

Montefortino (Italy)

SANCTUARY OF THE MADONNA DELL'AMBRO

FOLLOWING THE EARTHQUAKE IN 2016, THE SANCTUARY
UNDERWENT DELICATE RESTORATION AND CONSOLIDATION
WORK BEFORE BEING HANDED BACK TO VISITORS
AND WORSHIPPERS ON THE 24TH OF DECEMBER LAST YEAR



Situated in the Monti Sibillini National Park, the Sanctuary of the Madonna dell'Ambro is the most ancient place of worship dedicated to the Madonna in the Marche Region (Central Italy). At the beginning of the 11th century a small church, the Church of Santa Maria in Amaro, was built in the place where the Madonna had made an appearance and was entrusted to Benedictine monks from the nearby Santi Vincenzo and Anastasio monastery. At the beginning of the 17th century, under the jurisdiction of the diocese of Fermo, it was decided to construct a larger church. The work was designed by the architect Ventura Venturi from the Santa Casa di Loreto, who was commissioned to design a church that incorporated the original Church of Santa Maria in Amaro and 6 lateral chapels alongside the aisle of the church.

Following the earthquake that struck the area on the 24th of August, 2016, the structure was badly damaged with serious cracks that compromised its general stability.

Montefortino City Council made the Sanctuary safe by implementing a project by Luigino Dezi, a professor in Construction Technology at the Polytechnic University of Marche, and the engineer Massimo Conti.

THE CONSERVATIVE RESTORATION AND SEISMIC UPGRADING PROJECT

The work on the structure included consolidation of the brick vaulted ceiling over the aisle; the insertion of 510 steel chains with 36 mm diameter around the main arches; the construction of a system of kerbs and tie-rods along the top of the roof, partly in breccia rock on the 1.5 m thick walls to avoid creating too much transversal stiffness, and partly in reinforced masonry; the positioning of steel bars in the openings of the upper altar wall and of an embedded tie-rod to counteract out-of-plane loads; consolidation of the lateral chapels and the walls of the upper tombs; stitching of the dividing walls in the chapels; positioning of a band of carbon fibre to prevent the apse from collapsing; the insertion of dywidag anchor bars to



The Sanctuary was officially reopened last December, on the 21st.

prevent the tympanum of the main facade collapsing; the insertion of chains around the belfry and in the filler material used to stitch various cracks.

THE MATERIALS USED FOR THE RENOVATION

The sponsor of the initiative, the Cassa di Risparmio di Fermo bank, asked for Mapei's collaboration to carry out the work and Mapei, as Technical Partner for the project, supplied experts from the company's Technical Services Department and various cutting-edge product systems.

Consolidation of the vaulted ceiling was carried out in two phases. Firstly, the damaged areas were repaired with a product chosen for its compatibility with the existing mortar's mechanical properties and level of porosity, its resistance to physical and chemical aggression (freeze-thaw cycles) acting on the ceiling and its compatibility with the frescoed surfaces. A product suitable for repairing frescoed surfaces was chosen so that, during its application, the substrate would not need to be wetted and, while it was setting, it would not give off free lime that would have caused the formation of efflorescence and potentially damage the decorated surface. The ceiling was then consolidated by applying on the outer face a composite system with an inorganic matrix. All the products used contained no cement, as specified by the local Heritage Board. For the upper part of the apse, a composite system with an organic matrix was proposed, which consisted of car-



LEFT. The Sanctuary dedicated to the Madonna dell'Ambro upon completion of the work.

RIGHT. The Sanctuary had to be shored up following the earthquake in 2016.



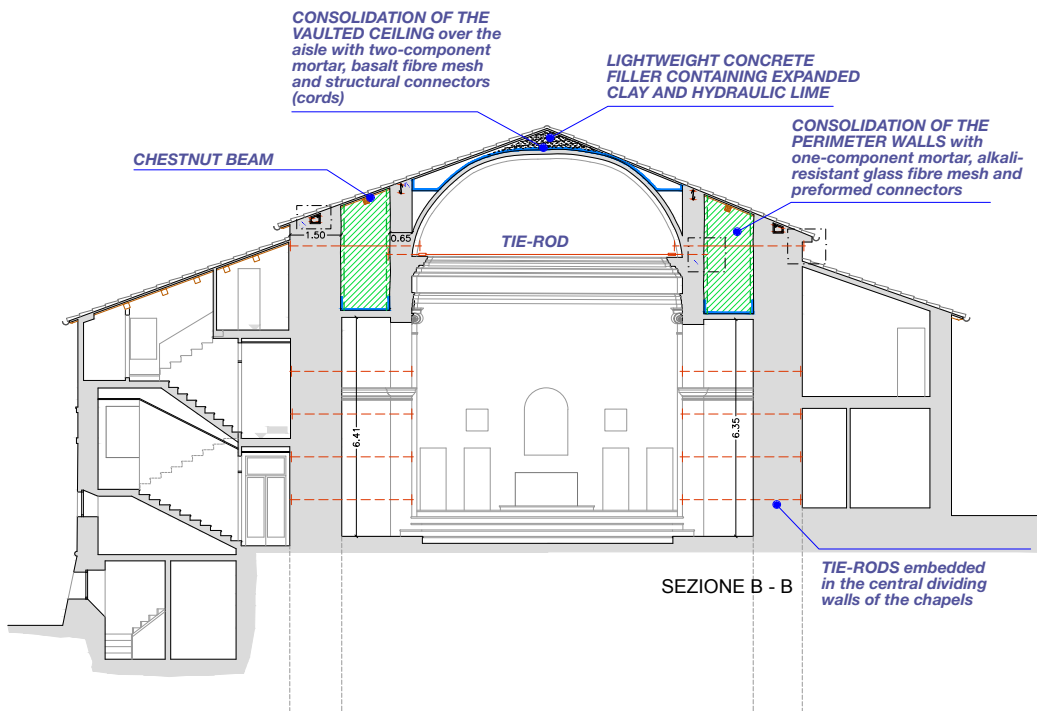


Restoration work on the Sanctuary was also used to carry out training in collaboration with the Fermo Association of Engineers (and particularly Antonio Zamponi, Marco Meconi and Daniele Ulissi). On the 26th of May last year, around 100 professionals took part in a special day to learn more on the project and to visit the site where the work was being carried out.

