Special Publication No. 70

Proceedings Of
The Egyptian - Italian Seminar

ON
GEOSCIENCES AND ARCHAEOLOGY IN THE MEDITERRANEAN COUNTRIES

Cairo , November 28 - 30/1993

E A O

ASRT

EGSMA

REPVBBLICA ITALIANA

THE GEOLOGICAL SURVEY OF EGYPT
CAIRO 1995

Proc. Geosciences & Archaeology Seminar (1995) pp. 253 - 260

ADVANCED RESTORATION TECHNIQUES AGAINST THE EFFECTS OF SOLUBLE SALTS IN THE STONE OF THE EGYPTIAN MONUMENTS

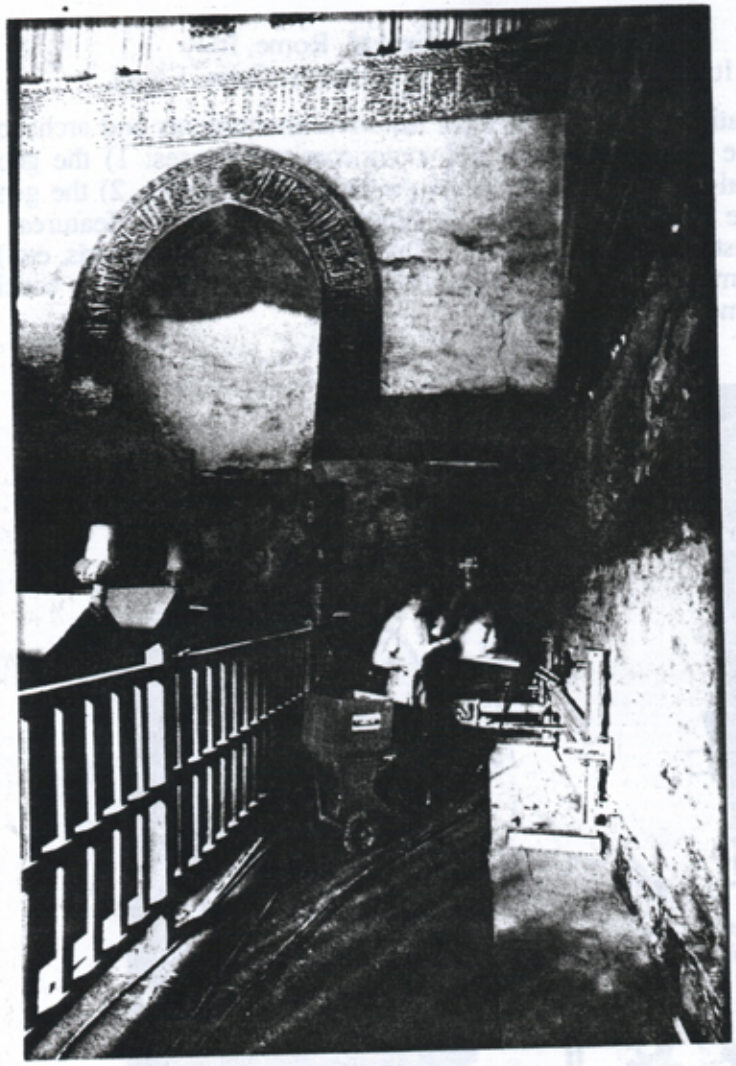
Luisa Bongrani[1], And Giuseppe Fanfoni[2]

1. Università "La Sapienza", Rome, Italy
2. Italian-Egyptian Restoration Center, Cairo, Egypt

The main conservation problems for most historical monuments and archaeological sites in Egypt and the Near East, are linked to concomitant causes: 1) the geological origin and the physical-chemical properties of the building materials, 2) the geological characteristics of the soil, 3) and the geographical and social features of the environment. We must add occasional ruinous events (earthquakes, floods, etc.) to the above-mentioned permanent factors of decay which have caused and are causing the loss of hundreds of monuments in Egypt.

