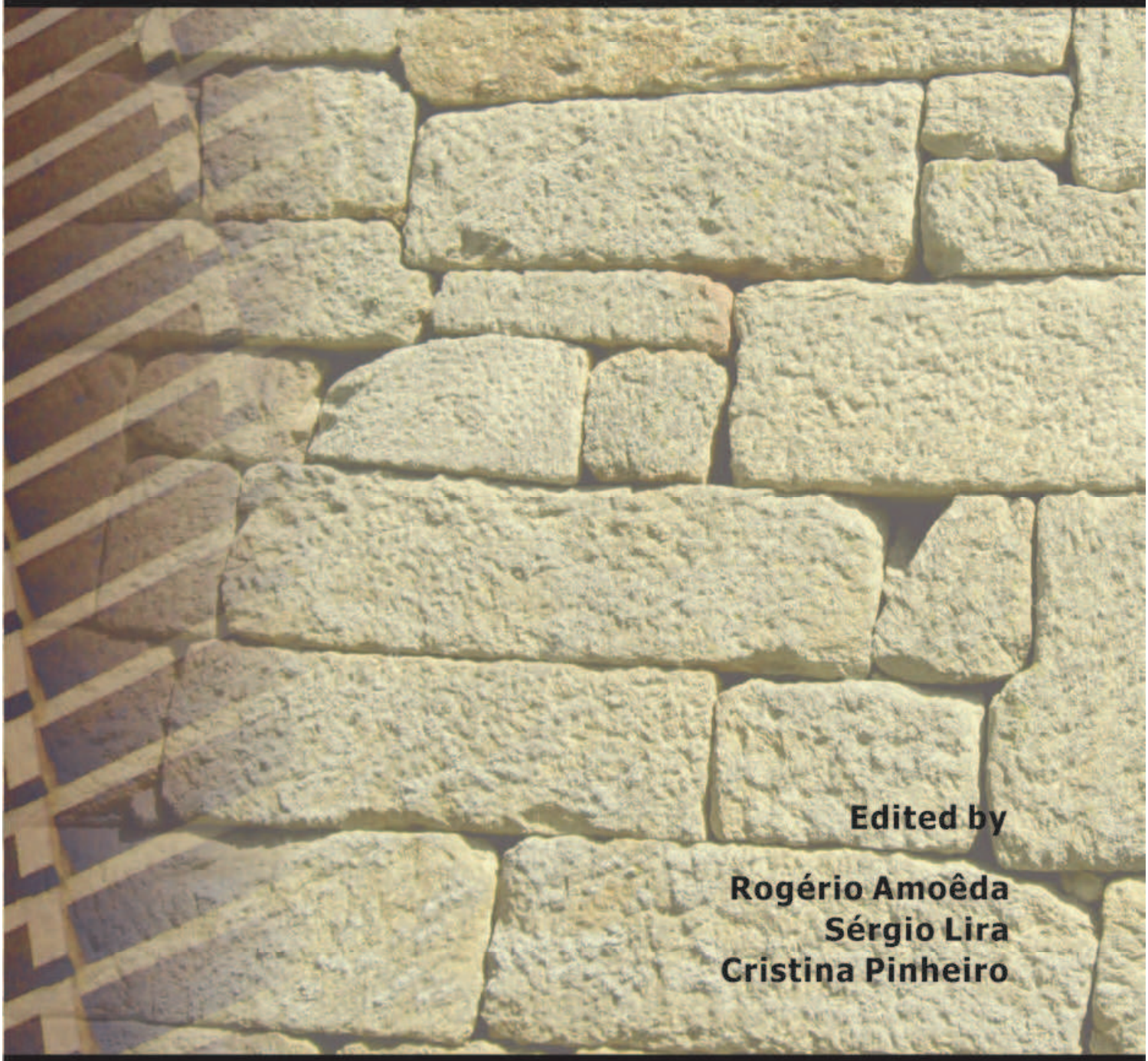
# REHAB 2014

Proceedings of the International Conference on
Preservation, Maintenance and Rehabilitation
of Historical Buildings and Structures



