Preservation of Temples in Mỹ Sơn (Vietnam)

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ABSTRACT: The design for preservation of group G of the temples at the archaeological site of Mỹ Sơn (Vietnam) is the result of a collaboration between the Politecnico of Milan (DIS and Fondazione Lerici), the Institute for Conservation of Monuments of Hanoi and UNESCO, with the assistance of two consultants, Pierre Pichard and Hoàng Đạo Kính.

The task of the project was: (i) to carry out an archaeological investigation and studies on the materials and on the building techniques in the holy area of Mỹ Sơn, under the protection of UNESCO, (ii) to realize a preservation project of a chosen group of temples (group G).

1 INTRODUCTION

The archaeological area of Mỹ Sơn (Fig. 1) is located in Central Vietnam, 30km South-West of Đà Nẵng; it is settled in a valley surrounded by low mountains dominated by the Rang Mèo mountain, and it is crossed by the Thu Bồn river.

The site is 15ha wide and hosts several groups of buildings made with brick masonry, each of them organized around a main temple (kalan). The buildings were constructed from the 7th to the 12th C. by the Cham people.

Mỹ Sơn is the most important holy place of the Champa kingdom; the Cham people built here more than seventy buildings, but nowadays only thirty with at least 1m in elevation are still recognizable. The area was burnt and plundered in the past centuries until it was finally ne-
The site was visited and studied at the beginning of the 20th C. by a French architect, Henry Parmantier from the Ecole Française d’Extrême Orient (EFEO). From 1982 to 1986, after the Vietnam war, a Vietnamese-Polish team lead by Hoàng Dao Kinhand Kasimierz Kwiatkowski carried out restoration works on some group of buildings damaged during the Vietnam war at the end of the sixties (Kwiatkowski 1985).

The Parmantier expedition in 1898, found the area completely covered by vegetation. About fifty buildings were classified, each group named from A to L and documented through geometrical and photographic survey (Parmentier 1904).

Nevertheless the heaviest losses were mainly due to the American bombs in 1969. Beside the complete destruction of several buildings (one of them, A1, was among the largest and most beautiful Cham towers), the vibrations and the fragments of the bomb shells indirectly damaged some other buildings.

The project concerns a group of five constructions built in the 11th-12th century and classified by the architect Henry Parmantier as group G (Fig. 2a). Archaeological excavations were carried out by him at the beginning of the XX century, but no restoration works were done. This group (Fig. 2b) is composed by five buildings situated on a low hill (kalan, manḍapa, gopura, pośa, kośagrha); the main temple, the so called kalan, is in the centre of the area. The study of the site started in 2000; in 2005 the first two constructions G3 (manḍapa) and G5 (pośa) were completely restored and some works were started on G4.

![Figure 2: Plan of the group G: (a) survey from H. Parmentier 1909; (b) survey made in 2002.](image)

2 ON SITE AND LABORATORY INVESTIGATION

Since 2000 all the studies and investigations have been concentrated mainly on group G: but material from group A and E were also studied the first samples of material were taken from the site in 2000 and characterised at DIS, Politecnico of Milan. The research went on from 2001 to 2003 and during this time also several visits were paid to Mỹ Sơn, during which the damage state of the building due to bombs and shells launched during the war and to the intensive and continuous biological attach was also evaluated by a direct study. The data from the investigation were reported on templates which were later used to study the vulnerability of the site (Core 2005).

The on site investigation and the analyses of the materials showed that all the building in the Mỹ Sơn area have been constructed with fired bricks jointed by very thin layers of natural resin; this is the peculiar characteristic of this brick masonry. In fact the bond between the bricks is so tight that they do not practically show a real joint (Fig. 3a). Were this bond is still preserved very small biological decay appears on the surface of the wall and the decay does not penetrate inside the wall as in the case of the restored or cracked masonries.

The stone was used as building material only for pillars, lintels and some decoration. The wall section is made of two leaves with weak connections (Fig. 3b), or three leaves with bricks externally and brick rubble in the centre.

The investigation of the materials followed two paths: the first with laboratory analyses at DIS, where joints and bricks have been characterised with the help of biologists and organic chemists (Ballio et al. 2001), the second on site, consisting of some simple tests carried out also during the restoration, but also of a long careful research on the existence of trees from which
the original resin had been taken (Fig. 4). All the materials tested in Milan came from the Mỹ Sơn area, particularly from group G. The natural resin tested for intervention was bought nearby the site.

Figure 3: The Mỹ Sơn masonry a) with thin joints and b) section of the wall.

Figure 4: The dàu rài tree and the resin extracted from it.

The aims of the investigation were the following: (i) to characterize bricks, stones and joint materials, (ii) to understand the construction technique of the Cham people, (iii) to find materials for the repair compatible with the existing ones.

At the end of the research the following results were reached: (i) all the bricks were made with good clay but fired at a temperature below 850 °C, (ii) the external joints of the walls were realized with a natural resin containing dammarenediol coming from dipterocarpaceae trees, (iii) a resin coming from the dàu rài tree (Fig. 4), similar to the one found in the walls was available on the local market, used to waterproof the boats, (iv) the internal joints were made with fired clay coming probably from brick powder (Binda et al. 2006).

3 THE PRESERVATION PROJECT

The study of the peculiar building technique, together with the characterisation of the materials became for the designer a starting point to set up the principles for the intervention. The thin joint made by natural resin excluded in fact the ordinary technique of intervention using mortar.

