CONSERVATION PROJECT OF NANDIN HALL IN THE
ARCHAEOLOGICAL ZONE OF THE VAT PHOU UNESCO SITE IN
LAOS

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Abstract
The work is the result of extensive surveys and analytic and technical evaluation of the structural behaviour for the future conservation of the Nandin Hall monument.

The temple is located in Laos, exactly in the Vat Phou archaeological area (World Heritage Site in 2001), and is connected to Angkor (Cambodia) by an ancient imperial road, 250 km long.

The temple complex of Vat Phou was erected at the foot of the Lingaparvata Mountain and 5 km west of the Mekong River.

On the left of the central pathway, it is possible to see the remains of a small building said to be dedicated to Nandin. This rectangular building is in sandstone, with pillared porches at its north and south sides. Its original destination is also unknown; it may be connected to the old Khmer road, of which it marks the end very precisely.

The soil survey (2006-2007) led to a comprehensive and detailed mapping of the Nandin Hall and territorial context; whereupon it decisions could be taken concerning its conservation project.

The temple is built with sandstone blocks, with dry joints (no mortar), which over the time have come loose, due to static-disrupting phenomena and events. Nandin Hall foundations are in poor condition, subjected to differential soil settlements which have caused structural damage.

Keywords
World Heritage Site, Archaeology, Architectural survey, Damage, Structural assessment.
1. INTRODUCTION

Since November 2006, the activities of the Politecnico di Milano, Department for Architectural Design, together with the Lerici Foundation of the same institution, are part of a broader project entitled: “Capacity Building in Cultural Resource Management through the Preparation and Implementation of Conservation and Management Master Plan, for the Preservation of Vat Phou and Surrounding archaeological Landscape within a Framework of Sustainable Development of Champasak, Lao PDR”.

The research performed by the Italian Archaeological Mission in the early to mid nineties was especially geared towards territorial analysis, to the anthropic and nature changes between the fifth and fifteenth century, the research was essential for contextualizing the monumental and archaeological remains in a broad historical framework. The reconstruction of the phases of formation, the development and decline of the Khmer civilization in the ancient kingdom of Chenla and a study of the urbanization processes linked to socio-economic events have also allowed for new interpretations in the architectonic and art-historical study of the sacred monuments.

The detection of the relationships between sacred and profane architecture - and therefore between city and temple, each located within the organizational framework of the area – by means of a study of the ways of communication and cultivated and forested areas led to register Vat Phou as a UNESCO World Heritage Site in 2001, with the name: “Vat Phou and Associated Ancient Settlements within the Champasak Cultural Landscape”.

The designated area covers a surface of 400 km² and its originality lies especially in the principle of “cultural landscape”: a set of archaeological, monumental and natural factors co-existing with current human activity. This area has remained almost unchanged since approximately 1,500 years ago.

The archaeological park’s main monumental complex is that of Vat Phou (the Temple of the Mountain), founded in the sixth century in honour of the god Shiva and a holy site for the Khmer culture. The temple was remodelled and enlarged in subsequent periods until it assumed the appearance it preserves today in what is called the Angor Vat Style (12th century).

The complex extends over an area of approximately 10 km² and is oriented on an east-west axis which includes the summit of a sacred mountain, the Lingaparvata, considered since the mid-5th century to be the home of the god Shiva, and the banks of the Mekong River, not only an important waterway but also a religious symbol analogous to the Ganges in India. There were two capitals, one erected on the banks of the Mekong before the unification of Chenla with Cambodia, and a second constructed between the 9th and 10th centuries in the vicinity of the Vat Phou; both were surrounded by villages and sites specializing in different artisan activities, as well as a dense grid of artificial canals and large-scale engineering and hydraulic works such as deviated rivers, basins for rainwater conservation for domestic and ritual use, and axial streets that put the Champasak province in contact with the capital at Angkor, that compose the historical landscape.

The enrolment of the area as a World Heritage Site has naturally made governmental authorities more sensitive and responsible, and has also attracted the attention of European countries (besides Italy) as well as non-European countries (Japan and India) who wish to contribute to the management and conservation of the park. The Italian contribution in
research, conservation and training has traced a consistent line. An on-site museum was established in 2002 (approximately 90,000 visitors per year); the ceremonial street which ran from the great basin for sacred ablutions to the Vat Phou temple was excavated and restored (500 m.); since 2006 the restoration of what is known as “Nandin Hall,” one of the service buildings annexed to the main temple, started. This project is being carried out in conjunction with the Politecnico di Milano and is being financed by the Italian Ministry of Foreign Affairs; the expected completion date is 2008 [1].