Edited by

Rogério Amoêda
Sérgio Lira
Cristina Pinheiro

Volume 1

green lines institute
for sustainable development

REHAB 2014

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Proceedings of the International Conference
on Preservation, Maintenance and Rehabilitation
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*Tomar, Portugal*
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## Proceedings of the International Conference on Preservation, Maintenance and Rehabilitation of Historical Buildings and Structures

Edited by
Rogério Amoêda, Sérgio Lira & Cristina Pinheiro

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# Foreword

REHAB 2014 – International Conference on Preservation, Maintenance and Rehabilitation of Historic Buildings and Structure aimed at pushing further the discussion on built heritage and the preservation of its legacy, establishing a settle of knowledge and experience from several parts of the world. The importance of conservation of historical constructions (built landscape, urban fabrics, buildings, and engineering works) are of utmost importance to preserve the cultural references of a community.

Under the main topics of discussion, subjects of preservation and rehabilitation methodologies and technologies, as well the importance of the economic and social impacts of preservation practices were covered by several papers as the main leading guidelines of this the conference. Furthermore, different communities' scales (local, regional national or even worldwide) raise different questions and approaches, and therefore different solutions that are worthily studying, in order to compare experiences and practices. The sustainability approach was also covered, highlighting the importance of the commitment between heritage preservation and technical requirements related to its occupancy and use, such as energy efficiency or materials recovery. Inclusivity was an important topic of discussion too during the conference, as public historical sites and buildings need to be adapted to receive different kind of visitors (children, elderly or handicapped persons) and to establish an adequacy with the perceiving of the physical environment and information contents.

As for the Special Chapter of this event Archaeological sites were brought in because they demand a particular approach specially on what concerns the preservation of historical elements that are to be maintained and visited long after the diggings and the field work is over and done. This kind of structures raises unique problems of preservation and promotion and therefore is the focus of special and specific solutions.

This conference also gave stage to early stage researchers and students willing to share the results of their research projects, namely post-graduation projects and doctoral projects. REHAB received a significant number of such proposals the quality of which was confirmed during double-blind review.

We would like to express our gratefulness to all the partners and sponsors of REHAB 2014 who joined efforts to make it a significant Conference.

Our special word of recognition to the Secretário de Estado da Cultura, Direcção-Geral do Património Cultural, Convento de Cristo, Câmara Municipal de Tomar, to the IPT – Instituto Politécnico de Tomar.

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# Tambo Colorado research and conservation project

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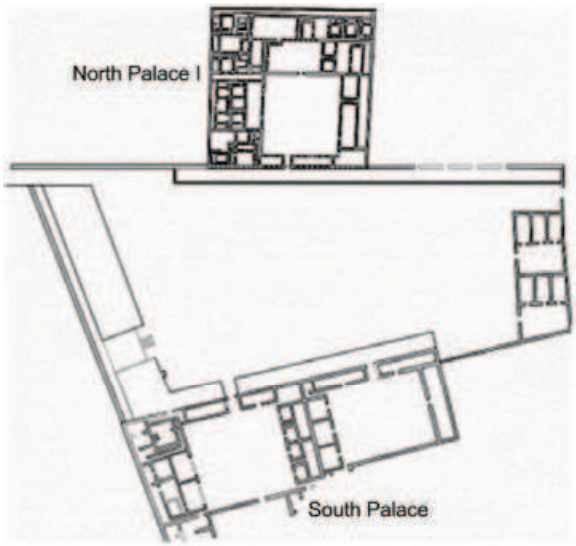
ABSTRACT: Tambo Colorado is one of the most impressive Inca sites in the southern Peruvian coast, because of its stunning architecture, its extraordinary pictorial decoration, and its strategic location in the section of the Great Inca Road. This site has been indicated as the best preserved in the Peruvian coast; despite it is located in Pisco one of the most seismic area at the Pacific coast. Unfortunately, despite the importance that this site involves, it has not been protected and actually is exposed to environmental factors and earthquakes, which affect its conservation. The Research Project Tambo Colorado has recently applied a comprehensive analysis encompassing nature of the materials (archaeometric analysis), 3D photomodeling; graffiti study as well as a proper understanding of its architectonic and finishes conditions. In this regard transdisciplinary research provides the necessary tools to conserve not just the site materiality but its significance.

