The Exterior Conservation Project of the Tower of Belem and its Sequel

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ABSTRACT

In 1992 the conservation project of the Tower of Belem was being considered by World Monuments Fund, and Phase I of the project took place between November 1993 and February 1994. The actual intervention was carried out from February 1997 to January 1998. In the last 17 years, some specific interventions, mainly in the interior of the Tower were carried out to improve the visitors' experience, such as new wood footbridge and the visitors' flow management system for the spiral staircase. Meanwhile, the exterior has soiled again while the interior stonework continued to show some deterioration issues that require a thorough study to identify their sources and the approach for this is discussed,

KEY WORDS

Tower of Belem, water infiltration, deterioration, soiling, remedial measures

INTRODUCTION

The Exterior Conservation Project of the Tower of Belem was conceived by World Monuments Fund (WMF) and its Portuguese affiliate, WMF Portugal, in 1992. By the end of the following year, Phase I of the project, Condition Survey, was carried out to assess the state of conservation and included some test cleaning and mortar replacement. It was completed by February 1994, when the scaffolding was removed to allow visitors to view the Tower during the year Lisbon was the Cultural Capital of Europe. This allowed time to evaluate the conservation actions required and to secure the necessary funds to complete the intervention. Three years later, the project was implemented in collaboration with the Instituto Português do Patrimonio Arquitectónico and was completed by the end of January 1998[1] in time for the World Exposition held in Lisbon.

THE EXTERIOR CONSERVATION PROJECT

The survey conducted in Phase I identified four key problematic points[2]: 1) structural problems from misaligned elements or highly deteriorated; 2) water penetration through horizontal surfaces, open joints, larger holes between blocks, and cracked or fissured blocks; 3) flaking or powdering stone surfaces; and, 4) soiled or stained surfaces from air pollution[3] and/or biocolonization[4]. Because of the extensive problems encountered, the

[1] Charola, A.E., Henriques, F.M.A., Delgado Rodrigues, J., Aires-Barros, L. *The Tower of Belem Exterior Conservation Project.* Internationale Zeitschrift für Bauinstandsetzen (now Restoration of Buildings and Monuments) 1998 4: 587-610.

[2] *Torre de Belém-Intervenção de conservação exterior,* IPPAR, Lisboa, 2000.

[3] Aires-Barros, L., Basto, M.J. Graça, R.C., Dionisio, A., Delgado Rodrigues, J., Henriques, F.M.A., Charola, A.E. *Stone Deterioration on the Tower of Belem*. Internationale Zeitschrift für Bauinstandsetzen (now Restoration of Buildings and Monuments) 1998 4: 611-626.

[4] Ascaso, C., Wierchos, J., Delgado Rodrigues, J., Aires-Barros, L., Henriques, F.M.A., Charola, A.E. *Endolithic Microorganisms in the Biodeterioration of the Tower of Belem*. Internationale Zeitschrift für Bauinstandsetzen (now Restoration of Buildings and Monuments) 1998 4: 627-640.

terraces, i.e., that at the top of the Tower, the round-walk, and the bulwark, were not included in the project[5], however, the Recommendations for a Maintenance Plan[6] suggested that they required specific attention during the regular inspections suggested.

The actual intervention, Phase II of the Project, focused on these issues and also can be subdivided into the following main categories: 1) addresssing structural issues; 2) sealing and repointing joints[7]; 3) cleaning[8]; 4) application of consolidants where the stone surface was in poor condition[9]; and 5) localized application of a water repellent or lime water-wash, the latter to provide a uniform color. Figure 1 shows the appearance of the Tower before the intervention and after it.

The main reason for the heavy soiling of the north façade was the presence of a coal gas manufacturing plant —from the end of 19th to mid 20th century— located in front of the Tower, where the plaza and gardens are now. Since then, the exhaust fumes of cars and tourist buses that were allowed to park right on the plaza also contributed to it and prompted the decision to no longer allow parking there.

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[5] Proença, N. "Conservação e restauro do exterior da Torre de Belém". In *Torre de Belém-Intervenção de conservação exterior*, pp. 99-139. IPPAR, Lisboa, 2000.

[6] Charola, A.E., Aires-Barros, L., Delgado Rodrigues, J., Henriques, F.M.A. Recomendações para o plano de manutenção do exterior da Torre de Belém. In *Torre de Belém-Intervenção de conservação exterior*, pp. 57-67. IPPAR, Lisboa, 2000.

[7] Henriques, F.M.A. Charola, A.E., Aires-Barros, L., Delgado Rodrigues, J. *The Masonry of the Tower of Belem and its Repointing*. Internationale Zeitschrift für Bauinstandsetzen (now Restoration of Buildings and Monuments) 1998 4: 667-682.

[8] Aires-Barros, L., Basto, M.J. Graça, R.C., Dionisio, A., Henriques, F.M.A., Delgado Rodrigues, J., Charola, A.E. *Cleaning of the Tower of Belem*. Internationale Zeitschrift für Bauinstandsetzen (now Restoration of Buildings and Monuments) 1998 4: 641-652.

[9] Delgado Rodrigues, J., Ferreira Pinto, A.P., Charola, A.E., Aires-Barros, L., Henriques, F.M.A. *Selection of Consolidants for Use at the Tower of Belem.* Internationale Zeitschrift für Bauinstandsetzen (now Restoration of Buildings and Monuments) 1998 4: 653-666.

