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

(Giuseppe Fanfoni)

The Italian-Egyptian Centre for Restoration and Archaeology (CIERA) operates as a work-site school in a monumental complex at the foot of the Citadel of Cairo, near the mosque of Sultan Hassan.

The Monumental area

The area is approximately 10,000 square meters wide, of which 2,500 meters are covered with debris.

The buildings of the area are (fig.1):

- The palace of Qusun-Yashbak-Aqbardi; dating from 14th and 16th century.
- The madrasa of Sunqur Sa'di; 14th century, with the underlying archaeological area and remains of different epochs, starting from 7th century A.D., (restored by CIERA 2002).
- The mausoleum of Hasan Sadaqa, (restored by CIERA 2008), adjoining the madrasa with its minaret; 14th century.
- The takiyya, which is the Convent of the Mevlevi Dervishes (fig. 2); 16th century, (restored by CIERA 2008).
- The Sama'khana, a theatre that was built by Mevlevi Dervishes, where they performed the circular dance, typical of their mystical confraternity; starting from 18th century, (restored by CIERA 1988).

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

The traditional technologies were generally characterized, in architecture, by so-called heavy structures, made with techniques of juxtaposition of constructive elements, assembled with bedding mortars or simply interlocking blocks without mortar (also mud bricks): as for the pyramids and also every building till to the industrialization age.

The modern technologies developed, in the historical industrialization process, a particular evolution by the production of new materials as cement, iron and plastic. Their application elicited advanced technical solutions, e.g. joints, truss beam, frame, to create structures designed to be stable and someway elastic. The Eiffel Tower is the start emblematic reference.

The attraction to modern technologies have exalted human ambition in various technical applications. In the matter of restoration of historical buildings, however, the materials and the modern techniques are useful only to support and preserve the original one and with application of special attentions. Consequently, the continuous and prudent control applied during the restoration intervention, recalls, once again, the artisanal laboriousness to which the very same antiquities belong.

Therefore, the organization of the work-site school evokes an artisanal laboratory, where each work goes through a cognitive and creative process with a new application.

Sama'khana and Sunqur Sa'di madrasa

The Sama'khana has a cubic shape crowned by a semi-spherical dome with a diameter of 10.50 m. The building covers an area of 250 sq m (fig. 3). The geometry and proportions of the plan as well as the vertical section reflect the elaborate symbolism connected with the Samà rite and Mevlevi

philosophy (fig. 4)

The walls of the Sama'khana were suffering from various causes of decay (fig. 5). The movements of the perimetrical walls caused the interior wooden pillars to deviate out of plumb; those on the east and south were especially affected. At the gallery level, torsion of pillars in front of the mihrab on both sides pushed them outwards. The connecting corner beams were distorted due to the excessive load from the roof structure and from the opening of a stairwell at a later stage. A complex engineering operation was conducted for each of the pillars; this resulted in freeing them from the load, while necessary interventions were made on the pillars as well as the connected beams restoring them to plumb by means of system of steel members support.

In order to ensure the maximum safety load suitable for the public use of the building, beams supporting the floor were integrated (the new ones are painted with an inner red strip for identification). The roof was also restructured and insulated with fiberglass to make it about 50% lighter.

When we started the 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. 6a).

The dome, which have a circumference of 34 meters and a structural thickness of 10 cm only, is among the largest and lightest wood-constructed stuctures in Cairo.

After supporting the dome from the inside with wooden scaffolding, we applied three iron belts on the outside (composed of six elements), one of which at its reins. By tightening the bands gradually and checking the reduction of each marked crack from inside, the dome recovered its original shape as far as it was possible, (fig. 6b) reducing the perimeter, at the reins, by 20 cm, with the effect of raising the apex of the dome by 12 cm.

The laths forming a covering under and over them were sewn up with strips of wire netting (fig.7). Glass wool, as a new recognizable material, was put inside the hollow spaces for thermal insulation. Finally, for didactic purposes, a movable panel on the dome extrados allows to see the restoration work that was carried out.

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 movement solicited by the earthquake, without causing disconnections to the dome.

All parts of the edifice were also sewn together with the support of tie-bars and iron connections system, as an anti-seismic retrofit of the building structures (fig. 8).

A perimetral concrete "cordolo" inside the thickness of the wall is fitted in deep by iron rods, linking the vertical walls with the 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.

Besides, excavations conducted for the consolidation of the foundations of the Sama'khana revealed that it was constructed on sub-structures belonging to the madrasa of Sunqur Sa'di (fig. 9). We made the archaeological excavation under the Sama'khana in order to recover the madrasa under it. To support the floor of the Sama'khana, a construction of steel beams and columns resting on the level corresponding to the floor of the madrasa was introduced. Therefore, the new foundation and the iron floor linking the perimetrical walls was made as an anti-seismic connection at the ground floor level of the Sama'khana.

The excavations that we carried out under the Sama'khana were very useful for the educational aspect of the work-site school since they required specific techniques and methodologies: the carrying out of an elaborate engineering and artisanal project complemented a methodical archaeological survey that allowed us to bring to light the general layout of the madrasa of Sunqur Sa'di.

The plan of the madrasa of Sunqur Sa‘di, that was historically thought to have four iwans, was instead characterized by two iwans, one to the west and the other to the east in the qibla position, on the short sides of a central open courtyard with a central area paved with bricks; rooms were on the long sides of the courtyard (fig. 9).

Half of the courtyard area had been deprived of the bricks (that were probably removed and reused for different purposes) and a fiskiya (fountain) was revealed, of which only the water basin remains. The fountain might have belonged to an older building, as this was an area of urban expansion at the time of Ahmed Ibn Tulun. We also reconstructed the perimeter of the fountain with a steel band, as a visual documentation for visitors.

Rising dampness in the Sama’khana

The walls of the Sama’khana were suffering from various causes of decay. As a result of the penetration of water from pipes in convent area and rising damp along the northern and eastern sides, walls were weakened by the loss of binding material; this caused a concave distortion of the eastern wall at the gallery level (fig. 5) and salt formation, 2 cm thick in places. The rotting of the wooden beam inside the south wall (belonging to the madrasa) at the ground level resulted in an incline of 20 cm out of plumb of the south wall. On the exterior elevation of the east and south walls we have graphically documented the previous utilization phases.

The northern and eastern walls, made of mixed stones, were consolidated through grouting, i.e. injection of lime and powdered inert with addition of acrylic or vinyl resins, whereas the southern wall (made of bricks) was strengthened with injections of epoxy resins (with an autoclave machine devised by CIERA for didactic purposes).

For the elimination of humidity in the Sama'khana walls, we made two rows of holes, filled with injections of particular epoxy-resins spanning the entire thickness of walls directly under floor level, providing a damp-proof course to solve the problem within the structure (fig. 18). But the complete elimination of dampness 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 effectively solved the problem (figg. 8, 18).

The paintings

Originally the Sama’khana (the actual shape of which dates back to the early 19th century) on the inside was simply painted in white and ivory yellow, with red and blue squares. The white dome was illuminated by eight windows (the number eight takes on a special mystic symbolism in the Mevlevi ideology).

The static difficulties due to the reuse of the madrasa south wall, very soon produced damage, as a result of which the Sama‘khana underwent some repairs between 1854 -1863. The landscape painting of the dome date from this period.