## 1 INTRODUCTION

Tambo Colorado is located on the right bank of the Pisco valley 35 km from the city of Pisco at the south coast of Peru (Fig. 1). This site is also called *Pucallacta* or *Pucahuasi* which means "red house" in Quechua; it was built by the Pachacutec Inca at the end of 14$^{th}$ century and was occupied till 1532. This site is historically important because is the first settlement that the Incas built in the coast while coming down from highlands to coast. Because of that, Tambo Colorado shows an impressive Inca architecture, represented on the uses of trapezoidal niches, colorful wall painting and local influence represented by use of laddered friezes and cornices. Despite its historical value, Tambo Colorado has not been properly protected and is currently exposed to different factors that affect its conservation; no proposals have been made to solve conservations problem. Considering Tambo Colorado´s importance, the seismic risk of the area where located and environmental affectation, the Tambo Colorado research and conservation project has proposed a transdisciplinary methodology that embraces structural conservation assessment finishes conservation assessment, archaeometry analysis, photogrammetric recording and graffiti recording. The area that has been worked is the North Palace I, and is the most complex and decorated of the site, and supposed to be the area were the Inca family lived (Fig. 1). The result of all this analysis and research allowed us to get a completed and detailed knowledge of the site.

1- © Projet de Recherche Tambo Colorado (PRTC, 2014).




2- Uhle in Protzen J., 2010.

Figure 1. Tambo Colorado location in the Inca empire map (1) and the archaeological complex plane with the North Palace I (2), where the project was focused.

### 1.1 *Antecedents and problematic*

Tambo Colorado monumentality, colorful and the apparent good condition are features that have attracted the attention of many visitors and researchers, who have made several records, observations and proposed many different interpretations of the site. However, despite these features, the site has not been investigated comprehensively, there are no analyzes of the apparent good condition of architecture, repeatedly mentioned by different researchers (Protzen and Morris, 2004; Protzen, 2010, etc). Neither has been determined the nature of paints that cover all the walls of the site.

The first visitors made descriptions and photographic records of the site; Bandelier in 1893 made plans and photographs (Engel, 1957). Later, in 1901 Uhle spent almost a month and a half in Tambo Colorado, impressed by its architecture; he developed a rigorous and detailed planimetric recording and analysis of the architectural features (Protzen, 2010). Uhle thought that this site was an Inca complex with hierarchical architecture; he emphasized the importance of the colors used in the architecture, proposing that these colors could have had a particular meaning (Protzen, 2010).

Bonavia mentioned in his publication "Richata Qellcani" that he obtained three samples of mural painting from Tambo Colorado, which turned out to be mixture of iron oxide (Bonavia, 1974). In 1970, archaeologist Pezzia makes a guide called "Pictorial Map of the Archaeological Department of Ica", he makes a description of the site and proposed different roles in each sector, based on architectural evidence.

During the last decade, research has focused on political and symbolic importance of the site. Morris suggested that Tambo Colorado was an Inca palace, based on the features described in Murua's chronicle, and architectural comparison with other Inca sites. Protzen and Morris also proposed an interpretative analysis of colors pattern used in the site, related to social hierarchies where the paint was a visual indicator to convey a social political order (Protzen and Morris, 2004).

In conclusion, we can see that most of the studies were focused on making architectural records, and based on this information were proposed functional and symbolic interpretations. Later interpretations have been focused on the role and use of areas as well as strategic importance during the Inca conquest, and finally some preliminary interpretations of the symbolic significance of the murals of the site.