These principles were for long time discussed among the authors and finally the following decisions were taken: the buildings should be preserved as they were found, that is partially at the state of ruins, no reconstruction should be made but only partial reconstruction by anastylosis were the original materials could be found in place and clearly recognisable.
More in details the principles can be summarized as follows:
- to preserve the remaining parts of the collapsed buildings as much as possible by repair and local consolidation (Fig. 5);
- to reconstruct by anastylosis the sections where stability or durability problems are present leaving intact the present profile of the ruins as much as possible;
- to maintain the original masonry adding a new binder only when necessary;
- to use new bricks, well distinguished from the old ones only in case of dangerous stability deficiency.

The above listed principles brought to the following decisions: (i) the bricks should be recovered as much as possible on site in place where the walls were partially lost, (ii) the joints could be realized in two different ways: a) with natural resin for the external leaves of the walls, b) with a mortar made of lime and brick powder (in case the original bricks would be pozzolanic) for the internal leaf of the walls where complete brick and brick fragment would be used to fill the gaps.

During the intervention the original parts of the wall should be distinguished from the reconstructed or repaired ones with clear signs as coloured lines or recession of the masonry. The careful investigation on the decayed parts allowed also to suggest some operative interventions as e.g.: (i) solution of the stability problems of the wall with also insertion and completion of new parts, (ii) insertion of small missing parts (substitution of decayed bricks or insertion of missing bricks, (iii) details for filling of the cracks.

The project responsible, L. Binda, together with P. Condoleo, submitted every step of the project to UNESCO for approval, with a monthly report.

4  PRESERVATION WORKS ON G3 AND G5

These operative steps, adoptable for all the ruins, were preliminarily applied so the building G3 (Fig. 6a), one of the most damaged of the group with its 1m of elevation, apart from one corner. Many parts of G3, which was previously subjected to the archaeological excavation carried out by M. Cucarzi and P. Zolese (Fondazione Lerici) being practically completely buried in the ground, were in a very bad condition, partly due to the large amount of missing walls, partly due to the localized collapses.

The intervention on G3 was started in 2004. In 2005, after the good results obtained on G3, the same procedure was applied to G5. This building was deeply damaged, with an elevation not higher than 60cm (Fig. 6b).
Before the operative phases of the preservation works, all the buildings of the G group have been photographed (plan and prospect) with a metrical grid in order to draw the exact position and size of the bricks.

A geometrical survey of all the buildings was carried out with a Total Station and the results reported in plans, prospect and sections, including the prospect of each face of the walls. The drawings reported in AUTOCAD contain partial and progressive dimensions (Fig. 7).

All the surface damages of the walls have been surveyed together with the missing parts and reported on drawings. This in order to facilitate the damage interpretation and the detection of its causes and to calculate the extension of the repair.

Both for G3 and G5 every single brick to be removed was numbered with a white chalk (Fig. 8), the area of the wall was photographed and during the disassembly phase all the bricks were stored nearby. In the reassembling phase the bricks still in good condition have been placed back in their original positions.

The damaged parts were disassembled layer by layer and all the phases photographed and/or drawn (Fig. 9). The reassembling phase followed the procedure previously described.

In case of deep damage at the foundation level, these parts were consolidated or substituted: e.g. the blocks of laterite seriously damaged (Figs. 10), when necessary they were substituted.
with blocks of new laterite.

Figure 9: General view, internal layer and detail of the section.

Figure 10: One of the corners before and after consolidation.

Figure 11: Cutting of the roots and poison injection.

The problem of the infesting vegetation, cause of the main damage to the masonry, has been solved in two different ways: (i) where the wall was seriously damaged it has been disassembled brick by brick in order to remove the tree from the roots and reassembled, (ii) where the masonry was still in good condition the tree was cut as much as possible and the remaining root injected with poison (Fig. 11).

Sometimes missing parts caused stability problems. This was the case of the North side of G3, where in the middle of the side some parts of the base were missing (Fig. 12a). A new half of the wall had to be rebuilt for statical reasons. The new bricks of the external layer were bonded with resin, while the layer inside the wall has been made with bricks and mortar, as in the general case. In order to clearly declare the new part, the profile of the new wall was built, as the 3D drawing of the project shows (Fig. 12b).
Figure 12: North side: (a) external view after reassembling work of the original internal layer; (b) project of the supporting wall made by new bricks (red part). The red part corresponds to the new wall.

The project for the rain water drainage out of G3 was proposed by P. Pichard (Fig. 13a); the water collected inside the building is conveyed with a smooth slope to two pipes that channel it to a central drain; from here it is collected by two plastic pipes passing under the foundations of the North and the South sides (Fig. 13b).

Figure 14 shows G3 and G4 at the end of the intervention. Figure 15 shows the kalan G1 which will be the rest to be restored.

5 CONCLUSIONS

The laboratory and on site investigation was essential for the knowledge of the geometry, materials, construction technique and damage of G3 and G5.

Very useful were also the simple tests carried out on site in order to detect the process of application of the resin for the joints and the consistency of the hydraulic mortar made with hydrated lime and bricks, used for the internal leaf of the masonry.

The principles adopted for the intervention could be applied practically always; the existing parts of the temples with good stability have been preserved and only small parts were reinstalled by anastylosis. Where new parts have been added, new bricks were used and the intervention was clearly distinguished from the existing ones.
The next steps will be the repair of G2, G4 and G1, the main building.

Figure 15: G1 before the restoration.

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REFERENCES

Binda, L. Tedeschi, C. Condoleo P. Characterisation Of Materials Sampled From Some My S’on Temples, Conf. 7th ICCE, 8-10/05/2006, Tehran Iran, to appear.