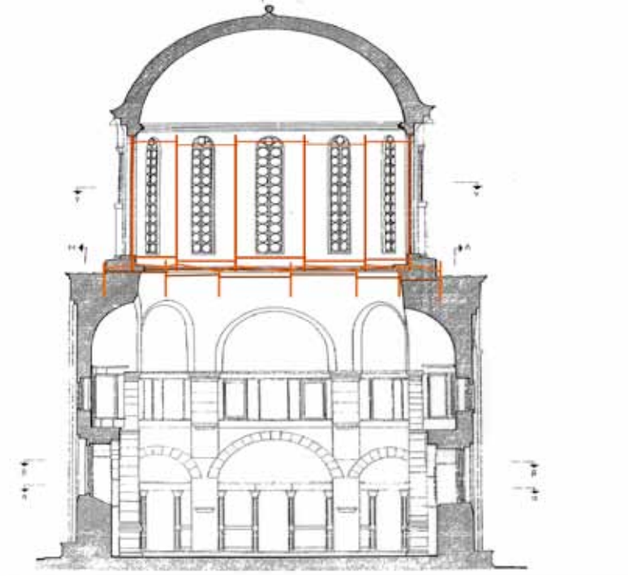

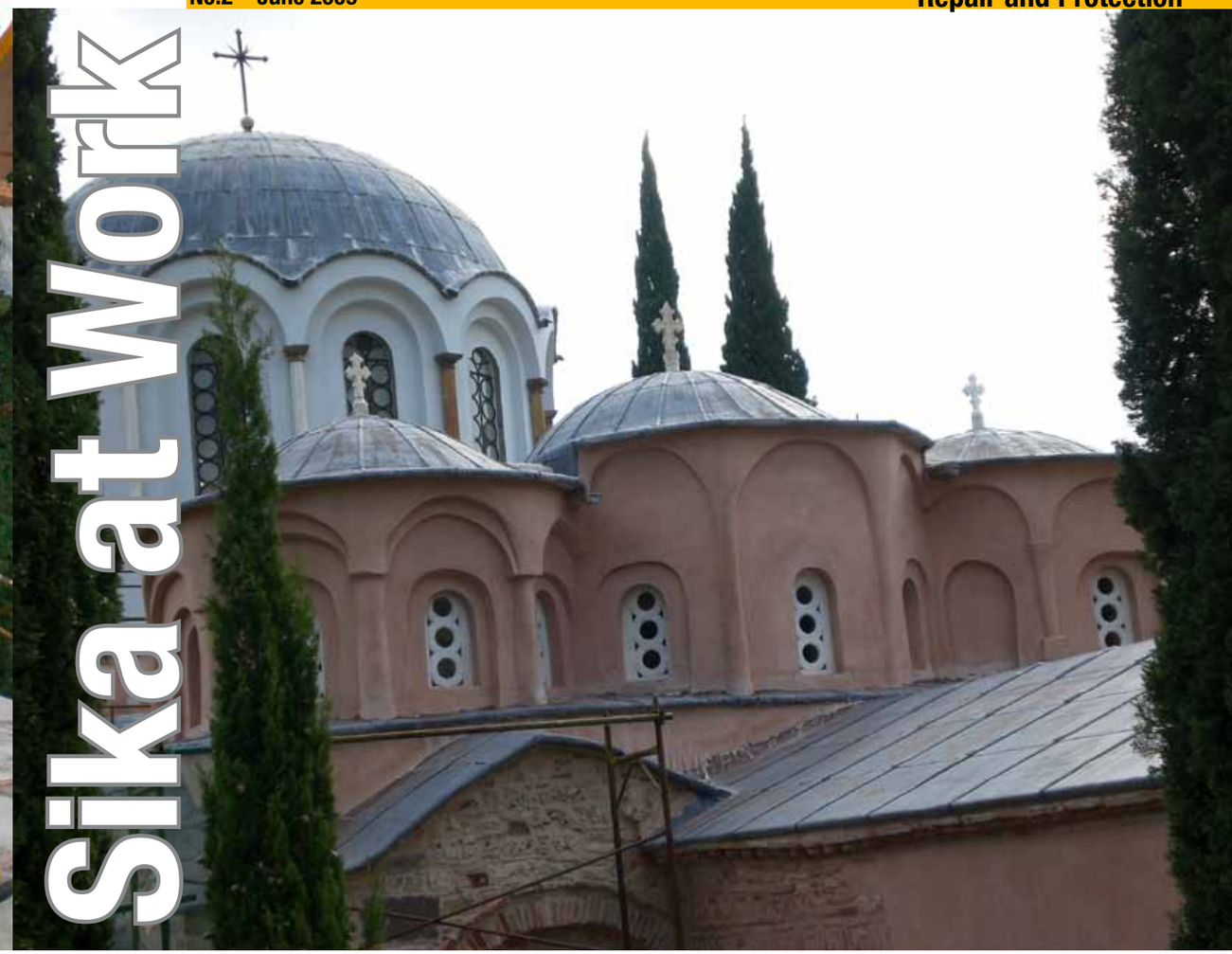

Sika at Work

For the preservation against corrosion of the embedded steel reinforcement of the masonry of the cupola in the major church (Catholicon) of Nea Moni of Chios, the technology of Cathodic Protection with discrete anodes **Sika® Ebonex®** was chosen. This is an intervention technique used widely allover the world for the protection of steel reinforced constructions in cases of high chloride content. The European Standard **ELOT EN 1504** "Products and systems for the protection and repair of concrete structures – Definitions, requirements, quality control and evaluation of conformity" states in Part 9, Principle 10 that Cathodic Protection is a technique used to improve the durability of steel reinforced concrete structures. Essentially the process is both electrical and chemical, that is electrochemical method, and is working by applying the external anode and passing current from it to the steel so that all the steel is made into a cathode. The best known and most established technique is cathodic protection. This subdivides into impressed current cathodic protection - **Sika® Ebonex®**, and galvanic (also known as sacrificial) cathodic protection - **Sika® Galvashield®**.

Cathodic Protection of Steel Reinforcement using Sika® Ebonex® Discrete Anodes

Case Study: Monastery of Nea Moni of Chios

Sika Hellas ABEE
15 Protomagias Str.
145 68 Kryoneri
Athens - Greece
Tel. + 30 210 81 60 600
