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Aix-La-Chapelle Cathedral

Mapei products and technologies played a major role in restoring the most ancient cathedral in Northen Europe

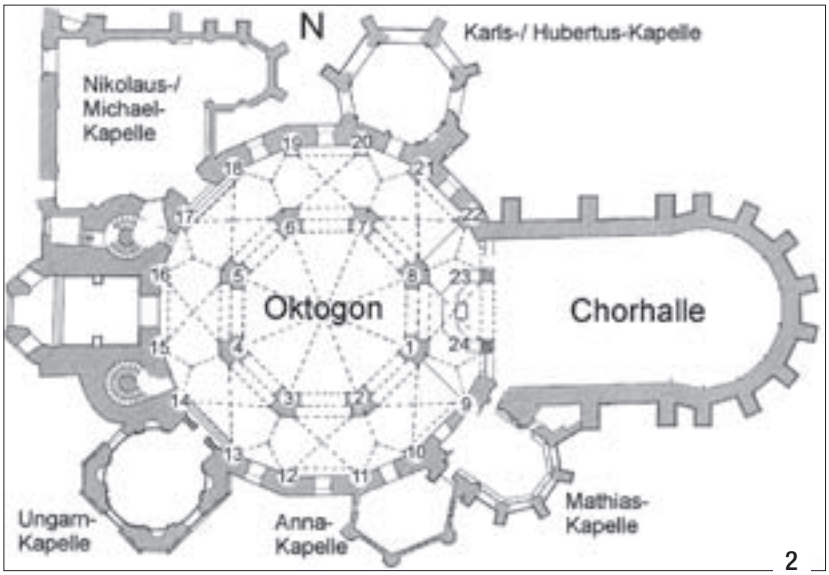
As a beneficence of Charlemagne, the Church of Our Lady (also called Marienkirche in German) was erected around 800 in the city of Aix-La-Chapelle (Aachen in German). In this church the emperor was entombed on January 28th, 814, the day he died. In succession of Charles, from 936 to 1531, the German-Roman kings were crowned in the Aix-La-Chapelle Minster. From the 14th century on, the Church of Our Lady became one of the most famous places of pilgrimage to the north of the Alps. In the sanctuary tour which is celebrated every 7 years, the dress of Maria, the so called "Jesus' nappies", the decapitation cloth of John the Baptist and Jesus Christ's waistcloth were shown. The increasing number of pilgrims, visiting the church was the reason for the extension in Gothic style of the Minster, starting from 1355. So the choir hall, a ring of 5 chapel extensions and a Gothic tower in the west section were built in the course of about 100 years.

The Church was severely damaged by the serious fire in Aix-La-Chapelle in 1856; the roofs and the tower including bells were destroyed.

The economic situation of the convent and the city of Aix-la-Chapelle only permitted a restoration in simple structures. In the 18th century, a late phase of baroquification started with the rise of Aix-La-Chapelle to a famous bath town. In the French period - in 1794 Aix-La-Chapelle was occupied by French troupes and belonged to France from 1801 to 1815 - the Minster was elevated to the Episcopal Cathedral of the first Aix-La-Chapelle diocese.

The restoration of the Aix-La-Chapelle Minster in the 19th century involved large-scale structural alterations. The Gothic elements were extensively renovated; a neo-Gothic West tower was erected in 1884 on the Carolingian West building. The neo-Byzantine interior decoration of the old Carolingian building is the impressive conclusion of this period.

Photo 1. View of Aix-La-Chapelle Cathedral.



Picture 2.
Ground view of the Cathedral with marking of the pillars of the octagon (no. 1 to 8) and of the pillars of the sixteen-angle (no. 9 to 24) which were involved in the restoration works.

Photo 3.
The middle building in the cathedral complex (called "octagon") with its neo-Byzantine mosaics.