The exterior of Hasan Sadaqa Mausoleum

Lucas (1915) gave an exact outline of the principal decay factors and the specifical geographical problems since 1902: "The disintegration is entirely a physical and not chemical phenomenon, and is caused by the crystallization of various salts, mainly sodium chloride, underneath the surface layers of the stone. For such crystallization to take place three conditions are necessary: first, the presence of water-soluble salts, secondly the presence of water to dissolve the salts, and thirdly the opportunity for the salts to be brought to the surface of the stone and there to crystallize out by the evaporation of the water holding them in solution". His correct diagnosis must be brought up to date, just regarding a limited industrialization which is adding environmental decay causes, known by Lucas only in Europe and North-America.



The works for cutting the walls of Hasan Sadaqa Mausoleum; dampness was rising a level of 5 m with 90-95 % of humidity.

The above -mentioned degradation process concerns all Egyptian monuments (since the salts are in large quantities in the geological formations exploited for building materials), and is presently hastened by recent environmental changes.

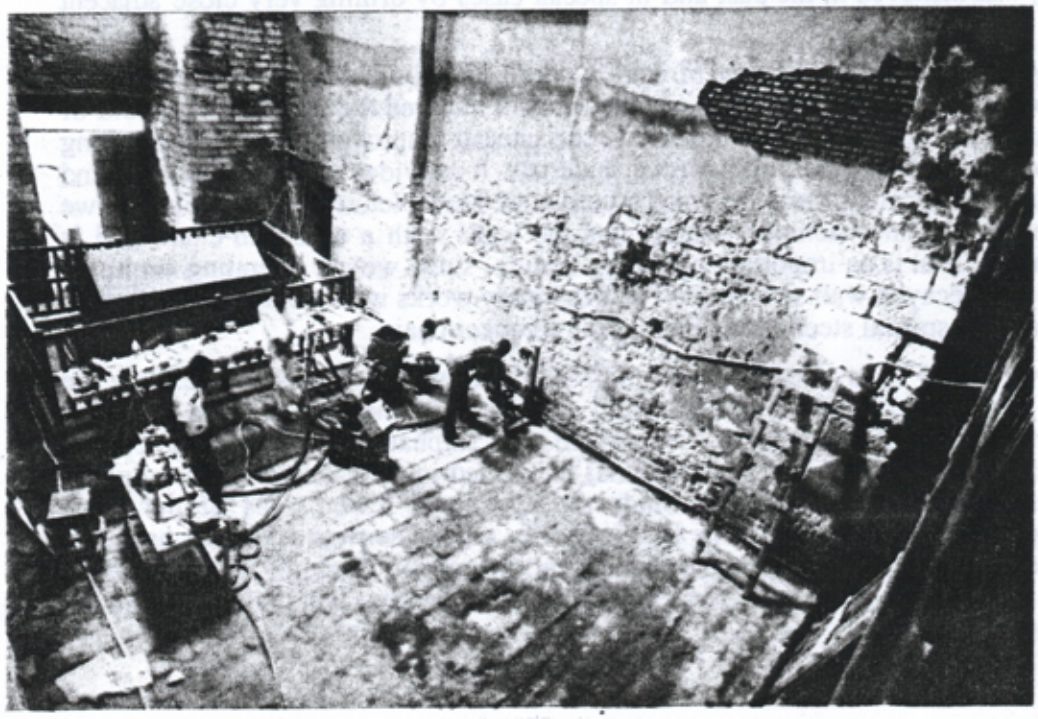
Since 1987 research has been under way by Prof. Fanfoni on the Hasan Sadaqa Mausoleum (in the Mawlawi architectural complex, where the Center is placed) with a financial contribution of the Italian CNR; it consists of periodic measurements of the moisture in the walls (carried on a grid of squares whose side is 50 cms.) and related to the ambient humidity and temperature.

The data analysis has essentially shown two kinds of action by the moisture; the absorption of humidity from the air by the salts inside the walls and the rising moisture from the ground. The same situation concerns, more or less, all Egyptian monuments.

The absorption of air humidity causes antiaestetic spots on the walls, but is not as dangerous for the building as the ascending moisture. The quantity and height of dampness depend on the depth to the ground water-table, the thermal difference between the lower level and the upper part of the buildings (particularly when they are insolated) the porosity of the materials, and the width of the suction cross-section. It causes external pulverization, swelling and falling of materials and sometimes sudden collapse of the structures. Any external restoration of the walls is useless and even dangerous in that situation; the only solution is to stop the capillary suction of dampness from the ground.