Fax + 30 210 81 60 606
www.sika.gr

Hot Line
801 700 sika 7452

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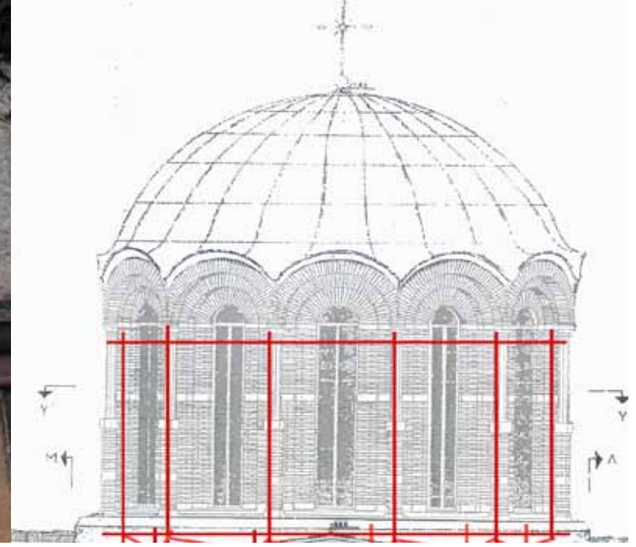

History – Chronology of the Restoration Phases

The Holy Nea Moni of Chios is at the same time one of the most important monuments of Greece and an internationally recognized Monument of Cultural Heritage of UNESCO. The monastery began being constructed at the end of 1042 or at the beginning of 1043 and its construction period lasted for 12 years.

The first most important destruction dates back to 1822 during the massacre of the Christian population by the Ottoman Empire. Its occupation was followed by lootings, larceny and its burning. The second large scale disaster took place relatively shortly after the first, at 1828, when Favieros set out at Chios. Moreover, at the end of the 19th century there are reports for a new burning down of the monastery. However, the largest destruction for the Nea Moni comes as a consequence of the catastrophic earthquake of 1881. This earthquake literally razed the island and caused the most serious damages to the major church (Catholicon or Katholikon). The previous and the newer fires, as well as the deterioration caused from rainwater, contributed to the strength reduction of the domes of the Katholikon, which could not withstand the powerful seismic strain. The central cupola and the eastern apse of the Katholikon with the arcs collapsed, and numerous cracks were formed allover the structure.