A study of the original paintings with the following restorations and repairs was carried out using ultraviolet shots and analyses of microscopic sections.

In order to keep the paintings and to make it possible to see the dome in the original light, we installed eight simultaneously movable window panes. A special mechanical system was devised and installed around the base of the dome from the outside which allows windows around the dome to the opened and closed with a simple lever on the gallery floor (fig. 7). Thus, the symbolism of the windows was retained, while the integrity of the painted decoration was saved (fig. 10).

In the Sama’khana dome, the integration of the missing parts was carried out using reversible colors, technically applied by pointing, “tratteggio” (hatching), or full colour (fig. 10). In all cases, one section was left without intervention to show the original work.

In the western iwan of the Sunqur Sa'di madrasa, (fig. 11) the integration of the missing parts of the Quranic inscription was carried out by "tratteggio", in lighter tone that the original parts, in order to differentiate them from the original ones. This way the inscription appear to be homogeneous and undifferentiated when seen from ground level (fig.12).

Sunqur Sa'di mausoleum

The internal space of the mausoleum has an irregular plan (length of the sides: 8.42 x 7.93 x 8.41 x 7.73m) and reaches, at the top of the dome, a height of 18.80m. The internal space is characterized by two bands of stucco inscriptions: the first is a visual reference at the height of 3 m, and the second, at the height of approximately 7.30 m, marks the transition to the intermediate level of muqarnas, which goes up to the springer of the dome (fig. 13).

Interior lower stucco band

The lower stucco band was seriously damaged by rising damp and was restored several times; some parts were missing and others were already about to collapse at the time of intervention of the "Comité de conservation des Monuments de l'Art Arabe", from 1915 to 1919.

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 gradually fastened the stucco on the wall, according to its elasticity.

At this level we avoided the use of acrylics in the stucco, because it prevent the porous material from transpiring and cannot endure on wet stucco saturated by salts (more than 11%).

The lower band, at the height of 3 m, is an essential visual reference for the appreciation of the architectural proportions inside the mausoleum.

In our intervention we planned different integrations to reconstruct the visual unity (fig. 14a).

Frames and repetitive decorations were completely integrated with reproductions obtained from copies of the preserved parts. Inscriptions were completed according to photographs from texts or archives, keeping the new ones 5 mm lower than the original. Those parts that were not documented were integrated according to literary reconstruction; the new letters were reproduced in negative on a level 10 mm lower than the background of the whole inscription. We highlighted the perimeter of the letters with a groove 5 mm deeper, obtaining an optical effect by which the letters come out more visible, even if in negative.

The whole inscription band thus appears unbroken and its essential visual function, in the internal architectural space proportions of the mausoleum, is recovered.

Interior upper stucco band

The cleaning of the upper band required long and precise manual work to remove the many different layers of "scialbatura" until the original surface was reached (fig. 14b). From a didactical point of view, this kind of practice is very useful to train both the concentration of the students and their manual skills, because when they work with chisels or similar metal tools they have to be very careful to remove the "scialbatura" without nicking the original stucco, preserving also the traces of patina previously formed on the piece.

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

Restoration of the windows and gratings

Above the upper band of inscriptions, a muqarnas section, 4m high, marks the transition to the drum. The drum, 2m high, is decorated with stucco and eight pentagonal windows, spaced by two false windows. In the middle of each side in the muqarnas section is a group of three windows, geometrically defined by the lines of the muqarnas motif (fig. 13). Of these groups, only the north side one is original; missing parts were integrated while the others were reinforced with acrylic resin (Acrilic AC 33). Glass was reintegrated with epoxy resin. Then we made a model of the window and enough copies to replace the windows on the other walls.

All the gratings protecting the windows on the outside were restored and a methacrylate plate was attached at the rear of every grating and then their edges were sealed after replacement, so as to ensure protection from dust and weather.

External restoration of the dome

Most of the external plaster of the dome, on the upper calotte, was missing. This plaster was applied by the work of the "Comité", from 1915 to 1919.

A reinforcing mesh was inserted in the new plaster layer to ensure better resistance. A "hilal" was placed on top of the dome.

Exterior stucco restoration and integrations

The consolidation of stucco to reintegrate the cracks and to ensure its adhesion to the wall was performed, as in the interior of the dome, with injections of mortar, brick powder and acrylic resins (Acrilic AC 33), using a total of 170 litres of material for the exterior inscriptions and decorations.

The missing parts of the band of Quranic inscriptions at the top of the dome were reintegrated to regain the complete architectural image of the dome. For this purpose, the letters and their connections were reproduced on the basis of external and internal inscriptions, recomposing missing words. The integration differs from the original inscription in the absence of background decoration and because letters are approximately one centimeter lower than the original (fig. 14c).

The restoration of the façade of the mausoleum

On the façade of the mausoleum, rising damp interacted with atmospheric pollution causing the formation of black crusts on stone facings.

The crusts formed on the intermediate sector of the façade including the area of the evaporation of rising damp. Crusts are less evident in the soaked lower part and in the upper part not affected by rising damp.

Cleaning the façade stone (with sandblasting machine devised by CIERA), required an attentive action in order to gradually remove the black crusts, leaving only the last patina layer, typical of the stone, not touched by sandblasting (fig 15). The controlled sandblasting action permitted to identify in some places the red layer of paint which is evident also in microscopic photographs of the thin sections on the stone (fig. 16). It might be a colouring added in 1869, when, on the occasion of the opening of the Suez Canal, all the Islamic monuments were coloured in stripes of red and yellow. This colouring had penetrated the stone, which was already altered, demonstrating that the monument did not have any colouring before that date.

After completing the sandblasting, we reintegrated the stone ashlars corroded by the action of salts. We preferred an action of integrative restoration instead of a replacement of the ashlars (fig. 21). We kept the original material and avoided the shock that would be caused by the replacement of ashlars and the consequent settling of the wall structures.

But, even more important, we gave the students the opportunity to practice in proportioning the components of mortars, colouring earths, and to have training for the stone conservation (fig. 21). Finally, 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.

The technique of physically barring humidity in the madrasa and the mausoleum

Leaking water, up to a few centimetres above the floor, has been attested in the mausoleum since the 1980, while the whole of the corridor was permanently flooded. Both inside and outside the mausoleum rising damp caused visible damage to stone facings, plaster, stucco decorations and even wall structures (fig 13).

In this case, we have resorted to modern technologies as 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 technique was applied to an old building, it consisted of cutting the walls at the base and inserting in it a waterproof layer throughout the entire thickness of the wall (fig. 19).

We are using special machinery for cutting the walls, made in Italy and 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.

The central wall between the iwan and the mausoleum was cut in June 1992 and, after the earthquake of October 1992, in light of the satisfactory results obtained, the intervention was gradually continued on the mausoleum and the madrasa.

After cutting 20-50 cm or more of the wall in the whole thickness, strips of PVC of special shape (from Italian Umiblok) were inserted in the void, with the injection of the particular mixture of expansion-controlled and sulphate-proof ferric cement without chlorides, sponsored by Italian Pagel.

This seam operation has also the characteristics of an anti-seismic structure, since it forms a joining "cordolo" of the all perimetrical walls at the foundation base.

