

# SANT'APOLLINARE NUOVO

High technology systems have been used in the restoration and reconstruction of the Basilica complex of Sant'Apollinare Nuovo in Ravenna.

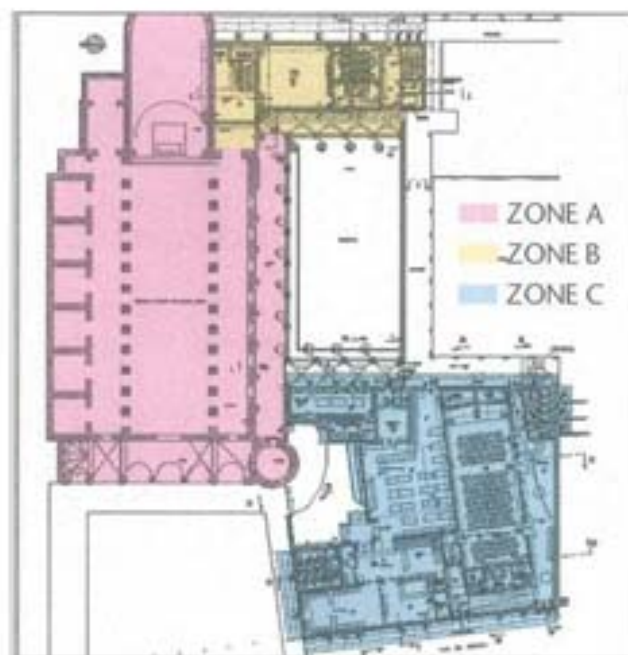
The Basilica of Sant'Apollinare Nuovo in Ravenna was built during the reign of Theodoric (493-526) as an Arian Christian Palatine Chapel attached to the adjacent Theodoric Palace. Its mosaics are among the works of art listed by UNESCO as being the "Heritage of Mankind". 1,500 years after its construction, the Basilica complex was badly in need of restoration. The work was one of the many projects financed as part of the Holy Year 2000. The contract was awarded to the Consortium Ravennate delle Cooperative di Produzione e Lavoro and the work was executed by the Ediltecnica company of Ravenna.

The project was divided into three main sections:

1. restoration of the Basilica of Sant'Apollinare Nuovo;
2. construction of the Mosaic Museum in the Theodoric Palace;
3. repair of the buildings located between the Basilica of Sant'Apollinare Nuovo and the Theodoric Palace, along with the construction of a multi-functional auditorium and a visitors' welcome centre (which includes the refreshment room).

The attention to quality required by the project prompted Mapei to make preliminary analysis of the materials originally used to build the Basilica complex. Tests were performed by the Mapei Research and Development Laboratories which used ultra-sophisticated technology to determine the various techniques and products to be used in the restoration.

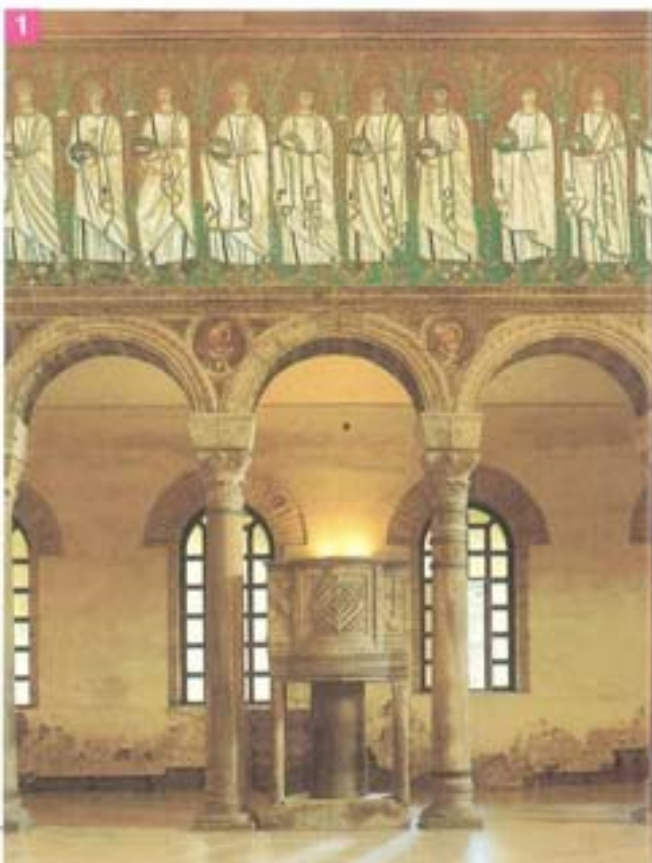
Above: the Basilica of Sant'Apollinare Nuovo in Ravenna built during the reign of Theodoric (493-536).

