Technologies and techniques applied to the restoration, in the CIERA work-site school

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The Italian-Egyptian Centre for Restoration and Archaeology (CIERA) operates in a monumental complex at the foot of the Citadel of Cairo, near the mosque of Sultan Hassan (*fig **1***). The area is wide approximately 10,000 square meters, of which 2,500 meters are covered with debris.

The buildings of the area are (fig.**2**):

- The Palace of Qusun-Yashbak-Aqbardi: 14th and 16th centuries.
- The Madrasa of Sunqur Sa'di: (14th century) with the underlying archaeological area and remains of different epochs, starting from 7th century A.D.
- The Mausoleum of Hasan Sadaqa: (14th century) and the adjoining the madrasa with its minaret.
- The "tekeyya," which is the Convent of the Mevlevi Dervishes. 16th century
- The Sama' Khana: which is a theater built by Mevlevi Dervishes (starting from 18th century) where they performed the circular mystical rite of their confraternity.

All the architectural remains of the area are covering the period from VII to XIX century, therefore they are made with traditional and artisanal techniques and technologies

(Fig. **3**)The traditional technologies were generally characterized, in the monumental architecture, by so-called heavy structures, made with techniques of juxtaposition of constructive elements, assembled, with or without, bedding mortars.

(Fig.**4**) The modern technologies, developed in the historical industrialization process, have had particular evolution by the production of new materials, cement, iron and plastic. Their application have made advanced technical solutions, of joints, truss beam, shaped frame: anyway, stable structures and in some way elastic.

(fig.**5**)The attraction to modern technologies have exalted human ambition in extreme technical applications. In the restoration of the historical buildings, however, the materials and the modern technologies are useful only, with special attentions in the applications.

(fig **6** sama'khana before and after) Consequently, the continuous and prudent control during the restoration intervention, recalls, once again, the artisanal laboriousness to which the same antiquities belong to.

(fig **6a**) Therefore, the organization of the work-site school evokes an artisanal laboratory, where each work is lived in the cognitive and creative process, till the in site application.

Restoration of the sama'khana dome

When we started restoration work in the area, the dome of the sama'khana was in danger of falling down as it had been flattened and distorted by a great deal of settling of the foundation. (fig **7**)

The *sama'khana* dome, having a circumference of 34 meters (fig **7a**) and structural thickness of only 10 cm, is among the largest and lightest ones constructed in wood in Cairo.

(fig **8**) We applied an iron belt (composed of three elements) on the outside at its reins. (fig **9**) By tightening the bands gradually and checking the reduction of the cracks from inside (fig **9a - 10**), the dome recovered as far as possible its original shape, (fig **11**) which reduced the perimeter, at the reins, by 20 cm, which has had the effect of raising the apex of the dome by 12 cm.

(fig.**12**) The laths forming a covering under and over the ribs were sewn up with strips of wire netting. (fig **13**) Glass wool, as new recognizable material, was put inside the hollow spaces for thermal insulation. As didactic aim, a movable panel on the dome extrados allows to see the restoration work carried out.

(fig **15**) The effectiveness of the intervention, for the dome structure stabilization, was evident in 1992, when the iron bands, mechanically sliding on the ribs, allowed to absorb any solicited movement by the earthquake, without causing disconnections to the dome

And all parts of the building were also sewn together with an anti-seismic system of tie-bars and iron connections.

A perimetrical concrete *cordolo* inside the thickness of the wall is fitted in deeply by iron rods, which are linking the vertical walls with wooden structure of the roof and the dome elements. The shape of the roof square has been strengthened by diagonal iron tie-bars anchored to the concrete *cordolo* beam.

(fig **15a**) Besides, it was made the archaeological excavation under the sama'khana for the stabilization of the foundation, which recovered, under it, the madrasa of Sounqur Sa'di. Therefore, the new foundation and the iron floor which is linking the perimetrical walls, was made as an anti-seismic connection at the ground floor level of the sama'khana. The injections in the walls (**16 -16a**) had been made, in the bricks structures, by epoxy resins (with autoclave machine made by CIERA), and, (fig **17**) in the walls of mixed stones, the injections had been made by lime and powdered inert with addition of acrylic or vinyl resins (avoiding acrylic in the walls having salts).

Rising Damp in the sama'khana

(fig **17a**) For the elimination of humidity in the *sama'khana* walls, we made two rows of holes, which were filled with injections of particular water dispersion epoxy-resins.

But, the complete elimination of humidity was ultimately ensured, by means of a one-meter-wide air space excavated around the *sama'khana* with two openings on the north and the south in order to provide continuous ventilation, which solves effectively the problem.