Mevlevi takiyya

The entire Mevlevi complex is a built area of about 2,000 sq m. The restoration intervention was aimed at linking the structures, giving them the necessary support, without changing their structural and compositional characteristics.

An iron cage was made by iron elements placed inside the walls, surrounding and binding all the structures from the foundations up to the roof, where a "cordolo" closes the cage and acts as a support for the roof.

These are the same consolidation principles which have been applied in the Sama'khana, the madrasa and mausoleum, with tie rods in site of the wall, sewing up together the various parts as an anti-seismic retrofit of the building structures (fig. 8).

The work-site school organization

A fundamental aim of the work-site school is the transfer of expertise to trainees at all levels of involvement in restoration, through participation in the various phases of the whole monuments conservation programme.

All the projects and works concerning archaeology, architecture, structures and the fine arts, were accomplished in the laboratories with the equipment of the Centre, by our staff and trainees.

The convent celles and rooms host the scientific and artisanal laboratories, workshops storage space, drafting rooms, library and the exhibition hall of the training Centre.

The various tasks are carried out, within a context of interaction, in the different specialized sectors from the technical and craft to the scientific and research levels. The wide range of the activities required by the project has called for the presence of workmen, artisans and inspectors offered essentially by the Ministry of Antiquities MoA, as well as students sent by Egyptian Universities for training or to write their academic thesis. Italian students, who volunteer come to gain experience or research for their thesis, engage in activities alongside their Egyptian counterparts, with participation of teachers from Italian Universities. Experts from Italian CNR and from Istituto Centrale di Restauro (ICR) and particularly from the Istituti Statali d'Arte (ISA) of Rome, Marino, and Anzio gave a special contribution to the work-site school.

The final exhibition "Restorations and Restorers" documents the restoration results and the activities carried out by each person who attended the training programme. The exhibition that was inaugurated in 2007 and after that circulated in Cultural Centres, Schools, Universities both in Egypt and in Italy, is now permanently exposed in the CIERA exhibition rooms.

In the work-site school people teach and learn how to operate by actually doing the work, which means to be aware of the action. In a sense, restoration is the instrument to live the feeling of the original craft. Therefore each participant receives, as a certificate of acquired professional qualification, a document attesting the activity he or she has performed.

In conclusion, the restoration interventions of the fabric of the historic buildings were guided by the purpose of retaining most of the original material as it was possible in both technique and shape, without drawing preferences between those contributions dating from different periods.

Finally, we adopted the principles of the "scientific" study of restoration and, where necessary, we applied sophisticated solutions using both traditional and modern technologies and techniques, but looking at them only as tools, since the essential objective of our activities is to protect the feel of the cultural heritage, as it is clearly defined in the "Theory of Restoration" by Cesare Brandi: art is a product of the Human Spirituality to be handed down to future generations.

Bibliography

C. BRANDI, *Teoria del restauro,* Torino, Einaudi, 1963.

P. CUNEO, *Verso una "Scuola Italiana" di studi e restauri di architetture e città del mondo islamico,* in "Bollettino d'Arte del Ministero Beni Culturali e Ambientali", N. 39–40, Roma, 1986, pp. 9–10.

G. CANOVA, *Iscrizioni e documenti relativi alla takiyya dei dervisci Mevlevi del Cairo,* in "Q.S.A." 17 (1999), pp. 123–146.

ID. *Le iscrizioni nel Complesso dei Dervisci Mevlevi del Cairo: il Mausoleo di Sunqur al-Sa'di (Qubba di Hasan Sadaqa),* in "Q.S.A." 1 nuova serie (2006), pp. 192–216.

G. FANFONI, *Il complesso architettonico dei dervisci Mewlewi in Cairo,* in "R.S.O." LVII (1983), pp.77–92.

ID. *An Underlying Geometrical Design of the Mawlawi Sama'hana in Cairo,* in "Annales Islamologiques" XXIV (1988), pp. 207–232.

ID. *Il restauro della sama'khana dei Dervisci Mevlevi al Cairo*, Il Cairo, 1988, (2nd Ed. 2006)

ID. *The Foundation and Organization of the Cairo Mawlawiyya,* in "Q.S.A." 17 (1999), pp.105-122.

ID. *La madrasa di Sunqur Sa'di e il museo Mevlevi,* Il Cairo, 2000.

ID. *The recovery of the Mausoleum of Sunqur Sa'di and restoration of Mevlevi Takiyya, Cairo, 2009*

M. GABBRIELLI. *I reperti ceramici del museo Mevlevi al Cairo*. In "RISE VI" vol. (2013), pp. 119-140.

L. LAZZARINI, - M. TABASSO, *Il restauro della pietra,* Padova, 1986.

G. MASSARI – I. MASSARI, *Damp buildings, old and new, Rome, 1993*

A. PATRICOLO, *Comité de conservation des Monuments de l'Art Arabe*, *exercices 1915–19,* vol. XXXII, Le Caire, 1922; pp.80–82

F. NICCHIARELLI, *Alcuni casi di Risanamento da Umidità, Il Complesso dei Dervisci Mevlevi (Il Cairo)*. In P. ROCCHI (ed), *Manuale del Risanamento, la difesa dall'umidità nella pratica edificatoria*, vol. I, Roma, 2000, pp 113-118.