Thanks to its unique historical and art-historical importance in the European context, the Aix-La-Chapelle Cathedral was the first German building which entered the UNESCO world heritage list in 1978. Today the Aix-La-Chapelle Cathedral is a living Lord's House as Episcopal Church of the diocese, re-established in 1930, where several Masses are celebrated every day. The sanctuary tours attract all 7 years a great number of pilgrims and continue the old tradition of pilgrimage. Thanks to its invaluable importance for the European mediaeval history of culture and art the Aix-La-Chapelle Cathedral draws every year about one million of international guests, who can visit the central building and the treasure chamber and, in the course of guided tours, also the choir hall and the High Minster.

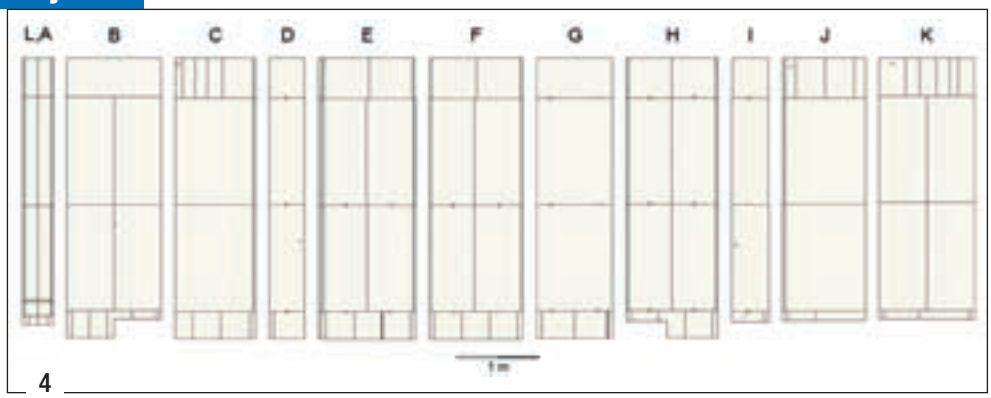
The Building Design

The ground plan and building design of the Aix-La-Chapelle Cathedral are evidence of the Church's changing importance and use. The Carolingian building, an octagon, arched by a cupola, is in sound condition for the most part. The octagon is surrounded by a two-storey, sixteen-angled gallery and is furnished with a tremendous foyer front. The mediaeval throne, which can be dated back to the Carolingian period, as the latest analysis show, is positioned in the Western span of the high Minster. The Gothic choir building joins in the East. This building, unique from the static point of view, is dominated by the about 26 m high window panels. 5 chapel buildings, designed with non-uniform outlines and on the majority carried out as two-storey units in the Gothic period, abut upon the exterior walls of the sixteen-angle. The central mosaic of the cupola with the *Majestas Domini* and the 24 Eldest decorative patterns was designed in 1880-1881 according to the plans of Jean Bethune. The further mosaic and marble decoration of the octagon traces back to the design of Hermann Schaper and Friedrich Schwarting in the late 19th century.

Restoration Works

The history of the restoration of the Aix-La-Chapelle Cathedral started in the middle of the 19th century with the re-erection of the pillars of the High Minster which were demolished in the French period; followed by the recreation of the decorations and the glazing of the windows of the choir hall, accompanied by the overal ligthening of the Cathedral. Having survived the 2nd World War relatively undamaged, the local damages occurred in the building were repaired and single parts of the structure worked over object-oriented.

In the course of an extensive documentation of the damages in the early 80s, an enormous need for reconstruction was stated. At the end of 2005 reconstruction work started: the interior reconstruction of the cathedral included the restoration and conservation of the mosaic and marble décor of the central building, as well as the repair of natural stone coverings on the octagon pillars, which began in 2007 and was completed in 2010.