The most effective and tested for technologies for blocking the rising dampness provide the setting of a waterproof layer at the ground-level of the buildings, either by the injection of resins and liquid chemical materials in holes (made in the thickness of wall, in two rows and at a distance of about 30 cms), or by cutting the walls and inserting a continuos water-proof layer.

The "injection system" is effective only for some kinds of masonry: it reduces the suction cross-section, but doesn't grant a good control on the injection of the isolating materials.



The cutting of the walls in the Iwan of Sunqur Sa' di Madrasa

The Italian-Egyptian Restoration Center, in the project of Prof. Fanfoni, used the "injection system" successfully in the Sama'khana of the Mewlewi Derwishes in Cairo which was built on the remains of the Sunkur Sa'di Madrasa, partly re-using them. But the final result of dampness control was achieved through a series of combined operations of "appropriate technologies in the following manner". Holes in two rows and alternate position, were made under the level of the floor (this was possible in this particular structure of the building which is placed on ancient remains) and filled with injections of epoxy-resins.

Besides this, a ditch (one meter wide) was dug around the Sama'khana beneath the outside ground-level, and then was covered leaving two openings on the north and south sides: the air-space provides a continuous ventilation, and further reduces the rising dampness.

Finally, different types of binders were selected for restoring the internal paintings and renewing the external paint, in order to cause a transpiration movement on the outside and keep the inner decorations. No rising dampness has been remarked till now on the building, after five years. Only few spots are present on the outside surface of the Sama'khana walls. They refer to the absorption of the air moisture by the inner salts of the old stones and not to the ground humidity. Restoration operations could be carried out to effective results, mainly because Sama'khana is located on archaeological remains we have excavated, so that there is a hollow space under it at present.

The Mausoleum of Hasan Sadaqa (where we are presently working) has the water level at grade with the ground-floor, or at few centimeters underground, as for other monuments in the district.

We resorted in that case to advanced technologies for cutting the walls and setting a waterproof layer at the ground-floor in order to block the great quantity of rising dampness caused by capillarity.

The waterproofing technique by making holes and filling them with special materials, was achieved in the past and in special cases by drilling very close adjacent holes.

The system required a long time of working and implied some danger due to the use of fresh water for cooling, but the adjacency of holes allowed the presence of a kind of continuous layer. The technique utilised is the present improvement of the blocking system, obtained by filling it with special materials. It provides a cutting machine and special elements forming the waterproof layer. In the Mausoleum of Hasan Sadaqa we used a special Italian machinery which cuts the walls with a sprocken-chain and is dry-operating. That is an important operating feature, since we are operating on huge, but weak and decayed wall structures. The machinery works with a blade (three meters long) made of a special steel alloy, lodging the sprocket-chain.