Fig. 1. GENERAL VIEW OF THE MEVLEVI ARCHITCTURAL COMPLEX

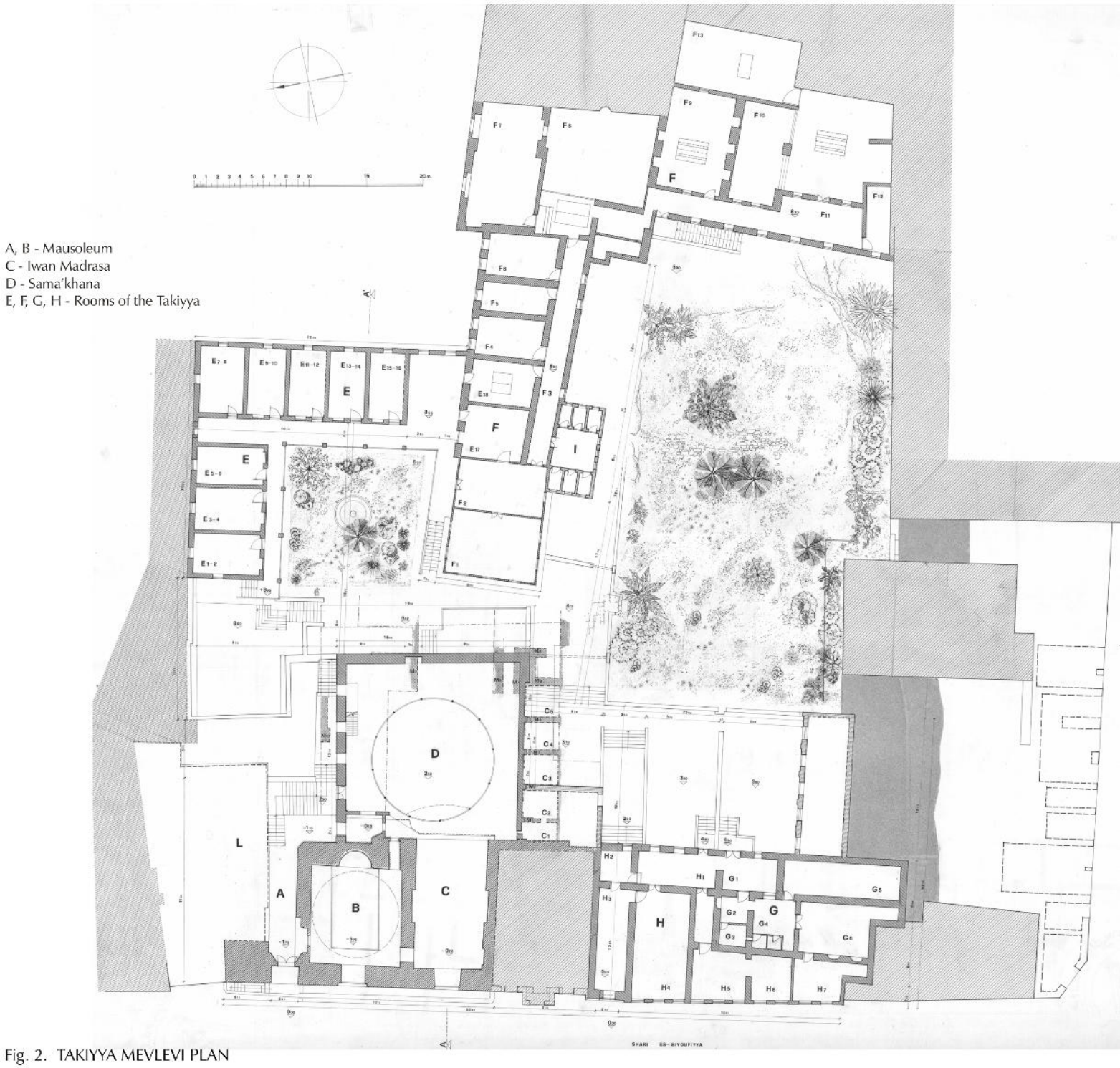


Fig. 2. TAKIYYA MEVLEVI PLAN

Fig. 3. AXONOMETRIC VIEW OF THE MEVLEVI TAKIYYA

Fig. 4. INTERIOR VIEW OF THE SAMA'KHANA BEFORE AND AFTER RESTORATION

Deformazione della cupola التغير فى شكل القبة
Deformation of the dome

Spinta della terra ضغط ناتج من آتربة الأرض
Earth pressure

Cedimenti هبوط
Settlement

Rotazioni دوران
Rotation

Torsione إلتواء
Torsion

Posizione delle travi marcite nelle sostruzioni muro sud
Position of the rotten beams in the burried south wall
اماكن الكمرات المعفنة فى الجزء المدفون للحائط الجنوبى