bon fibre fabric and epoxy resin to guarantee a constraint on mechanisms out-of-plane of the macro-element.

INTERVENTION WITH MAPEI SYSTEMS

To consolidate the outer face of the existing vaulted roofs PLANITOP HDM RESTAURO was used, a product made of an inorganic matrix of natural hydraulic lime and Eco-Pozzolan. This product, which was applied in an even layer using a flat, metal trowel, allows to smooth and level off masonry surfaces such as stone, brickwork and tuff. When used in combination with MAPEGRID B 250 alkali-resistant basalt fibre mesh, as in this case, it has the capacity to strengthen masonry and reinforced concrete elements. To ensure the strengthening of the side walls, MAPEWRAP B FIOCCO high-strength basalt fibre cords were prepared and then bonded in place with MAPEFIX EP 470 SEISMIC pure epoxy resin-based chemical anchor for structural loads. MAPE-ANTIQUE F21 super-fluid, salt-resistant, fillerized hydraulic binder made from



RIGHT. The design project for the renovation and seismic upgrading of the Sanctuary. **PHOTOS 1 and 2.** The vaulted ceilings before and after the renovation works.





IN THE SPOTLIGHT
MAPEWRAP C UNI-AX
 High strength, uni-directional carbon fibre fabric with high modulus of elasticity. It is suitable for the repair of reinforced concrete elements damaged by physical-mechanical action, for the confinement of axial loaded or bent concrete elements and for seismic strengthening of structures in earthquake zones.
 It can be also used for the reinforcement of load bearing elements in buildings that have been restructured for architectural reasons or change of use.



PHOTO 3. The FRP SYSTEM was used to strengthen the apse.

PHOTO 4. The outer faces of the ceilings were consolidated by pouring in MAPE-ANTIQUE F21 and then applying PLANITOP HDM RESTAURO and MAPEGRID B 250 basalt fibre mesh.

PHOTO 5. The masonry was strengthened with MAPE-ANTIQUE STRUTTURALE NHL and MAPENET EM40.

lime and Eco-Pozzolan was poured into the masonry, including the masonry decorated with frescoes.

To strengthen the masonry, it was rendered with MAPE-ANTIQUE STRUTTURALE NHL high-performance mortar made of hydraulic lime and Eco-Pozzolan, reinforced with MAPENET EM40 alkali-resistant glass fibre mesh and L-shaped MAPENET EM CONNECTOR fasteners made from alkali-resistant glass fibre and thermosetting vinylester-epoxy resin.

In the apse area of the Sanctuary, the FRP SYSTEM was applied, consisting of MAPEWRAP C UNI-AX 600 high-strength, unidirectional, carbon fibre fabric with a high modulus of elasticity, MAPEWRAP PRIMER epoxy primer, MAPEWRAP 31 medium viscosity epoxy resin, which was used to impregnate the fabric, MAPEWRAP 11 thixotropic epoxy paste and MAPEWRAP C FIOCCO unidirectional, high-strength carbon fibre cord to form structural ties.

Afterwards, the FRP system was protected with a layer of MAPE-ANTIQUE ECOLASTIC two-component, elastic, salt-resistant, cement-free, lime and Eco-Pozzolan based coating which is used for waterproofing and protecting construction elements, including those in listed buildings.

TECHNICAL DATA

Sanctuary of the Madonna dell'Ambro, Montefortino (Italy)

Original design: Ventura Venturi

Period of construction: 17th century

Year of the intervention: 2018

Intervention by Mapei: supplying products for consolidation and structural strengthening, as well as

for renovating the renders

Design: Diego Damen, Giulia Alessandrini, Luigino Dezi

Client: Cassa di Risparmio di Fermo, Amedeo Grilli

MIBACT (Marche Regional Office for Archaeological and Landscape Heritage and Fine Arts) supervisor: Domenico Cardamone

Works direction: Diego Damen, Giulia Alessandrini

Main contractor: AR Alessandrini Nello Srl

Mapei coordinators:

Pasquale Zaffaroni, Daniele Arnone, Lorenzo De Carli, Massimiliano Petti, Dominica Carbotti, Stefano Geminiani, Luca Consorti, and Francesco Carboni, Mapei SpA (Italy)

MAPEI PRODUCTS

Statical consolidation: Mape-Antique F21, MapeWrap B Fiocco, Planitop HDM RestauRO, MapeGrid B 250

Structural strengthening:

Mape-Antique Strutturale NHL, Mapefix EP 470 Seismic, MapeNet EM40, MapeNet EM Connector, MapeWrap 11, MapeWrap Primer 1, MapeWrap 31, MapeWrap C UNI-AX 600, MapeWrap C Fiocco
Protecting masonry surfaces: Mape-Antique Ecolastic

For further information on products see www.mapei.com