mosaic covering of the façade. For the remake of the pavements and floors, and in particular when laying new coverings, particular attention was paid to adhesive selection. Lastly, the functional repair of the impacted structures of the Building was achieved by reinforcement with post-tensioned cables, to restore permanent and accidental load-bearing capacity, and plating with pultruded carbon fibre laminas, to restore load-bearing capacity for exceptional loads.

TECHNICAL DATA

Pirelli Building, Milan (Italy)
Work: repairing the façade's glass mosaic coverings, remaking the external pavements laying the internal floors and consolidating the concrete structures
Years of construction: 1956 - 1960
Years of the preservation works: 2002 - 2004
Contractor: Grassi & Crespi Srl. and Marcora Srl.
Mapei Co-ordination: Andrea Aliverti, Tiziano Cerulli, Luigi Coppola, Fulvio Bianchi, Paolo Giglio, Massimiliano Nicastro and Matteo Venturini, Mapei S.p.A.

***Mapei Products:** *the products referred to in this artiche belong to the "Products for Ceramic Tiles and Stone Materials", "Buidling Speciality Line" and "Products for the Installation of Resilient, Textile and Wood Floor and Wall Coverings" ranges. The technical data sheets are available on the "Mapei Global Infonet" CD/DVD or at the web site: www.mapei.com. Mapei adhesives and grouts conform to EN 12004 and EN 13888 standards.*
***Adesilex MT32:** adhesive in water dispersion for the installation of wall coverings.*
***Adesilex P4 (C2F):** high performance rapid setting full contact cementitious adhesive for ceramic tiles and stone material.*
***Adesilex P10 (C2TE):** white high performance cementitious adesive with no vertical slip and extended open time for glass, ceramic and marble coverings.*
***Adesilex PG1:** thixotropic epoxy adhesive for structural bonding.*
***Carboplate:** pultrused carbon fibre plates pre-impregnated in epoxy based resin, protected by a double film of plastic.*
***Epojet:** two-component superfluid epoxy resin for injection.*
***Epojet LV:** two-component very low viscosity epoxy resin for injection in micro cracks.*
***Eporip:** two-component epoxy based adhesive, for cold joints and monolithic sealing of cracks in screeds.*
***Eporip Turbo:** very fast hardening two-component polyester resin.*
***Granirapid (C2F):** high-performance, deformable, fast setting and hydration two component cementitious adhesive for ceramic tiles and stone material.*
***Gravel 0-8:** cementitious binders to be used, mixed with Stabilcem or Stabilcem SCC, in place of cement to manufacture pumpable controlled shrinkage concrete or self-compacting concrete for the repair of damaged concrete structures.*
***Isolastic:** flexible latex additive to be mixed with Kerabond, Kerafloor and Adesilex P10.*
***Keraflex (C2TE):** high performance cementitious adhesive, with no vertical slip and extended open time for ceramic tiles and stone material.*
***Keraquick (C2FT;** class **S2** according to EN 12002 when mixed with Latex Plus**):** high performance, deformable, rapid setting cementitious adhesive with no vertical slip for ceramic tiles and stone material.*
***Latex Plus:** latex admixture inducing elasticity to be mixed with Keraquick.*
***Mapefer:** two-component anti-rust mortar for the protection of reinforcing rods.*
***Mapewrap Primer 1:** epoxy primer specific for the Mapewrap system.*
***Nivoplan:** levelling mortar for interior and exterior walls and ceilings.*
***Planicrete:** synthetic-rubber latex for cementitious mixes.*
***Planitop 400:** fast setting shrinkage compensated thixotropic mortar for cortical restoration and the finishing of reinforced concrete by applying in a single coat a thickness of mortar variable between 1 and 40 mm.*
***Primer G:** synthetic resin based primer in water dispersion.*
***Primer MF:** two component solvent free epoxy primer to be used as a adhesion promoter for the Mapefloor product range and to consolidate and waterproof cement substrates.*
***Stabilcem SCC**: cementitious binder for manufacturing dimensionally stable self-compacting concrete mixtures to repair concrete structures.*
***Topcem Pronto:** pre-blended ready to use mortar with normal setting for fast-drying screeds (4 days).*
***Ultrabond Eco 540:** adhesive in water dispersion with low emission of volatile organic compounds (VOC) specifically formulated for installing linoleum flooring.*
***Ultrabond Eco V4SP:** universal adhesive in water dispersion with low emission of volatile organic compounds (VOC) for resilient floor coverings with extended open time.*
***Ultracolor (CG2):** fast setting and drying grout for 2 to 20 mm joints, available in 26 colours; does not produce efflorescence. **N.B.** The product has been replaced by Ultracolor Plus.*
***Ultraplan:** ultra-fast hardening (12 hours) self-levelling compound for thicknesses from 1 to 10 mm per coat.*