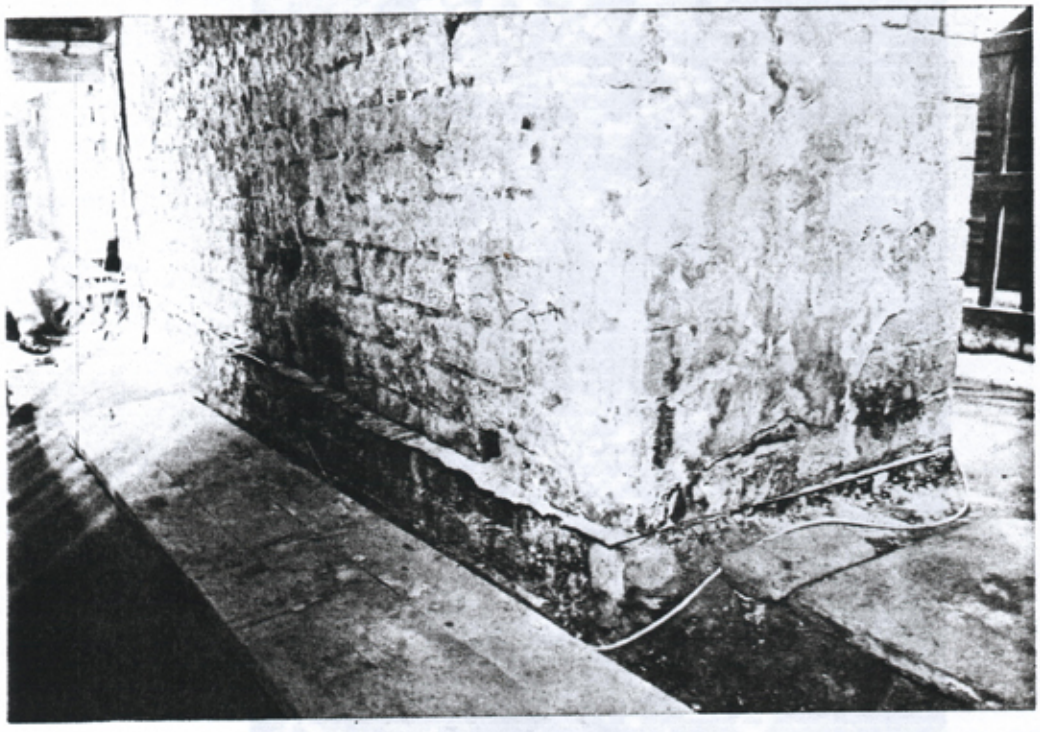
The waterproof layer, we set, consists of PVC strips of a special shape: they are inserted, for every 20-30 cm into the void cut through the wall by the blade. A particular mixture of expansion - controlled and sulphate - proof ferric cement without chlorides (granted by Pagel Italiana) is injected immediately after the slipping of the sheets. The mortar injection binds the upper and lower sides of the strips (featuring grooves) to the wall. The layer also has an anti-seismic function, as tested on the occasion of the latest earthquakes in Egypt. Moreover, it can be easily removed with the same machinery used for cutting, respecting the reversibility restoration principles.

A stone of the Madrasa wall at the upper level of humidity evaporation: the layer of salts is 2 cm. thick.

The technique we have successfully used in the Hasan Sadaqa Mausoleum may solve the problem of the rising dampness wearing the Egyptian heritage, also in the case of huge monuments.

Of course, that kind of operation requires specific technical devices for every case (for example, we had to strengthen the decayed and weak walls of the mausoleum, before cutting them), a machinery fit for the intervention, a specialized technical staff, and proportionate expenses.

Prof. Fanfoni has planned a technical project for blocking the process of decay caused by the rising damp in the Great Sphinx; the executive program has been presented in the "7th International Congress on Deterioration and Conservation of Stone" in Lisbona, one year ago. It is based on the above reported cutting and water-proof layer system, by using a more powerful and improved machinery studied in collaboration with the Italian firm Umiblok.



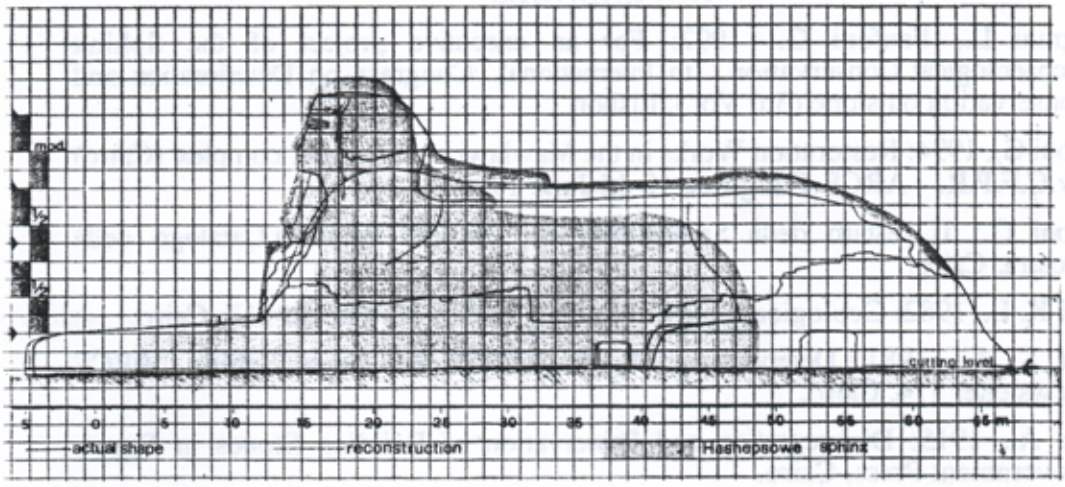
The water-proof layer inserted at the base of the Mausoleum wall.