All these information have contributed to understand the architectonic and aesthetics characteristics of the site. Unfortunately, there has not been any conservation work, neither interpretation about functionality, or symbolic importance of the site. In this regard we consider necessary to conduct a comprehensive investigation involving the analysis of the nature of the materials (archaeometric analysis), as well as a proper understanding of the structural and finishes condition of the site.

### 1.2 *Objectives*

Our main purpose is to develop interdisciplinary research to provide the necessary tools to conserve the materiality and significance of the site. In the first work season (October 2013), our objectives are focused on developing a suitable condition assessment of the site, specifically in one of the most significant area which is known as North Palace I (Fig. 2), area that highlights for its colorful wall painting and architectonic display (Wolgang, 1999). Other objective is to characterize the wall painting pigments, to record one of the areas using 3D photo modeling and finally to make graffiti record in each wall.

Figure 2. Tambo Colorado - North Palace I (© PRTC, 2013).

## 2 METHODOLOGY

Transdisciplinary methodology is the most important aspect of the project. Indeed, the monument has been to consider as a unit, and to attend all its issues it has been used multi-protocol methodology, combining archeology, archaeometry, and structural and finishes conservation.
At field three teams were conformed: condition assessment (structural and finishes) team, archaeometry, and graffiti recording team.

All the team work walk together trough the 66 rooms of North Palace I, area that has been choose for its condition, color display and architectonic complexity. By using a plan of the site (Uhle 1901 in Protzen J., 2010), were marked the walls that needed to be preserve urgently, these chooses were done according to a list of priority where the structural damages were consider the most important issue, followed by the presence of wall painting and lastly the presence of significant graffiti (with possibility of colonial date). Letter “A” was used for the most damaged wall and B, C, and D for the walls less damaged or interesting (Fig. 3).

This procedure will allow us to compile the necessary data for each aspect, in all rooms of this area and then to compile enough information for a complete diagnosis of the site.