2. DESCRIPTION OF THE TEMPLE: SHAPE, MATERIALS, MASONRY AND CONSTRUCTION PHASES

The building so called ‘Nandin Hall’ is located south of the ceremonial way (west-east axis) leading to the upper sanctuary of Vat Phou. It has a unique shape, similar found to Angkor libraries ones.

The temple Nandin Hall of Wat Phou is a building that stands on a two-tiered platform. Its rectangular and elongated shape aligns from south to north: a porch on pillars, an entrance room, a central room, another entrance room with porch similar to the south one. The whole building is therefore constituted of five successive sections, under a double symmetry longitudinal as well as transversal. Only one side (east elevation) has three windows with little vertical stone columns (Figure 1).

In conformity with the Khmer building technique of the Angkorian period, it is built with sandstone blocks of various size but generally quite large, very precisely adjusted so as not to leave any gap or open joint between two adjacent blocks, and with no mortar.

In addition, laterite is used on the surrounding walls: in the foundation levels of the platforms and under the sandstone floors.

Masonry of sandstone is used on the surface, but laterite is used inside the platform. This material was originated through an extended transformation process of tropical Asian humus containing a large amount of manganese and iron.

The seasons in Laos are two: rainy and dry. Laterite works very well in the foundation in the rainy season because is a highly porous material and it prevents capillary rise of water.

The four corners of the platform, seen on a level terrain, are splayed. Each of the two tiers of the platform gradually becomes smaller than the one below. The platform in sandstone (five parts) has carved mouldings with easy relief, while the laterite platform (only one part) is simply vertical.

Figure 1: East prospect, constructive phases

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The steep stairs, on the two short sides of the lower platform (south and north sides), correspond, between open-sided porches, to the central structure entrances, enabling to reach the top of the raised area.

At the south entrance there are traces suggesting that the heads of timber beams were inserted into the upper portions of the walls. Beams, located on top, supported the roof. There are also traces of what appear to have been pivot holes on the sills directly below. From these signs, it is assumed that there used to be a wooden double swinging door that opened inward. There are four doors in the temple.

From the constructive technique of the doors and windows it is possible to suppose that, in the upper part, a timber beam was distributing the loads.

On top of the west and east elevations there are round–edge roof tile decorations.

The construction of the temple started by a platform with two layers: laterite and sandstone. After the Khmers, architects erected the central room, still in better condition than the other parts, which have been added on its both ends.

The junctions between the five parts are only made by an off-set of (juxtaposing) the stone blocks, without any connecting member. Actually, the joints between these parts are opened up to 10 cm, and the walls are no more vertical.

Their stability is not yet directly affected, the movement is continuing and cannot be halted without a structural intervention.

3. GEOMETRICAL APPLYING SURVEY METHODOLOGIES FOR THE DOCUMENTATION OF HISTORICAL BUILDINGS

Before the conservation project started, a geometrical survey was carried out of Nandin Hall in order to obtain precisely not only the building dimensions and its anomalies/changes, but also an appropriate graphic base for the following processing of analysis and project charts, as well as every in-situ operations and observations. For this reason the graphical restitution has been represented in 1:20 scale, redrawing every single stone constituting the monument.

The building, apparently has simple constituting lines, a particular connection of the facade’s vertical planes and differ in horizontal scanning between the planes/platforms, of the two lateral rooms and of the central one; in vertical scanning from the modeled frames and the overlying masonry. During the graphic redrawing, particular attention has been focused on an efficient restitution of this structure.

The survey operations have been carried out by integrating topographic measures, obtained through a digital theodolite, with direct longimetric measures simple with tool like: straight measuring rods, flexometers, pony band saws, plumb-lines and levels.

The temple has been surrounded and crossed by a grading network closed on five stations (one for each position and one in the central room) appropriately located in order to guarantee the maximum visibility from every point of view. This network has been connected with two of the permanent positions previously created for the survey of the whole Vat Phou site. Therefore detailed measures have been achieved of the appropriately marked points to be used for the photographic rectifications of the east and west positions and of natural points or points highlighted by a retro reflector, in order to return four positions and six sections (one longitudinal and five transversal).
The 950 detailed points and more have been integrated with punctual monographies for both natural points, marked by chalk and read through a microprism, and points detected through a retro reflector.

Particular attention has been focused on the monographies of the points achieved in correspondence to the changes of the vertical planes; infact owing to the peculiar constructive technique of these planes, they are generally set with bondstones appropriately worked for being simultaneously at different levels.

The sections survey has been carried out, by setting an appropriate network of plumb-lines which has allowed the signalisation of the external positions through retro reflectors on every bondstone detected and through simple direct longimetric measures on internal positions.