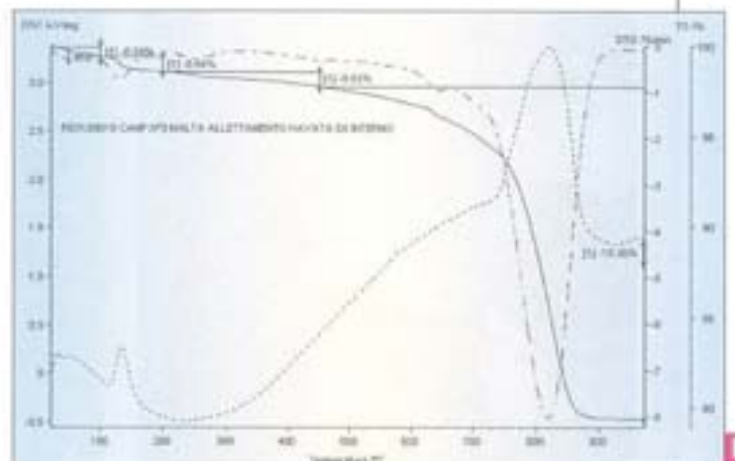
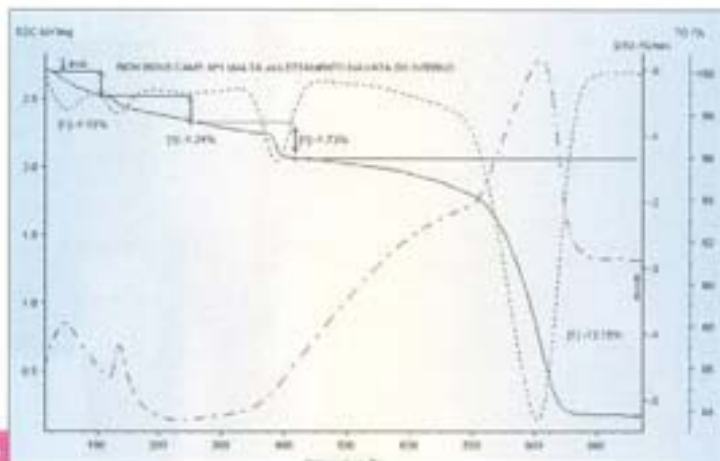


## RESTORATION OF THE BASILICA

Restoration of the Basilica of Sant'Apollinare Nuovo involved:

- restoration of the façade and the counter-façade, cleaning of the stone, consolidation of the mortar, and repair of the brick facing;
- dehumidifying, plastering and painting the side walls;
- restoration of the Baroque Saint Anthony Chapel;
- restoration of marble portals in the side chapels.





**A.** TG/DSC analysis of the brick mortar bed in the right-hand aisle revealed the amount of gypsum present, along with the amount of organic substances, lime and calcium carbonate contained in the mortar.

**B.** TG/DSC analysis of the brick mortar bed in the left-hand aisle.

1. The interior walls of the side aisles were badly decayed, as can be seen to the rear of the 6th-century pulpit.
2. The right-hand aisle where the plaster was separating from the underlying masonry because of rising damp.
3. Pointing the joints in the brick masonry with MAPE-ANTIQUE MC light-coloured dehumidifying mortar, formulated in the Mapei Research and Development Laboratories.

## Dehumidifying and plastering of the walls

The interior walls of the Basilica were in such an advanced state of decay that the repairs had to be performed by demolishing the old plaster, removing the mortar from the brick walls, washing down the surface and covering the walls with a vapour-permeable mortar inside the Basilica up to a height of two meters (except for some sections of the right-hand aisle where the original brick had been left exposed and only needed pointing).

### Right-hand aisle: the diagnosis

Tests made on samples of the mortar bed in the right-hand aisle of the Basilica showed that the mortar was composed of common lime (that had completely carbonated), mixed with siliceous aggregate, quartz, and sodium and potassium feldspar. The amount of gypsum found suggested it did not result from pollutants present in the atmosphere but that it was originally used to modify the plasticity of the mortar (a technique used in the past).

During restoration, the presence of the gypsum made it necessary to use a special technique based on technologically advanced material. Gypsum reacts with cement-based materials to form ettringite. Ettringite causes delamination of the strata and destroys the material.

### Left-hand aisle: the diagnosis

Here the analysis of samples from the mortar bed showed the mortar was composed of lime mixed with siliceous aggregate. X-ray diffraction revealed the presence of ettringite produced by the reaction between the free lime, gypsum, and clay present in the sand that was used in the plaster.

This suggests that in modern times the

masonry was touched up here and there with lime.