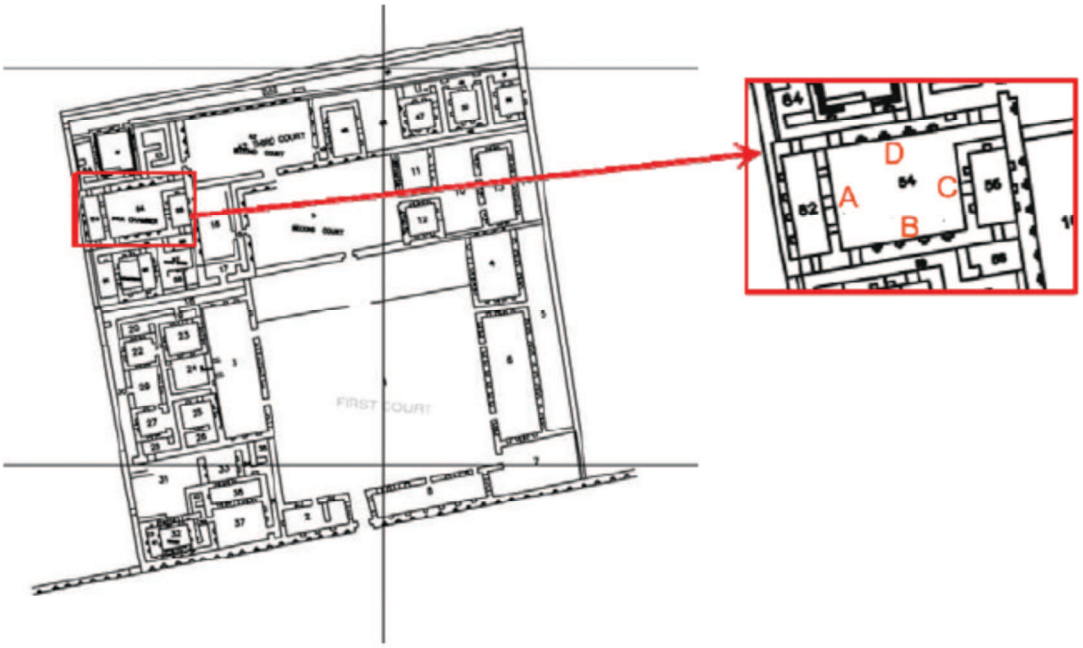



Figure 3. North Palace I (according to Uhle 1901), it shows the letters code system for each wall of the rooms according to damage level. Letter A indicates the wall that needs priority intervention.

## 2.1 *Structural Condition assessment*

The architectonic complex North Palace I, was built completely with adobe masonry. These adobes have a quadrangular shape and heterogeneous measures, there is no archaeological evidence about the adobes production, but it's possible to establish the use of molds on manufacture (Fig. 4). The walls width is between 65 and 95 cm, and has from 2.40 to 3.00 m heights. Most of the walls' bases were made with stones; the rooms have remarkable niches presence, as well as windows and trapezoidal entries.

Figure 4. Details of the masonry of the archaeological site (© PRTC, 2013).

Through almost 450 years, the south center Peruvian zone has suffered more than 17 telluric movements, with intensities that arise between VII and IX type on the Mercalli scale (MM). The last Pisco seism reached 7.0 ML Richter, VII MN was the largest scale ever recorded in central Peru region in the last 100 years (Tavera, Bernal and Salas, 2007). The Getty Conservation Institute reported this seism got a VII (MM) on Tambo Colorado area, and about the damages caused, reported: "*diagonal cracking between adobe block and mortar. Vertical cracking at the junction of perpendicular walls, among others, was observed"* (The Getty Conservation Institute, 2011). In the report they couldn´t find any structural condition antecedents or data before 2007, for this reason the 2013 record is the first one on its kind and it will be used to monitor the site structural condition on the future.

The adobes used on walls construction have different sizes, and were made with molds. There are adobes 52 cm long, the mortar between each adobe is 2-5 cm and they don't have vegetal fibers or any other additive. The walls' bases are usually built with stones and mortar, and their height is variable.

The moorage used on masonry has influence on walls stability. There are some areas where it can be seen that the adobes are put along the wall crossing through wall faces, and in the next level the adobes are put along the wall, this advantage the walls resistance.

The width-high ratio, for most of the walls lies between 1:3 and 1:4 ranges, which allow these structures have adequate strength and rigidity, the measurement described ensures in most cases a pattern, detecting an established proportion used by manufacturers.

There are evidences of reinforced walls placed at the base of the walls, one located in the tower ("Torreón" rooms 32 and 41, Fig. 9) and another in the enclosure 65, both chambers have evidence of a second level, both have part of its structure in stone but are not fully constructed in this material, and finally both reinforcements have the same cross section 75 x 160 cm.

Currently no rooms have ceilings, however can be seen traces of the beams that were used in the roof structure, it is possible that roofs contribute to earthquake-resistance.

In order to achieve a proper condition diagnosis it was identified the structural problems that currently affects the site, for this porpoise, it was used a glossary in which was identified the main problems in walls of the North Palace I. Subsequently an inventory was made in order to establish the recurrence of these conditions in each of the enclosures. This inventory was made by visual inspection wall by wall; in total we have verified 250 walls faces in the 66 rooms.

Finally it was made a map of the vulnerable areas with walls or wall segments that have serious collapse risk and that its fall could represent a serious risk to visitors, this plane also allowed us to establish that visitors access from the patios to the enclosures should be restricted in order to safeguard the integrity of the people and the building.

### 2.2 *Finishes condition assessment*

The methodology of finishes condition assessment is guided by cultural heritage guidelines. Conservation and recording was considered an interdisciplinary work which embraces different techniques that helped to heritage protection and its study. In order to embrace a complete record it has been considered a precise written, graphic and photographic documentation.