For the planimetric survey, the topographic reading of the important points has been performed to identify level and slope changes in the stone elements constituting the most external basement, as well as angle and edge points. On the contrary, the detailed survey of the internal floors in the three rooms and two platforms has been carried out by local operators on scale paper with direct longimetric measures referring to the 1x1m archaeological mesh, which frames the whole building, and then appropriately re-elaborated and inserted into the total planimetry.

Following the phase of metric data acquisition a detailed photographic campaign has been added of the manufactured elements and of all the points achieved so that the images can help to solve possible problems or critical points raised in the restitution phase.

This operation has been carried out starting from the photographic rectification of the east and west positions achieved by mottling eight photograms, corresponding to the different planes, in which they are articulated; this has allowed the redrawing of the planes through a continuous metric control by means of preliminary surveys and monographies. The “angle situations” have been solved by integrating the metric data referring to the two converging prospects.

The north and south positions, for which important photographic rectifications could not be processed, have been restituted in a traditional manner by integrating the points topographically read with direct longimetric detailed measures.

For all four prospects, the slope of the plane at the basement has been detected topographically by reading the points and with a regular base of one meter per meter.

This operation was very important to read the contour lines and the erosion phenomena.

The redrawing of the sections has been carried out starting from the building’ external profiles, where topographic points were reported and then ending up with:
- longimetric measures achieved to detect the internal profiles;
- every element, crossing the direct measures;
- every element already represented for redrawing the external fronts;
- the result of the planimetric restitution, in particular of the external basement, in order to define the visible elements.

The planimetry restitution has been made starting from the most external basement around the building, redrawing positions and sections and ending with the redrawing of the floors achieved by direct measures.

A great attention has been paid to the final editing of the documents in order to represent the fair reading of the different planes and the different floor levels, the moulded frames and the basement in the planimetric vision, thanks to the right calibration of the lines.
The length of the central structure is approximately 13.00 m, the width at the central room is 4,00m, the length of the entrances rooms is 4.00 m and the porches 5.00m. If we include the south and north porches, the length of the sides is about 23 m.

The height of the lower platform is different between north and south, but also between west and east because we have an erosion of the soil.

Mapping was also made particularly difficult by the building poor conditions.

4. INVESTIGATION ABOUT THE STRUCTURAL AND PHYSICAL DAMAGES

The investigations - survey and identification of the various construction phases - carried out at Nandin Hall were based on the analysis of direct sources, which were used to understand the building’s historical evolution and the consistency of the construction materials.

Thanks to the basic method of dating buildings - stratification of elevations, typology of wall constructions – and to the visual analysis carried out, the composition of the construction has been identified in all its complexity: the dating and the geometric aspects of the structure tell its past history and hold considerable information.

The following phase of the project consists in a structural damage control through the study of the: topographic context [2]; trials archaeological test; variation in the inclination of the temple’s walls on all prospects and sections, but also the horizontality lines of the platforms (with the readings and topographical station); crack pattern survey conditions of movement and deterioration of the elements. The whole building rests on a thick layer of filling material, which made an approximately horizontal surface at the foot of the mountain (an archaeological test pit on its west face showed a 1.8 m thickness of anthropic dammed layers of sand and gravel with brick and stone debris). Through the centuries however, this filling has been intensely eroded by the water run-off from the mountain, threatening the foundations and the structural integrity of the building. This erosion is presently continuing, and its disrupting action could be seen in the recent years: it is at its worse on the south part of the building, where the soil has been washed out for one meter, exposing the lowest level of the foundation and resulting in an important differential settlement (30 cm) and in the dislocation of the structure (Figure 2).
The mapping of the walled structures has led to the identification of the structural damage precisely: lack of joint (disjointedness) and knot junction, the interconnection of walls at corners or its absence, continuity and discontinuity of the perimeter walls, punctual and areal sinking, shifting of the direction, inclination of the temple walls, stone rotation, missing parts, presence of cavities (where there were the timberbeams), local and diffuses lack of stability, micro and macroflora, broken stones, and various other signs important for the building safety. These have been the principal reasons of partial collapse of the temple’s structures. Many longitudinal and transversal sections, intentionally carried out, present the in or outside rotation of the temple walls. Moreover, another drawing represents also the different levels of the platforms referred to a “reference line”. This line - that turns all around, with continuity, the temple’s lower platforms – is very important because it shows clearly the alignment of the floors. In particular the alignments of the east and west positions are confronted and the result is that the whole temple height reduces from north to south of an average of 30 cm and from west to east of a few centimetres.

The temple is situated on one of the earthworks in the archaeological area and unluckily from the mountain and the ceremonial street (with two different plunges) in the rainy season,
waters are not sufficiently transferred into adequate collection systems. The “movements” of the monument follow these two directions with the consequent water erosion at the temple’s sides. It has to be reminded that the Nandin Hall has no roofs (important horizontal connection) and it is exposed to rain. Now it is open to the sky with rainwater falling freely inside and percolating to the foundations (Figure 3).