## Solutions

The lab results enabled Mapei to determine the test techniques to be used for the restoration of the Basilica. The MAPE-ANTIQUE system was used for the restoration. On both aisles a scratch coat of MAPE-ANTIQUE LC was applied. MAPE-ANTIQUE LC is a special cement-free, sulphate-resistant binder for macroporous renders.

MAPE-ANTIQUE MC was used for pointing the brick, part of which was left exposed. MAPE-ANTIQUE MC is a light-coloured dehumidifying mortar which is insensitive to aggressive agents. However, it has a degree of porosity, modulus of elasticity and mechanical strength similar





to those of antique lime-based mortars. MAPE-ANTIQUÉ FC, a pre-mixed ready to use fine grain sulphate-resistant mortar, was used to finish the renders. Using the MAPE-ANTIQUÉ system also enabled dimensional stability to be achieved in a short time because of the low level of lime present in the system. After only one week the concentration of lime was minimal, unlike normal binders in which the level of lime stays high for years.



4. Applying a coat of MAPE-ANTIQUÉ MC mortar which is insensitive to aggressive agents, yet has performance characteristics similar to those of antique lime-based mortars.

5. The right-hand aisle where a transpiring render was applied using the MAPE-ANTIQUÉ system.



## THE MOSAIC MUSEUM

Consolidation of the Mosaic Museum in the Theodoric Palace regarded:

- remodelling of the 16th century Rectory adjoining the Basilica with an entrance from the old cloister;
- consolidation of the columns and crowns of the cloister supporting the floor of the Museum;
- construction of a transpiring render up to approximately two metres high;
- consolidation of the floor of the Rectory;
- installation of an industrial floor in a Museum room.

### The 16th-century cloister

The cloister adjacent to the Basilica was built in the 16th century and supports the floor of the Mosaic Museum. The solid brick arches that rise from the cloister's stone columns were in need of structural consolidation and in need of a transpiring render on the wall adjoining the Mosaic Museum. A system developed in the Mapei Research and Development Laboratories was used for the consolidation. This tried and tested system consisted of injecting materials formulated with high-performance resins.

First the old plaster was demolished.



6. Detail of the metal tie rods reinforcing the arches of the cloister before the start of restoration.

7. One of the damaged arches of the 16th-century cloister. The statics of the structure, which supports the Mosaic Museum, were seriously jeopardised.

8. Coating the arch with MAPE-ANTIQUÉ MC mortar in order to contain the injection. Note the reinforcement rod treated with MAPEFER.

9. EPOJET being injected into the brick arch. This product is a super-fluid epoxy resin with extremely high performance characteristics.

10. After restoration, the arches of the 16th century cloister can support the weight of the floors.

11. The two-metre high transpiring render applied using MAPE-ANTIQUÉ MC + MAPE-ANTIQUÉ FC.

12. The same system was used in some rooms around the cloister. In this photo the private sacristy of the Archdiocese of Ravenna





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Ravenna and in the entrance of the Museum.

#### An unobtrusive floor

The Mosaic Museum houses the

13. The area dedicated to housing the Mosaic Museum and its 5th century mosaics prior to laying the new flooring. The surface will have a neutral, unobtrusive look so as not to distract from the mosaics on display.

14. ULTRAPLAN being applied over the TOPCEM screed. ULTRAPLAN is a fluid, cementitious self-levelling compound that dries ultra-fast and gives the screed a compact, even finish that will provide a perfect neutral surface for the Museum floor.

Then the damaged brick surface was soaked with water, saturating the cracks as well. The tie rods were given a protective coating of MAPEFER, a cementitious mortar with corrosion inhibitors for metal reinforcement. Then the bricks were coated with MAPE-ANTIQUE MC mortar in order to contain an injection of EPOJET through tubes. EPOJET is a super-fluid epoxy resin that is waterproof and polymerises without shrinkage. MAPE-ANTIQUE FC was used as a finishing.

The same system made up of MAPE-ANTIQUE MC + MAPE-ANTIQUE FC was used to construct a two metres high transpiring render on the wall of the cloister that supports the Mosaic Museum. The same system was used in the private sacristy of the Archdiocese of



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mosaic floors of the Theodoric Palace that date back to the 5th century A.D. The exhibit spaces required a very neutral type of floor that would not distract from the mosaics. A sheet of polythene was laid over the concrete slabs before placing a floating TOPCEM screed 5 to 6 cm thick over it. TOPCEM is a fast drying special,

normal setting hydraulic binder. ULTRAPLAN, a fluid, cementitious self-levelling ultra-fast setting compound, was later poured over the screed. The hardened ULTRAPLAN was then treated with a wax finish.