Fig. 5. SCHEME OF THE SAMA'KHANA SETTLEMENTS

a

b

Fig. 6. THE SAMA'KHANA DOME AND THE RECOVERY OF ITS GEOMETRIC FORM

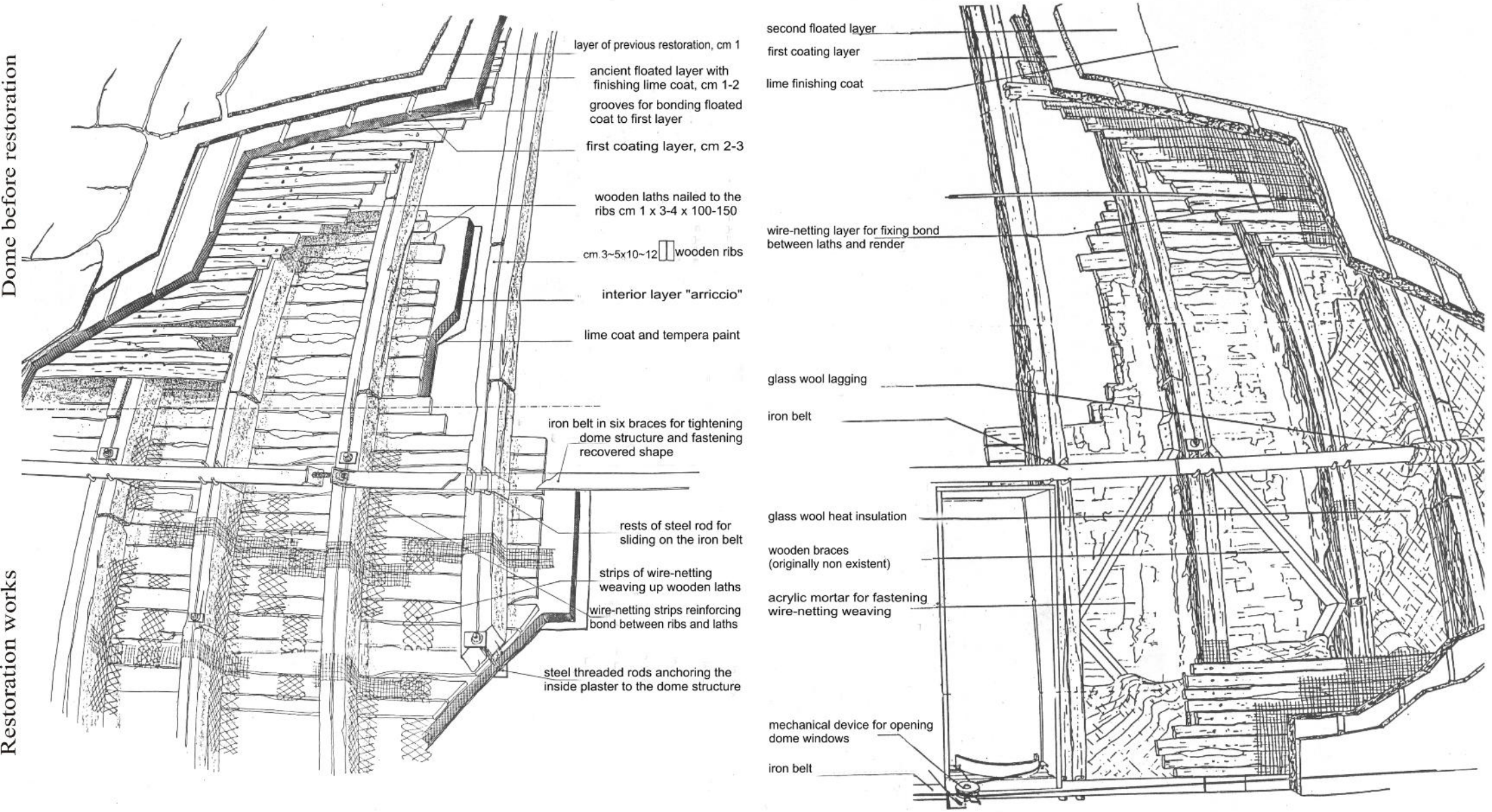


Fig. 7. STRUCTURAL ANALYSIS AND RESTORATION WORKS OF THE SAMA'KHANA DOME

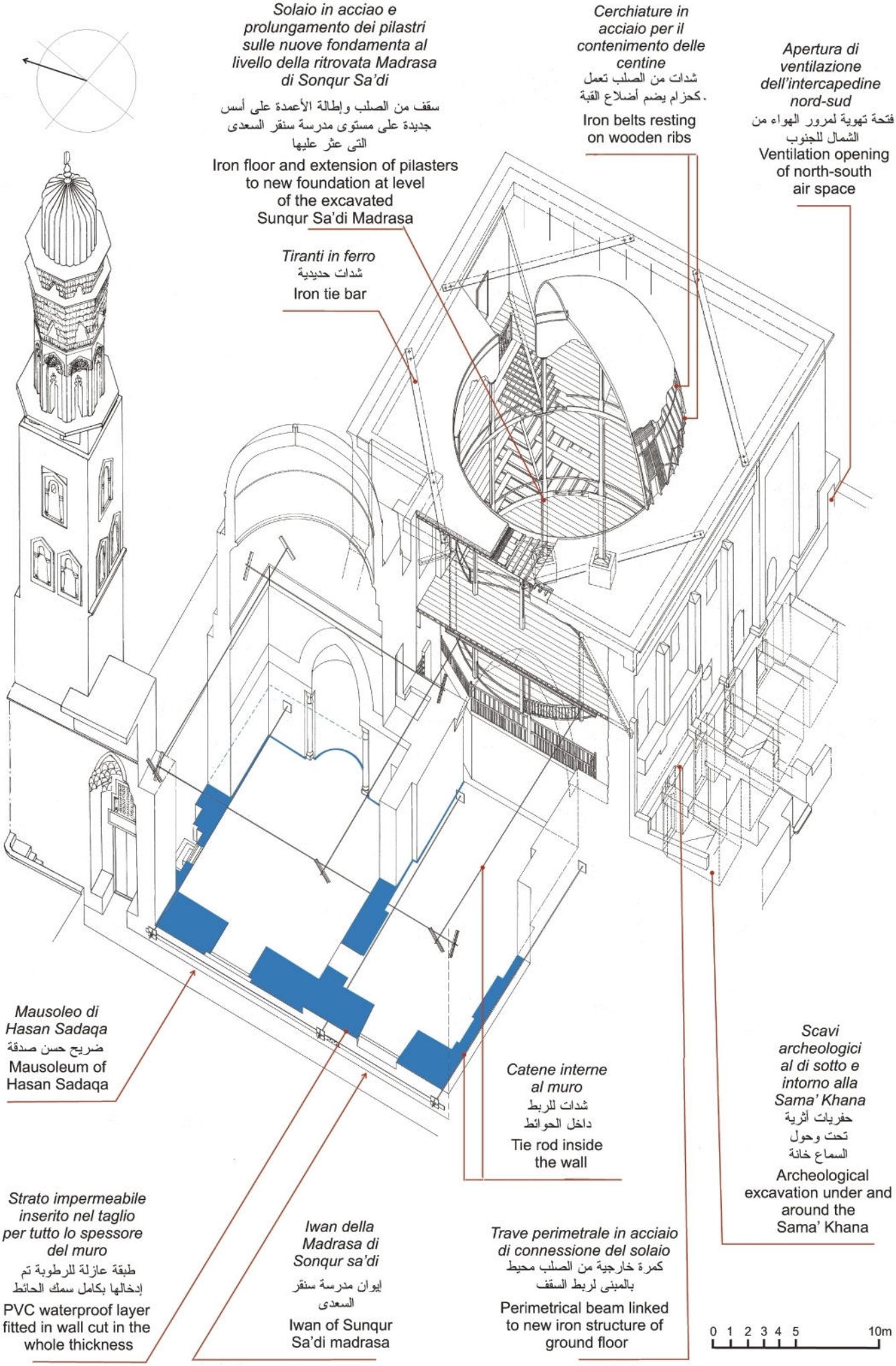
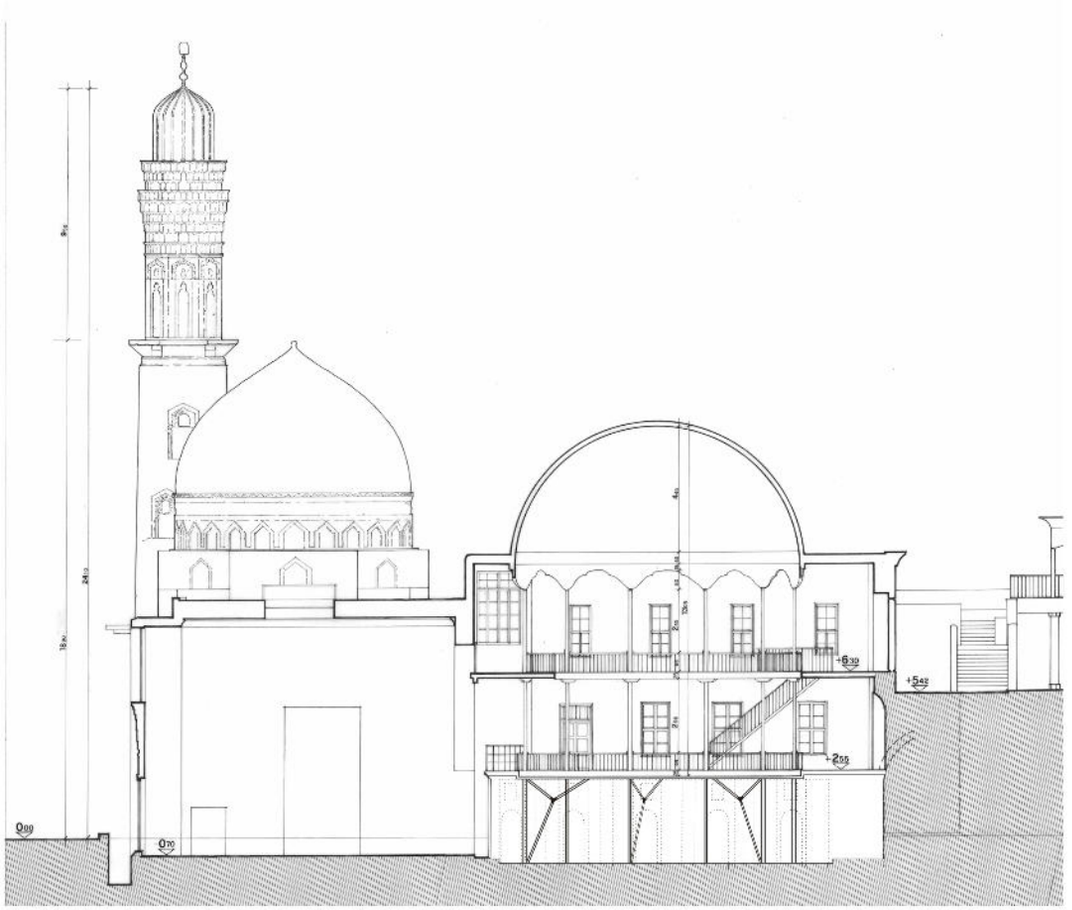