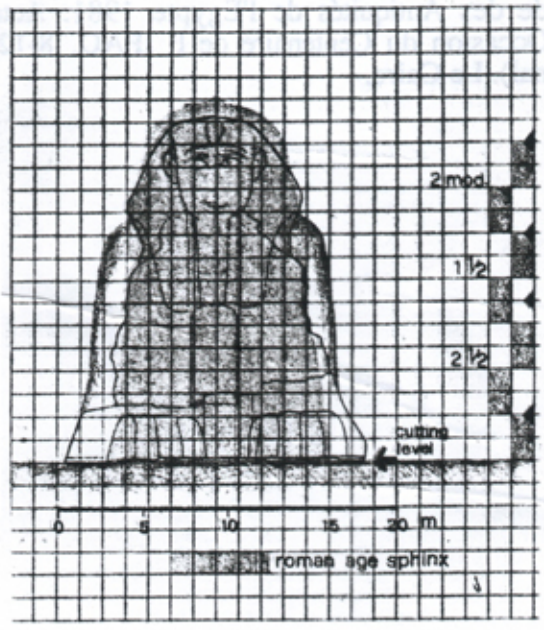
The project provides a vibration-proof and dry-operating blade (17m long) it moves by hydraulic system on parallel rails along the sides of the Sphinx. An automatic leveling equipment will prevent the flexure of the long blade. The cutting step will be 1-2 m. long (depending on the consistency of the rock) and 5cm. thick: that space will allow the insertion of internal optical soundings in order to control either morphological problems (eventual fissures) and the acquisition of archaeological data (as assumed, we don't know how much rationally), before inserting the water-proof layer.

The void will be filled by the waterproof layer consisting of PVC specially shaped strips immersed in an expansion-controlled and sulphate-proof ferric cement without chlorides; its consistency will prevent capillary penetration into the rock. We propose the PVC elements, we have successfully used, instead of a polyester sheet (as generally used) or a titanium steel plate: they will make a separated block with the special cement, and may be easily destroyed in the case of removal of the whole layer.

The filling will be verified by sound waves, and a computerized check will keep control of the program.

Our experience proves that the blocking of the rising dampness and the elimination of the main factor of decay of the Egyptian monuments is preliminary to any further restoration operations which may prove to be dangerous.





The Great Sphinx:

1) the present shape is in yellow colour;

2) the prportions of a canonical sphinx are over-impressed in dark colour;

3) the hypothetical original proportions in blue colour.

REFERENCES

Bongrani L., Fanfoni G., 1992: For an executive project of the Sphinx archaeological Conservation. 7th International Congress on Deterioration and conservation on stone (3rd Vol.), Lisbon.

Fanfoni G., 1994: Restoration Works in the Mawlawi architectural complex (Cairo) by C.F.P.R. - ARCE Congress, 12-15 June 1993.

Fanfoni G.: II restaro della Sama'khana dei Dervisci Mevlevi.Catalogo della mostra. Cairo.

Gauri K. L., 1982: Geological Study of Sphinx. ARCE Newsletter 117, Cairo.

Gauri K. L., 1981: Deterioration of the stone of the Great Sphinx. ARCE Newsletter 114, Cairo.

Lucas A., 1915: Disintegration and Preservation of Building Stones in Egypt. Government Press, Cairo.

Mamillan M., 1992: Review of the Work on Application of Modern Auscultation Methods in Diagnosis of State of the Great Sphinx. The First International Symposium on the Great Sphinx. Cairo.

Prospection et Sauvegarde des Antiquités de l'Egypte 1981: Actes de la Table Ronde Organisée à l'Occasion du Centenaire de l' IFAO. 8-12 Janvier 1981 (Edités par N. C. Grimal). Le Caire.