The first efforts to restore all these damages took place originally at the beginning of the 20th century. During this period, in an effort to improve the resistance of the construction to earthquakes, a steel reinforcement was added to the cupola. However with time and due to the airborne chloride transportation, the corrosion of the steel reinforcement was initiated and as a result of that, there were new severe damages due to the swelling of the iron oxides.

Next in this case study, there are technical proposals mentioned regarding the protection of the steel reinforcement from the disastrous consequences of corrosion.

Holistic Management of Steel Reinforcement Corrosion with Sika Technologies

Conventional Restoration – Protective Coatings

In the general frame of the techniques that could be used for the restoration of the monument, there were various that had very adverse consequences for the Katholikon, such as the total dismantlement and reassembling of the masonry of the cupola, so as to liberate totally the metal frame. However, this act allows in a next phase, either to use protective coatings **SikaCor®,** coating slurries containing corrosion inhibitor **SikaTop® Armatec® 110 EpoCem®** in already existing metallic elements, or even to totally replace them with a higher durability metals (e.g. stainless steel, titanium alloys).

Application of a Corrosion Inhibitor through Impregnation

The successful use of corrosion inhibitors dates back many years in other types of applications and is established more and more in the Civil Work constructions, as a part of the integrated control strategic of the steel reinforcement corrosion control. Essentially we talk about liquid, amino-alcohol based impregnations (**Sika® Ferrogard® 903+**) that penetrate into concrete/ mortar, creating a monomolecular protective layer on the surface of the steel reinforcement. The result of the use of this type of technology is twofold: from one side it suspends the initiation of the corrosion and on the other side reduces the corrosion rate, resulting in prolongation of the service life of the construction.

Electrochemical Chloride Removal Technique

In the framework of the intervention techniques, during the past years there have been developed technical solutions of a high technological level that impart a high degree of durability to the construction, enabling thus a direct intervention to the mechanism that is responsible for the wear of the construction. The electrochemical technique (**Norcure®**) that is based on the abstraction of the chlorides from the masonry formed a methodology that had to be evaluated before making the final decision. This practice is based on the principle of electro-osmosis according to which during the application of electrical current on a porous material, the liquid contained in its pores tends to move towards the negative electrode. This procedure manages to direct the chlorides (negatively charged) to a positively charged metal frame (anode), which is surrounded by an electrolyte (a tank for assembling the ions).

Cathodic Protection Technology from Sika

Cathodic Protection

One of the systems of total protection of the corrosion phenomenon is Cathodic Protection. Its principle is based on the application of a voltage opposite to the corrosion voltage, transforming thus a metal bar into a cathode of an electrolytic cell. Therefore, through this procedure, the oxidation reactions in the anode are suspended and in their place we have reduction reactions. The voltage of the Direct Current is caused by two different ways, which are either the imposition of voltage from a DC source, using at the same time **Sika® Ebonex®** anodes, or either by the galvanic actions provoked due to the voltage developed between a metal / alloy of higher potential (**Sika® Galvashield®** anodes) than the one that protected steel reinforcement has.

The system of the cathodic protection with application of DC electricity is comprised of basic components, such as the anodes (i.e. grids, coatings, paints, discrete anodes), the power supply/ rectifier for the supply of the electrical current, the surveillance system (reference electrodes) and the feed and communication wires. This assembly allows the electrons to flow from the anodes (anode) throughout the mortar (electrolyte) towards the reinforcement (cathode). Through the application and the adjustment of electrical current up to an accepted level, the flow from the most reactive zones is reversed and all the reinforcement is transformed into a cathode element, putting in operation the mechanism of corrosion control.

For the cathode protection of the Nea Moni of Chios, the impose of voltage from a source of electrical current was chosen, in combination with suitable discrete anodes **Sika® Ebonex® CP 18/100**, with a diameter of only 18 mm and 100 mm length, which were embedded in the masonry. The service life planning is significantly extended and all the actions for maintenance and replacement of the discrete anodes are very easy. Additional characteristics of this technique with the discrete anodes contrast the conventional techniques of cathodic protection even more (grids, paints, etc.), proving thus even more the need for such a choice.