At present, above all the south porch, but also two lateral entrances and many walls on the platforms of the temple are in a high risk of collapse (Figure 4).

5 CONSERVATION PROJECT

The Nandin Hall will be restored through the method of partial dismantelling and reconstruction. This method has been applied always in the history of preservation on especially for the Angkor monuments. As in other Angkorian monuments, the condition of the building shows that no method could provide long term protection and stability without improving the state of the original foundations and the stability of the stonework: as soon as a differential settlement occurs, the stone blocks are disrupted, the dry joints open and the load bearing system is altered by new load concentrations resulting in the collapse or the partial cracking of the lower blocks (Figure 5). Given these conditions, the method of dismantling the disrupted stonework to give access to the foundation level and of re-assembling the stone blocks, at their original level and position on improved foundations has been successfully adopted for numerous Khmer monuments, inside and outside Angkor; several of them have now passed the test of time. In all these projects, preliminary technical studies were performed, documentation collected and alternative techniques evaluated, to conclude that this methodology was the most appropriate. It should be noted that it is particularly suited for the Khmer building technique: as there is no space and no mortar between the stone blocks, each one should fit exactly its own location and space, thus preventing errors or approximations during reconstruction.

When preparing the project for Nandin hall, it was agreed that the central part does not need integral dismantling, as it has retained its original level and structural integrity, and that the north and south wings, severely affected by soil erosion and differential settlement, should be
dismantled and rebuilt on stable foundations in order to recover their shape, their level and to restore the structural integrity of the building.

The conservation process will include the following steps:
1 - clearing of the site and the monument, archaeological investigation;
2 - removal, sorting out and temporary storing of fallen stones found in and around the building;
3 - accurate survey of the building, with precise record of actual levels;
4 - dismantling of the damaged structures from top to bottom, individually marking and documentation of each stone, detailed survey of each course and systematic, course-by-course, storing of stones;
5 – strengthening of the exposed foundation, filling gaps and holes with lime and brick powder mortar, replacing laterite blocks found altered, damaged or crushed;
6 - installing a drain under the stone floor to evacuate rainwater from the roofless interior;
7 - rebuilding the structure from the lowest layers by adjusting the original stones to their accurate level and relative position;
8 - fitting back to their original position the fallen stones and isolated fragments removed under step 2, which in the meantime have been identified and assembled together to reinstall the collapsed parts; this step is especially necessary where the wall stability is weak due to these collapses;
9 – remodelling the upstream area to divert the rainwater run-off away from the structure, refilling the soil around the building to recover the original soil level.

Figure 5: Sections

6 CONCLUSIONS

A preliminary study of the building condition was performed in 2003 by a Japanese team. But the investigation conducted by the Lerici Foundation in 2006, with accurate architectural and morphological survey of the building and its surroundings, showed clearly that the condition of the foundations, the intensity of erosion and the disruption of the structure were more serious than initially, considered analytic technical evaluation by the Politecnico of Milan (Diagnostic Laboratory for Conservation and Reuse of Cultural Heritage with the Observatory on Woodwork Preservation of the Department for Architectural Design, and the Laboratory of Material Testing – Section “Masonry structures, stone materials, mortars, diagnosis for the Cultural Heritage” of the Department of Structural Engineering) confirmed that the improvement of the foundation and the repositioning of the base and of the walls in
their original, precise position are an absolute necessity to ensure the future stability of the structure. It is however agreed that the intervention will be restricted to the minimal necessary, and that no attempt will be made to reconstruct missing parts or complete structures left unfinished. In other words, this methodology does not presume the restoration of a disused asset but expresses the need to comprehensively understand the technology of construction of the structure and of the constituent materials and to protect the integrity of the remains in the future within their complexity.

Politecnico of Milan and Lerici Institution do not recommend to build a new roof. The new structures could show a larger size and consequently have an impact on the people, with a very negative visual shock. Nandin Hall foundations are in poor condition, subjected to differential sinking which has caused structural damage above all in the portal part and in the entry to the first room both facing south. But the subsoil has gradually acquired its hydrological balance and, at present, the structural evolution is very slow and stabilized. To cover the building could change the whole situation, today the rain is equally dispersed all over the area. It is hoped that, after the conservation project has been realised, the structural stability of the building will increase and the differential movement stop thanks to the repair of the foundations and the stabilization of the subsoil. In the meanwhile, it will be possible to collect the water through a specially designed drainage system inside the temple and direct it far from the monument.

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REFERENCES

[1] Following is the list of principal participants of the project (titles, positions and organizations):
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