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The Restoration of the Natural Stone Slabs

The natural stone coverings of the inner walls of the pillars of the octagon and of the sixteen-angle, which were installed only 120 years ago, showed clearly visible damages. The natural stone slabs which were applied here are made of a natural stone variety called "cipollino", classified as an ophicalcite from petrographical point of view. The type applied here comes from Saillon in Switzerland. The repair of the damages was absolutely necessary, in order to be able to counteract the destruction of this cultural-historical building structure. In 2006, the expert office Rock and Mineral Consulting, Albrecht Germann & Ralf Kownatzki GbR, which is based in Herzogenrath (Germany), was entrusted with the examination of the damaged natural stone covering of the pillars of the octagon and sixteen-angle by the Cathedral master builder Helmut Maintz from Cathedral chapter Aix-La-Chapelle. The first aim of this examination was to find the reason for the deterioration of the wall slabs. It could be demonstrated, that a considerable part of the chemically caused damages to be seen on the surface of the wall slabs, must be traced back to natural alteration processes. They are the result of the attack by carbonic acid, which is a product of the reaction of carbon dioxide with water.

The measurements of selected gases in the compartment air of the octagon in the Aix-La-Chapelle Cathedral could verify that a serious part of the gas carbon dioxide comes from the exhaled air of the visitors. On peak days, especially in the pre-Christmas period, 15,000 visitors per day are registered. The water which is necessary for the formation of the carbonic acid is provided from the air humidity, which condenses on the surfaces of the stones on colder days.

In a further step of the analysis, the damages of the octagon and the sixteen-angle in the ground floor were documented and assessed in detail. 1,200 wall slabs with a total area of 385 m² were examined. The scope of the damages, caused by weathering, ranged from losses due to polish to bigger breakaways. Moreover, cracks in the stone were of particular interest, which were separately examined and assessed because of their enormous frequency. Basing on these findings, measures for a purposeful restoration of the wall slabs were discussed and worked out in close collaboration with Helmut Maintz.

With regard to the restoration

Picture 4. Execution of the pillar n. 1 in the octagon.
Photo 5. Removal of the natural stone slabs from the pillars.
Photo 6. Cleaning of the back sides of the slabs from mortar residues.
Photo 7. Storage of the stainless steel sheets and the prepared natural stone slabs for acclimatisation in the octagon.
Photo 8. Mounting the stainless steel sheets on the pillars.
Photo 9. Determination of the deformation behaviour of the sandwich elements in the climate chamber.

IN THE SPOTLIGHT

KERALASTIC T

It is an improved **(2)** reaction resin adhesive **(R)** and slip resistant **(T)** as class **R2T** according to **EN 12004.** It is ideal for indoor and outdoor, wall and floor bonding of ceramic tiles, stone material and mosaics of all types on screeds, renders, concrete, asphalt, wood, metal, PVC, reinforced polyester, asbestos-cement, gypsum board, gypsum panels, etc. KERALASTIC is a two-component solvent and water-free thixotropic adhesive which is flexible and waterproof.

It is made up of a polyurethane base (Part A) and a special hardener (Part B). When mixing the two parts together, the result is a paste with easy workability; excellent durability and resistance to ageing; perfect adhesion on all surfaces used in building; high deformability. It is highly thixotropic: it can be applied vertically without slump and without letting even heavy or large tiles slip.

It can contribute up to **2 points** for the **LEED** certification.


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Photo 15. Stainless steel sheets mounted as supporting layer.
Photo 16. Application of KERALASTIC T on the stainless steel sheets.
Photo 17. Mounting of the natural stone slabs.

in the demonstration area of the Mapei GmbH Technical Service Department. The practicability of mounting the natural stone slabs from the scaffold, as well as the accurate adjustment of the slabs considering their thickness tolerances and the still considerable tolerances in the evenness of the support, were tested at the exhibits. KERALASTIC T proved to be the optimal choice thanks to its slip resistance and the possibility of applying it in layer thicknesses from 5 to 15 mm. Front sides and side surfaces could be mounted perpendicularly and horizontally, despite the partially considerable tolerances in evenness.

After complete reaction of the adhesive, adhesive strengths of >1,5 N/mm^2 were measured, which guarantee the permanent adhesion of the natural stone slabs to the stainless steel sheet.