Fig. 8. AXONOMETRIC VIEW WITH DESCRIPTION OF THE RESTORATION INTERVENTIONS



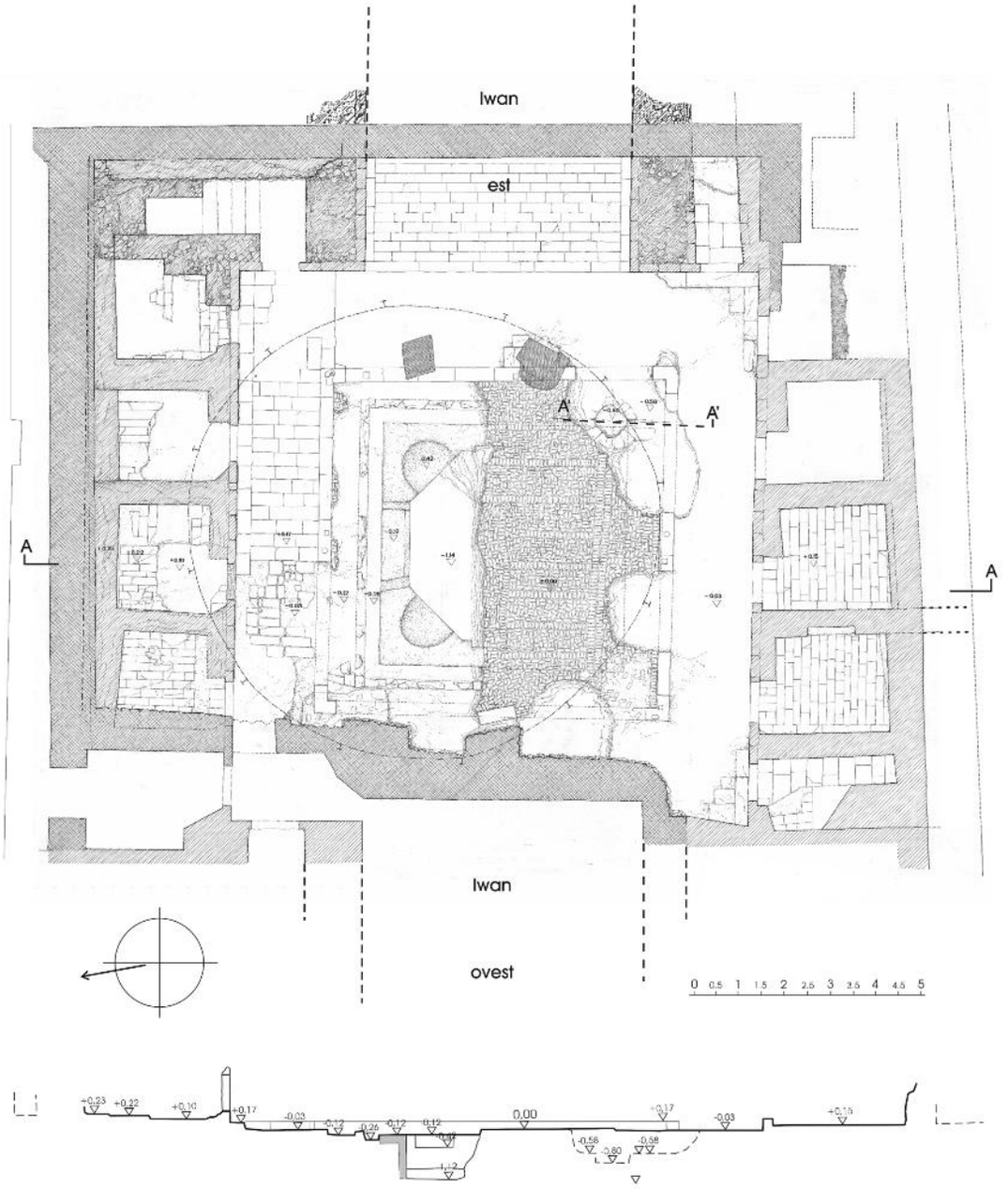


Fig. 9. SECTION OF THE SAMA'KHANA WITH THE ARCHAEOLOGICAL FINDS OF THE MADRASA