The condition assessment looks forward to identify common affectations, and the factors that cause it; for this reason each face of wall were considered as a unit. The qualitative record was done in each wall face and a detailed qualitative and quantitative record, with a wall print picture, was done in the most injured wall of each room ("A" wall according to methodology). In the pictures were indicated the damages using color marks, for example it was used: PT in black color for partial loss, A in orange for abrasion, G in orange for graffiti (Fig. 5). This methodology considered three complementary tools: record sheets, photographic record, and drawings of wall faces. The use of these tools will allow us to complement and compare different information.

Figure 5. Picture of the "A" wall face, room 56 with the marks indicating finishes damages (© PRTC, 2013).

### 2.3 *Wall painting analyses and Graffiti recording*

To support the diagnosis of conservation areas we have made an archaeometric wall painting study, taking samples in almost all of the walls of the North Palace I. This study allows us to characterize the coloring materials used on wall paintings and make microscopic observations to understand the "micro - changes" that will improve conservation treatment. The use of physics embraces two phases: analysis *in situ* and analysis in the laboratory on samples collected.

*In situ*, the study began with instrumental colorimetry. This machine measures each color attributing mathematical coordinates on diagrams and data tables, and allows following through time the colors evolution. In the colorimetry measuring points we have made color fluorescence analysis with X-ray machine: Brucker Tracer III SD. These measurements allow getting the elemental composition data of pictorial materials.

Next, in laboratory phase were done microscopic observations in section by optical and scanning electron microscopy. These experiments allow appreciating the degree of conservation and adhesion of the paint layer in the plaster of raw land and so locating and identifying the micro - changes involved in these painted surfaces. On the other hand, it can detect the presence of contaminants, such as salts and / or fungi, which are not always visible to the human eye. This observation phase is completed by structural analysis by X-ray diffraction, infrared and Raman spectroscopy, experimental protocol that allows highlights all the mineral and organic components.

These compositional data set will allow potential chemical treatments applied in conservation treatments on the future.

Moreover graffiti detailed recording allowed us to identify a number of interesting facts that had not been previously reported. Among the graffiti were identified Incas character draws in colonial style, inscriptions in old Spanish language with dates of 1700 and inscriptions reporting the presence of Catholic missions in the site. These data have not been published previously, and we consider these provide important information to the site, for this reason we propose not to cover the graffiti, as is done regularly in conservation treatments, but to preserve its information.

## 3 RESULTS

The Tambo Colorado earth structures have different pathologies that have affected its stability and have influence greatly their performance against earthquake forces; the walls have a series

of injuries that have affected many different ways, conditioning its architectural conservation (Table 1).

Table 1. Pathologies affecting walls structure of the archaeological site.

| **Structural problems in the North Hall 1 of Tambo Colorado** | |
|---|---|
| Cracks in access vain. | Horizontal cracks. |
| Diagonal crack in corner. | Partial loss of the wall. |
| Vertical crack in the plane of the wall. | Loss lintels. |
| Local instability of wall segment. | Biological damage / vandalism agents. |
| Damage at the walls intersection. | Loss of the corner of the wall. |
| Rolling out of the plane of the wall. | Drastic loss of the wall section. |
| Cracks in-plane shear. | Widespread cracks. |
| Relative displacement between walls. | Cracks in the cross section of the wall. |
| Damage to the base of the wall. | Total loss of walls. |

The pathologies inventory results show that: 35% of the walls have cracks in-plane shear, 37% have partial loss and 34% of the walls have cracks in the cross section. These pathologies show the archaeological site serious condition and demonstrate that is necessary to take corrective actions to reduce in short-term the risk of loss of the structures of the archaeological site (Fig. 6).