The paintings (fig **18)**

(fig **19**) A study of the original paintings and the following restorations was carried out by using (fig **20**) ultraviolet photos and analyses of (fig **21**) microscopic sections, which showed that (fig **22**) originally, the sama'khana was simply painted in white and ivory yellow, with red and blue squares. The white dome was illuminated by eight windows afterwards closed from paintings
Since the eight number has a special mystic symbolism in the Mevlevi ideology, we installed eight simultaneously movable window panes in order to keep the paintings and to make it possible to see the dome in the original light, (fig. **23**).
The integration of the missing parts was carried out by using reversible colors, (fig **24**) technically applied by "pointing", *tratteggio,* or "full colour", as the ability of the students. (fig **25**)
(fig **26**) (fig **27**) The integration of the missing parts of the Qura'nic inscription, in the madrasa, was carried out by *tratteggio,* in lighter tone that the original parts, in order to differentiate them from the original ones. In this way, the inscriptions when seen from ground level, appear to be homogeneous and undifferentiated with the original.

(fig **28**) **The Stuccoes Restoration of Sunqur Sa'di mausoleum**

In **the Interior lower band** of the mausoleum, the frames and repetitive decorations were completely integrated with reproductions obtained from copies of the preserved parts. (fig **29**) Inscriptions were completed according to photographs from texts or archives, keeping the new ones 5mm lower than the original. Those parts that were lost and not documented were integrated according to the reconstruction from the literary text; the letters were reproduced in negative on a level 10 mm lower than the background of the whole inscription. (fig **30**) We highlighted the perimeter of the letters with a groove 5 mm deeper, having the optical effect that the letter are emerging and more visible, even if in negative.

(fig. **32**) Therefore, the inscription band at the height of 3 m, thus appears unbroken and, its essential visual function for the internal architectural space of the mausoleum was recovered.

In some cases, the stucco layer had come off the stone wall as a consequence of the accumulation of crystallized salts between the two materials. In this case we fastened the stucco on the wall, according to its elasticity (figg. **33, 34**).

At this level of the mausoleum we avoided the use of acrylics in the stucco, because it hinders the porous material from transpiring and cannot endure on wet stucco saturated by salts

Interior upper band

(Fig **35**)The cleaning of the upper band required, by students, long and precise manual work to remove the many different layers of *scialbatura* until the original surface was reached (3)

(Fig **36**) The upper part of the mausoleum was not attacked by the effects of rising damp, and the percentage of salts here is very low. The stucco inscriptions and the decorations on the drum and on the dome were treated with Paraloid B72 (3%) to protect the surfaces and to facilitate ordinary maintenance.

Exterior stucco restoration and integrations

(fig. **37**) The integration differs from the original inscription in the absence of background decoration and because letters are approximately one centimetre lower than the original.

Integrations of the façade stone

(fig. **39**) Cleaning the façade stone (with sandblasting machine made by CIERA), required an attentive action in order to gradually remove the black crusts, (fig **40**) leaving only the last patina layer of the stone, without the sandblasting.

(fig **40a**) We reintegrated the stone corroded by the action of salts, instead of replacement of the ashlars. (fig **41).**

All the external surfaces of the mausoleum, (decorations, stuccoes and stone facings) were protected with ethyl silicate (Rhodorsil RC90) by Rhone Poulenc and then with water-repellent Rhodorsil H224.

(fig **41a**) **The technique of the physical barring of the humidity in the madrasa and mausoleum**

In this case, we have resorted to modern technologies like in the new buildings, where an insulated bitumen layer is used for setting a physical block against the water present in the foundations. But,

since the new technology is applied in an old building, it is consisted by cutting the walls at the base and inserting in it a waterproof layer throughout the entire thickness of the wall.

We are using special machinery, made in Italy, for cutting the walls, sponsored by the Italian firm Ansaldo. It works with a three meters long blade, made by CIERA in Egypt with a special steel alloy, and lodging, the sprocket-chain, operating the cutting (fig.**42**).

The central wall, between the *iwan* and the mausoleum was cut in June 1992 and, after the earthquake of October 1992, considering the satisfactory results obtained, the intervention was gradually continued on the mausoleum and the *madrasa* (fig **43**)

(fig **44**) After cutting 20-50 cm or more of the wall in the whole thickness, strips of PVC of special shape are inserted in the void, with the injection (over and under) of a ~~in~~particular mixture of expansion-controlled and sulphate-proof ferric cement without chlorides.

(fig **45**. This seam operation has also the character of anti-seismic structure.

Restoration interventions in the Takiyya

(fig **46**).
An iron cage was made by placed iron elements inside the walls, by surrounding and binding all the structures, from the foundations up to the roof, where a *cordolo* closes the cage and supports the roof.

(fig **47**) The same retrofit principles have been applied in the mausoleum and madrasa, by sewing up together the various parts with tie rod in site the walls

I would like to conclude with the words of the Italian Architect Renzo Piano, who, was looking the rubble of the recent earthquake in Central Italy and, referring to the restoration of the traditional buildings, said: "…they required of subtle, delicate operations, almost homeopathic... And the timing, of the lightweight construction site, are longer. Because, it is required mending, microsurgery, sew up together, without destroying... It is needed lightness, as technical and human dimension".
(fig **48**) In those words and suggestions of Piano, is the kind of the activity carried out by CIERA work-site school, since the beginning: we used together new and old technologies and techniques but considering them only tools. **Since the final objective is to protect the spirituality of the heritage as Cesare Brandi has well defined in the *Theory of Restoration* "art is a product of the Human Spirituality"** (fig **48**a)