Fig. 12. THE MADRASA IWAN BEFORE AND AFTER RESTORATION

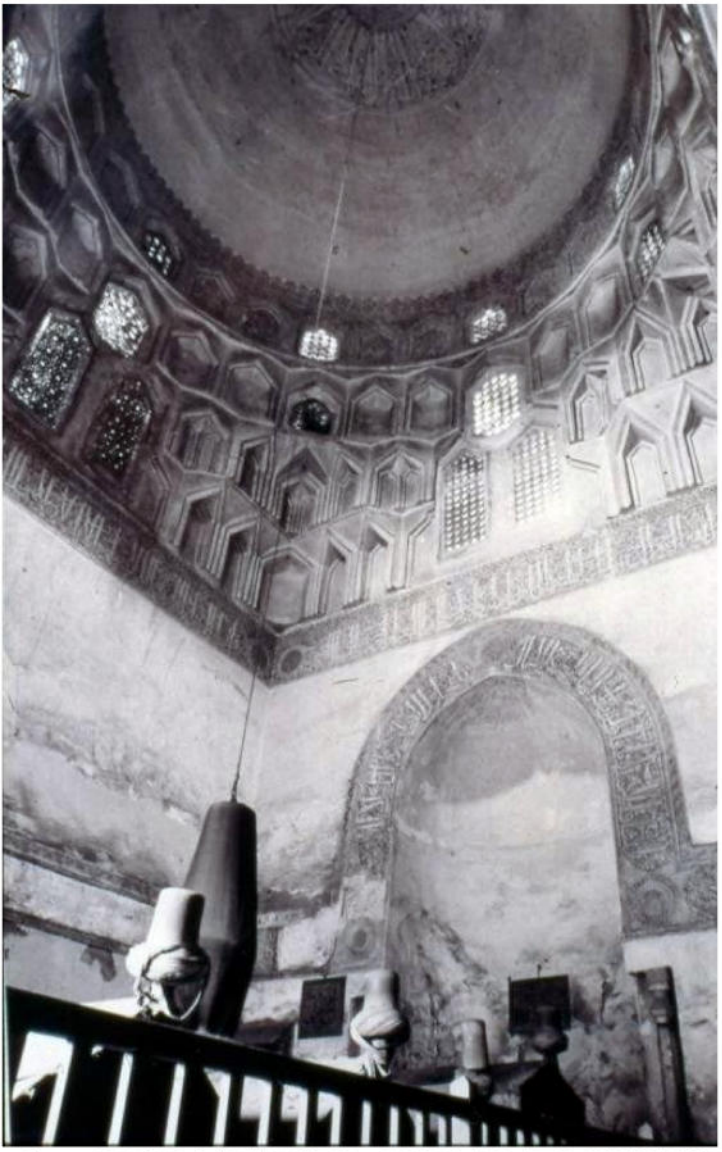
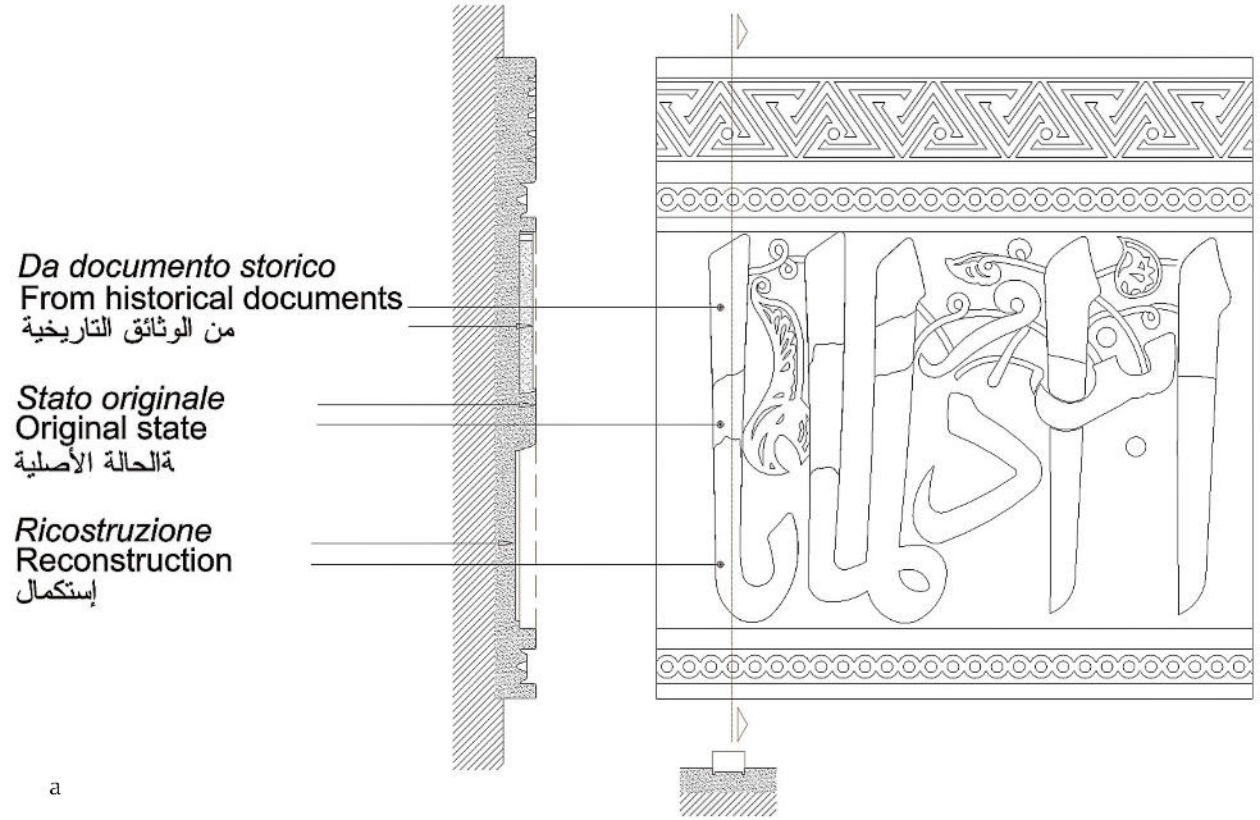
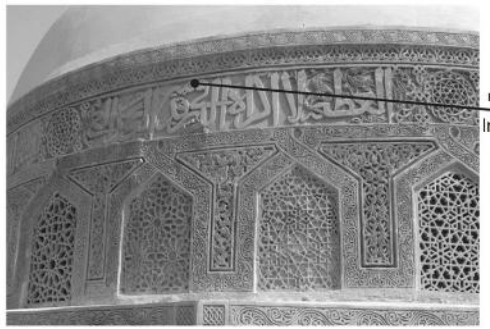
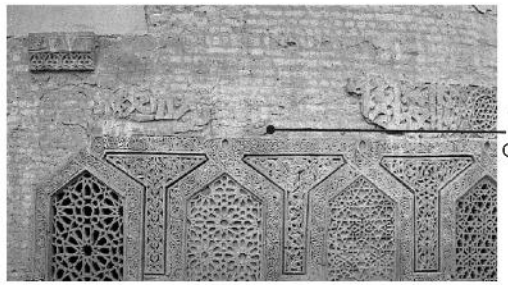