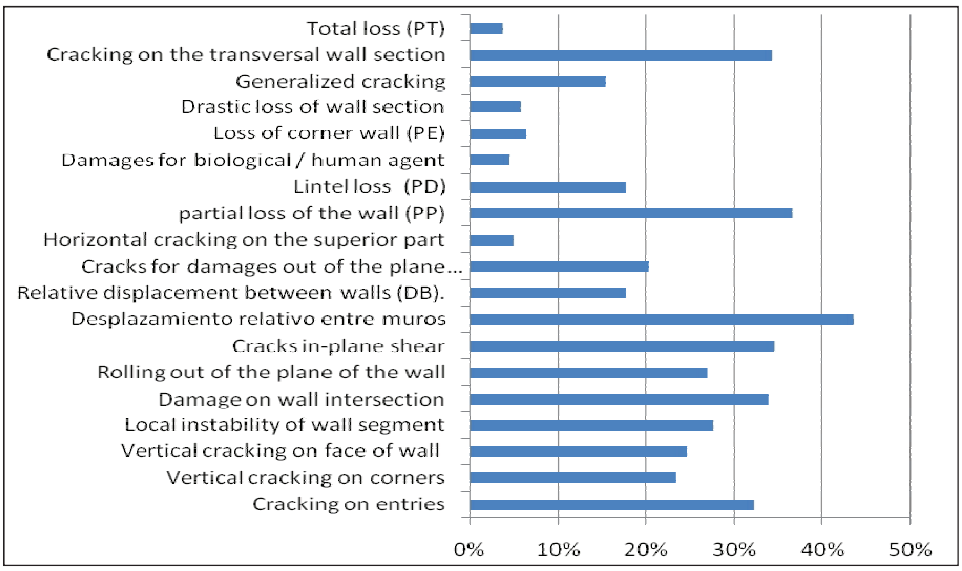


Figure 6. Pathologies affecting the walls of the archaeological site (© PRTC, 2013).

The general condition shows 27% of the walls or parts of them are in risk of collapse. We are convinced that in a next severe earthquake they could collapse (Fig. 7). The vulnerable areas in the plane allow identifying this serious problem; damages are distributed in 46% of the North Palace rooms, they are represented by heavily cracked walls and unbalanced walls from its original position.

The information collected, indicates that is necessary to analyze the earthquake resistant behavior that currently presents the building, which is in a phase of cracking. The study of this is an important issue to know the behavior of the adobes structures in inelastic status in the heritage buildings.

Figure 7. North Palace I vulnerability it shows enclosures with walls in risk of collapse (© PRTC, 2013).

Similarly to structure condition assessment, it was made a glossary for finishes damages. In this glossary was classified the conservation problems according to its severity in 5 categories: total loss, partial loss, damages without material loss, intrusions, and biological damage (Table 2).

Table 2. Pathologies affecting walls finishes of the archaeological site.

| **Finishes problems in the North Hall 1 of Tambo Colorado** | |
|---|---|
| Plaster local loss | Plaster detachment |
| Wall painting local loss | Wall painting detachment |
| Perforations | Plaster cracking |
| Abrasions | Wall painting cracking |
| Mortar loss | Wall painting map cracking |
| Blistering | Biological damage |
| Plaster erosion | Rain deposit |
| Wall painting erosion | Wasp nest |
| Plaster lamination | Graffiti |

These damages were rated according the area affected: 0 for absentee damage, 1 for isolated damages extend on 1-5% of the wall face area, 2 for low damage extend on 6-30% of the wall face area and 4 for high damaged, with extension of 81-100% of wall face area (Matero, 2011).

The general condition shows 30% of the walls present total loss between 2-4 level, and 29% present plaster and wall painting detachment in 2-4 level. We consider that the amount of finishes that are in imminent state of loss is significant and in eventual raining season it could increase the total lost area of 29% of Tambo Colorado walls (Fig. 8).