The different temperature extension behaviour of the materials (natural stone, stainless steel, epoxy resin and polyurethane resin) which were applied in the "sandwich-like" system, required the examination of the elements in the climate chamber, considering the climate conditions in the cathedral. For this purpose, the sandwich elements were stored in the climate chamber at a relative humidity of 50% and exposed to 24-hours-climate cycles of 40°C-10°C-40°C.

The tests were carried out in order to determine the elongation and deformation of the sandwich elements and the possible alterations of the adhesion between the different materials. The result of the measurements was a maximum deformation of 3.5 mm. This means, that a temperature difference of +/-5°C must be achieved, prior to the start of the works. Basing on the average deformation rate (3.5 mm), the real elongation results to be of 0.55 mm, which can surely be relieved with the 1 mm wider joints between the sandwich elements. A reduction of the adhesion spectrum, resulting from the different temperature extension behaviour, can be excluded in case of professional mounting. The result of the practice tests carried out in the Mapei GmbH Technical Service demo area and the tests in the climate chamber showed that the Mapei solution, developed by the experts, could be realised in the practice and perform well.

Visitors to the Cathedral can now enjoy the sight of properly restored pillars with natural stone coverings brought back to their original beauty.

This article was taken from Realtá Mapei n. 7/2009, the in-house magazine published in German language by the German, Austrian and Swiss subsidiaries of the Mapei Group, whom we would like to thank.

TECHNICAL DATA

Aix-La-Chapelle Cathedral, Aix-La Chapelle (Germany)
Period of Construction: late 8th century

Period of the Intervention: 2007-2010
Intervention of Mapei: supplying products for restoring and laying natural stone slabs on several pillars in the octagon and in the sixteen-angle
Client: Diocese Aix-La-Chapelle
Project: Helmut Maintz, Aix-La-Chapelle Cathedral Building Management
Works Direction: Helmut Maintz
Contractor: Aix-La-Chapelle Cathedral Building Management
Laying Company: Steinmetz- und Steinbildhauerei Christoph Schwarzenberg (Aix-La-Chapelle)
Geo-scientific Analysis: Rock and Mineral Consulting Dr. Albrecht Germann & Dr. Ralf Kownatzki GbR (Herzogenrath,Germany)
Laid Materials: natural stone slabs (ophicalcite)
Mapei Distributor: Schmidt Rudersdorf, Würselen (Germany)
Mapei Co-ordinator: Walter Mauer, Mapei GmbH (Germany)

MAPEI PRODUCTS

The products mentioned in the article belong to the "Products for Ceramic Tiles and Stone Materials" and "Building Speciality Line" ranges. The technical data sheets are available at the web site: www.mapei.com. Mapei's adhesives for ceramics and stone materials conform to EN 12004 and have been awarded the CE mark in compliance with Annex ZA, standard EN 12004. Mapei grouts for ceramics and stone materials conform to EN 13888. Almost all the Mapei products for laying floors and walls are also GEV-certified and have been awarded the EMICODE EC1 ("very low emission level of volatile organic compounds") mark by GEV. Mapei products for the protection and repair of concrete surfaces and structures have been awarded the CE mark in compliance with EN 1504. More than 150 Mapei products can contribute points to obtain the LEED certification.

Eporip (CE EN 1504-4): two-component epoxy adhesive for monolithic sealing of cracks in screeds.
Eporip Turbo: fast-hardening two-component polyester resin for sealing cracks in screeds.
Keralastic T (CE EN 12004, R2T): high performance two-component polyurethane adhesive with no vertical slip for ceramic tiles and stone material.
Mapetex: special non-woven fabric that can be used as a substrate for the installation of floor and wall coverings that can be easily removed.
Primer MF: solvent-free two-component epoxy primer to be used as an adhesion promoter of Mapefloor line products and to consolidate and waterproof, from residual damp, cementitious substrates. Also used to impregnate surfaces of unsound concrete floors.