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## BETWEEN THE BASILICA AND THE "THEODORIC PALACE"

Restoring the buildings located between the Basilica of Sant'Apollinare Nuovo and the "Theodoric Palace" involved:



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- conversion of the former Corso Cinema into a multi-purpose auditorium seating 180;
- remodelling the mezzanine into a conference room;
- construction of a visitors' welcome centre with a restaurant seating 120;
- construction of the Basilica bookshop;
- construction of living space for the Basilica custodian;
- installation of industrial flooring.

### The former Corso Cinema

The building that stands between the Basilica and the Theodoric Palace is the former Corso Cinema. Parts of its exterior



walls were badly decayed. Analysis revealed the composition of the original mortar which was now completely carbonated: 1 part gypsum, 1 part hydraulic lime and 3 parts inert silicas. Here, too, the presence of ethringite led Mapei to assume that there had been an attempt at restoring the building using antique materials in more recent times.

The new restoration was performed using a mortar with cement-free binders. A scratch coat of MAPE-ANTIQUE MC was applied, followed by a finishing coat of MAPE-ANTIQUE FC. The same system was used on the two metre high support columns and walls of the modern cloister.

### Industrial floors

In the last few years the use of



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15. The waxed ULTRAPLAN Mosaic Museum floor.

16. The exterior of the former Corso Cinema before restoration: the plaster was completely carbonated due to the presence of ethringite.

17. MAPE-ANTIQUE MC being finished with a coat of MAPE-ANTIQUE FC, a light-coloured, cement-free fine-grain mortar.





18. A new façade for the Holy Year: the external masonry walls face the Corso (main thoroughfare) and are plastered with MAPE-ANTIQUE MC + MAPE-ANTIQUE FC.

19. A detail of the arch in the modern cloister.

20. The modern entrance hall of the Mosaic Museum with its unobtrusive floor.



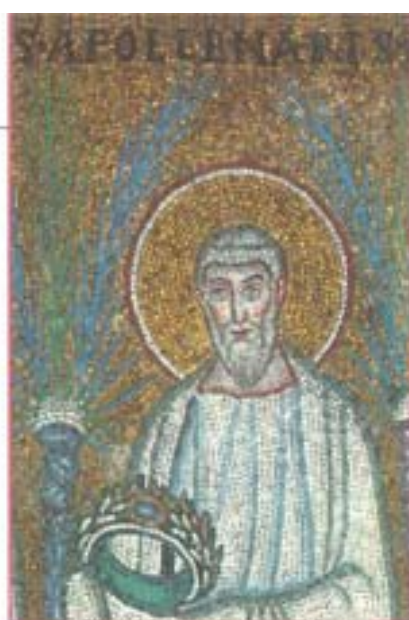
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industrial flooring in buildings and especially in show rooms has become a fast growing phenomena if not a fad. The system TOPCEM+ULTRAPLAN was used because of its excellent practicality, quality, and aesthetic effect and was used for the floors of a room in the Mosaic Museum and in different areas between the Basilica and the Theodoric Palace. The areas restored with this system are the entrance hall, the multi-purpose auditorium, the visitors' welcome centre, the restaurant and the management offices.

Graphs made by: Milan Research and Development Laboratory - Tiziano Cerulli  
Photographs 12, 15 and 20: Paolo Radi



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## TECHNICAL DATA

Sant'Apollinare Nuovo - Ravenna (Italy)

Year Built:

Basilica: 493-526

Mosaic Museum: 16th century

Former Corso Cinema: 20th century

Restored: 1999

Commissioned by: The Archdiocese of Ravenna and Cervia

Supervised by: The Superintendence of Environmental and Architectural Resources of Ravenna

Artistic Supervision: Dr. Roberto Evangelisti, Arch.

Project Manager: Dr. Massimo Bagnoli, Arch.

General Contractor: Consorzio Ravennate

Cooperative di Produzione e Lavoro

Contractor: Cooperativa Ediltecnica of Ravenna

- Eng. Paolo Cicognani - Frediana Morganti -

Arch. Cristina Garavelli

Site Supervisor: Davide Bubani (qualified surveyor)

Mapei Products used:

in the Basilica (zone A):

MAPE-ANTIQUE MC

MAPE-ANTIQUE LC

MAPE-ANTIQUE FC

In the Mosaic Museum (zone B):

MAPE-ANTIQUE MC

MAPE-ANTIQUE FC

MAPEFER

EPOJET

TOPCEM

ULTRAPLAN

For the former Corso Cinema (zone C):

MAPE-ANTIQUE MC

MAPE-ANTIQUE FC

TOPCEM

ULTRAPLAN

Mapei coordinators:

Dario Turci, Fabio Costanzi, Paolo Sala

Technical data sheets for the products mentioned in this article are available in the following Mapei binders: No. 1 "Ceramic Tile Installation Products", and No. 3 "Building Specialty Line".