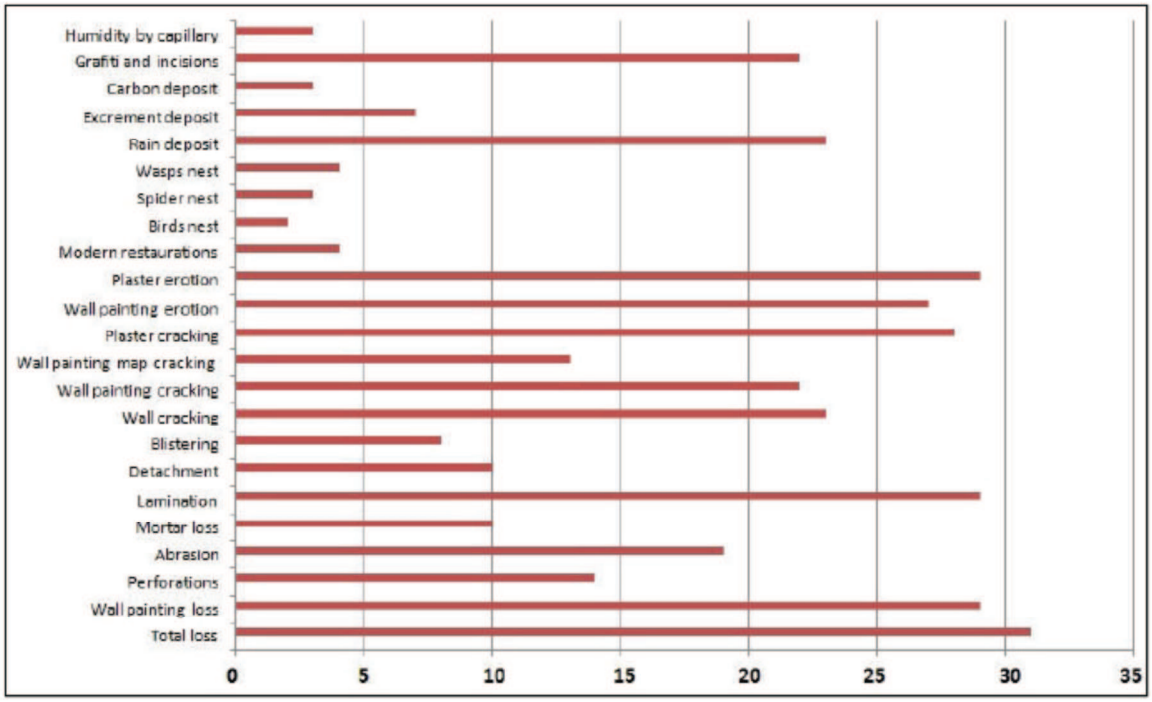



Figure 8. Pathologies affecting the walls finishes of the archaeological site (© PRTC, 2013).

## 4 CONCLUSION

The results we got, although are preliminaries, allow us to get a global structural and finishes condition assessment and to propose specific actions to prevent more damages, this proposal consider to begin taking on count the most affected areas.

The methodology has allowed distinguishing structural damages from finishes damages, consequently, a better understanding of the kind of damages and a specific conservation proposal for each case has been developed.

All the data acquired from the condition assessment work, lead us to understand that the area known as the "Torreón" of the North Palace I (rooms 32 and 41) (Fig. 9) is the most vulnerable and must be intervened urgently. The photogrammetric survey on this sector gave us the opportunity to record appropriately this area and plan the first stage of our future work.

In the other hand, thanks to the first results of the condition assessment, the authorities of Peruvian Ministry of Culture, based on the vulnerability map, has recently restrict the tourism access to the areas diagnoses as the most damages and with collapse risk. This sets an important step on the site conservation, due to the fact there were no protection action taken before.

The condition assessment work has allow us to plan, in short term the conservation work properly, taking in count the most damages areas, and to complement this work with archaeometric analysis and graffiti record, this information will enrich the knowledge of the murals and the building.

Figure 9. *Torreón* photography and 3D photogrammetry survey. This area was diagnosed as the most damaged, and will be treated priority (© PRTC, 2013).

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