Fig. 13. SUNQUR SA'DI MAUSOLEUM BEFORE AND AFTER RESTORATION







c

b

Fig. 14. VISIBILITY OF THE INSCRIPTIONS' RESTORATION ON THE INSIDE AND OUTSIDE OF THE MAUSOLEUM

Fig. 15. TEST OF THE STONE BLACK CRUST SANDBLASTING

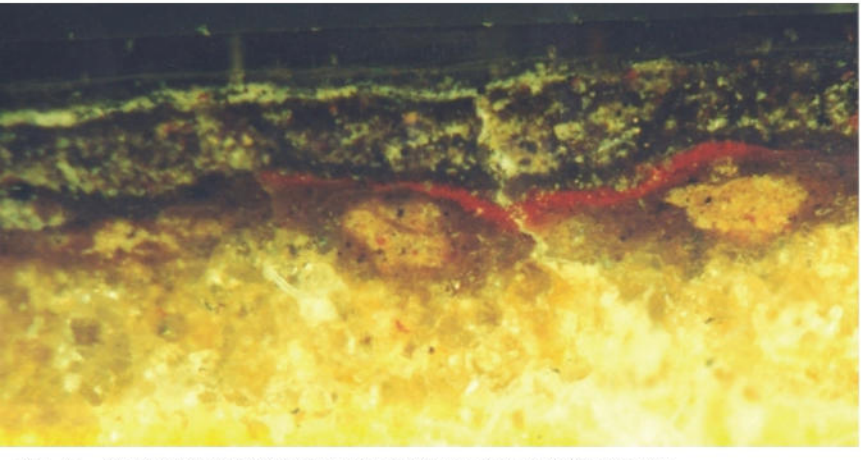


Fig. 16. MICROSCOPIC THIN SECTIONS OF THE BLACK CRUST

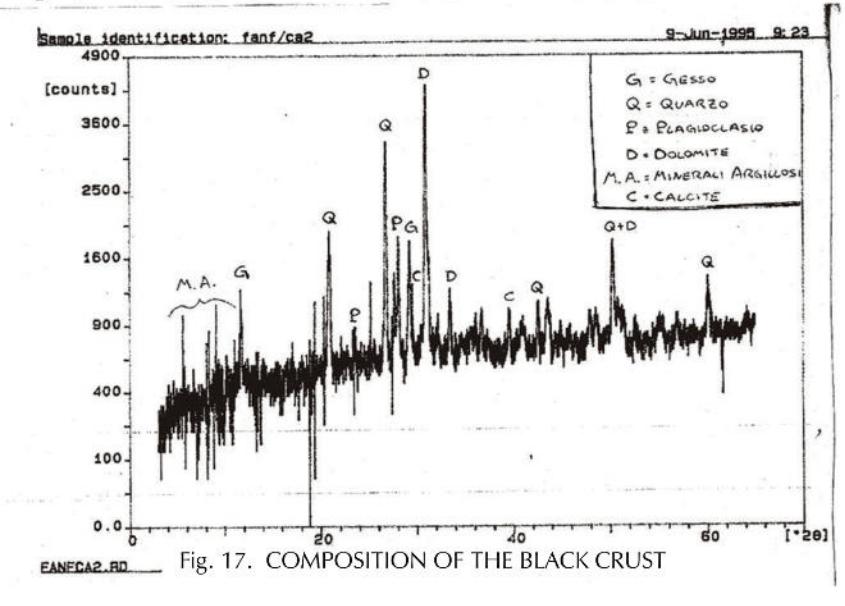


Fig. 17. COMPOSITION OF THE BLACK CRUST

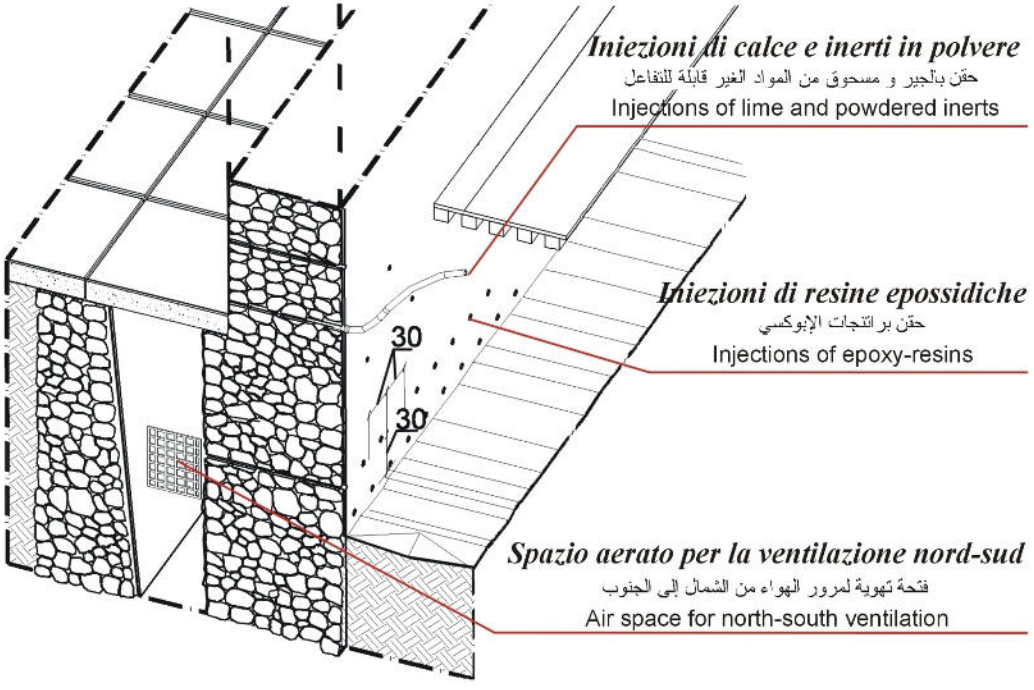


Fig. 18. ELIMINATION OF RISING DAMP FROM THE SAMA'KHANA WALLS

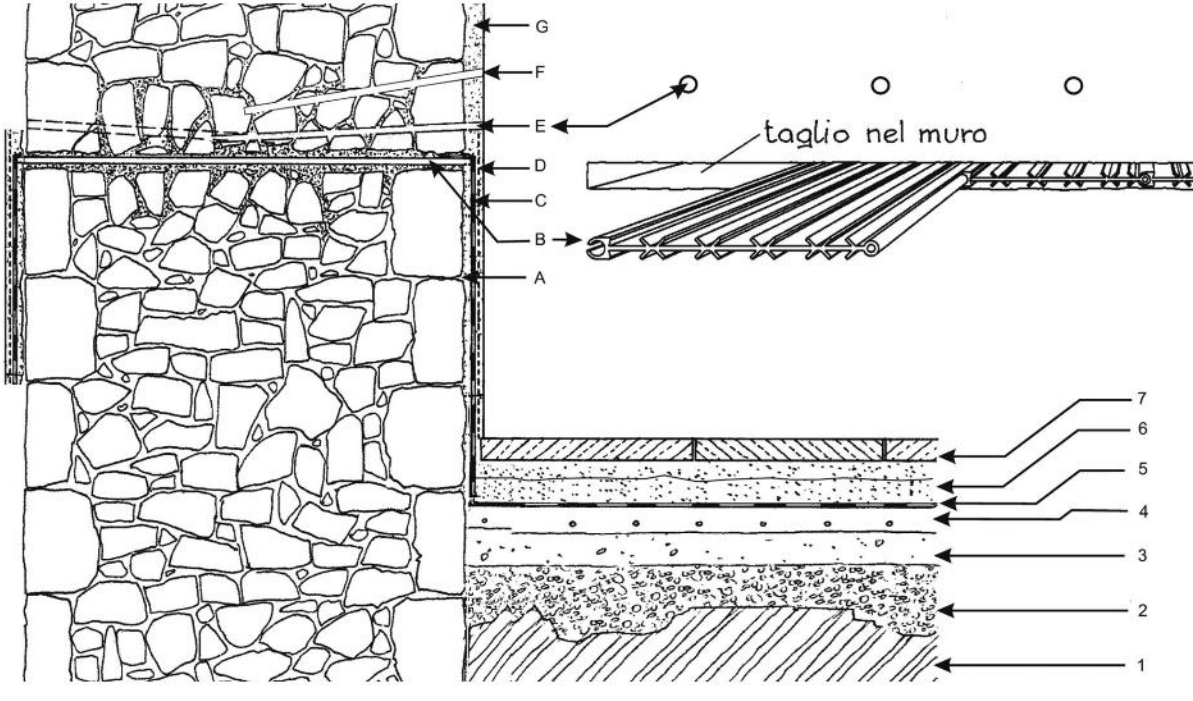


Fig. 19. THE PHYSICAL BARRIER OF MOISTURE IN THE MADRASA AND THE MAUSOLEUM

Fig. 20. THE VIEW OF THE SAMA'KHANA FROM THE MADRASA WEST IWAN

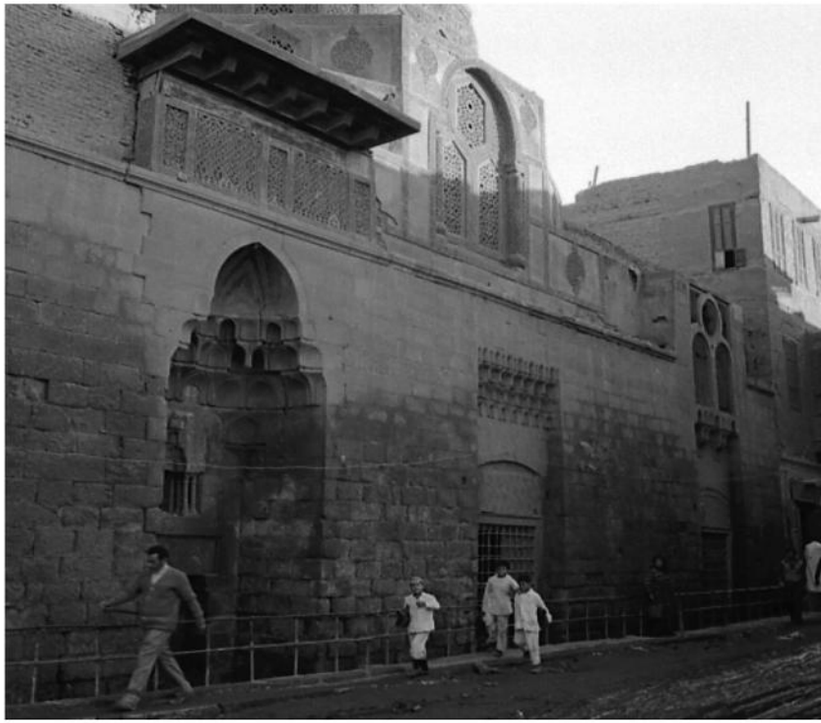


Fig. 21. EXTERIOR OF THE MAUSOLEUM BEFORE AND AFTER RESTORATION