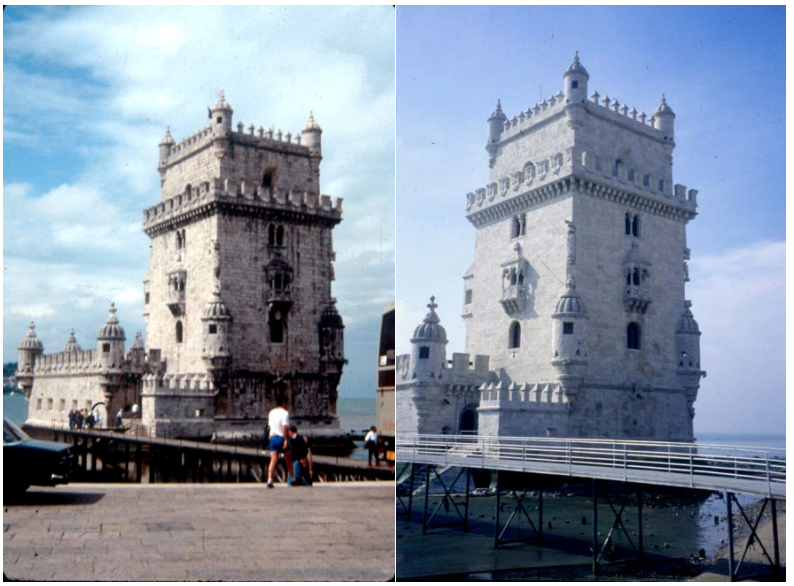

Figure 1. View of the east-north façade of the Tower before (1993) and after the intervention (1998). Please note in the earlier photo the end of a car and a bus parked close to the walk-way to the Tower. Photos A. E. Charola, WMF-P.

Among the structural issues, apart from the south balcony which will be discussed in more detail below, misaligned elements were removed and reset where possible, such as the top sphere of the NE bartizan on the bulwark, or one of the roof sections of the NW bartizan on the Tower terrace. These were reattached appropriately using stainless steel pins where necessary and injecting appropriate epoxy resins. One interesting example that illustrates the care with which these interventions were undertaken was that of the Archangel Michael statue on the NE corner of the Tower. The statue was missing the top part of the left wing and given its location it was considered that it was likely that this piece had fallen into the water surrounding the Tower. Sheer persistence in looking for the piece resulted in its being found thus allowing it to be reattached to the statue[5].

Sealing open joints, replacing the poorly performing ones, and redressing those with poor workmanship was probably the most labor intensive operation and one of the most critical one since an open joint will allow water penetration. Some 10 km of joints were treated during the intervention. This included in-depth injection of grouts, bedding and pointing mortars. A

thorough study of different formulations was carried out to select the most appropriate that subsequently could be adapted to the specific requirement[10]. It should not be forgotten that the rubble-fill construction of the walls showed two areas which have significant voids: the east façade, where the Tower had been connected to the Bom Succeso fort; and, the lower part of the north façade. These voids, resulting from inherent problems in the original construction or from restructuring, have very likely been enhanced from years of water percolation through them. While during the intervention many the water entry points were addressed, there is no doubt that some still remain, and identifying these is a challenge that still has to be met.

Consolidation of stone was required mainly for the variety of Lioz limestone that contains some significant amount of clays, since these minerals, due to swelling and shrinking in wet-dry cycles induce flaking or powdering of the surface. The most notable examples were found in some of the corbels of the north balcony and the ribbings of the vaulted ceiling of the south balcony, in a reddish variety of a later geological formation. Only the two lower blocks of the two corbels to the right of the N balcony were consolidated with an epoxy resin applied by an ingenious capillary absorption system, while for the ribbings of the S balcony, the resin was applied by poultices[11]. The top blocks of the previously mentioned corbels and the other two corbels of the N balcony were treated with a silicate ester product applied by brushing.

Protective treatments, such as water-repellents or lime-wash, were applied to specific areas. For example, the unique naturalistic sculpture of the rhinoceros found at the bottom of the NW bartizan of the bulwark, showed some powdering on the west side that was consolidated with a silicate ester, the fissures sealed with a mortar and the whole figure protected with a siloxane based water-repellent. Water-repellents were applied

[10] Henriques, F.M.A. "Critérios e condicionantes da selecçãodas argamasas para o refechamento de juntas. In *Torre de Belém-Intervenção de conservação exterior,* pp. 87-97. IPPAR, Lisboa, 2000.

[11] Delgado Rodrigues, J., Ferreira Pinto, A.P. "Estudo de productos consolidantes para a Torre de Belém". In *Torre de Belém-Intervenção de conservação exterior,* pp. 60-85. IPPAR, Lisboa, 2000.

selectively to the roofs of the bartizans, rope moldings and sculptured figures, i.e., surfaces that receive most rain. The carved portal of the Tower, because it only had a superficial powdering of the surface, was treated with the more traditional approach of lime water application.

Phase II of the Project was carried out within the defined time-frame and allotted budget. Table I gives the relative costs of the key items in the project, for both Phase I and Phase II.

	Phase I	Phase	Total
Scaffolding	3.6%	14.5%	18.1%
Scientific Support	1.8%	6.0%	7.8%
Documentation/Conservation	4.2%	60.2%	64.4%
Administration	0.4%	9.3%	9.7%
Total	10%	90%	100%

Table I. Relative costs of the main project items for both phases and the overall total.

The Exterior Conservation Project of the Tower of Belem received the 1999 Europa Nostra Prize for the technical and scientific standard of the conservation work carried out.

UNFORESEEN PROBLEMS

In 2003, five years after the intervention and following the recommendations made at the end of the project, a visual assessment was made of the situation. Unfortunately, it was impossible to obtain access via a lift for a close-up examination of any of the upper walls of the Tower[12]. But

[12] Charola, A.E., Henriques, F., Delgado Rodrigues, J., Aires-Barros, L. "The Tower of Belem: Half a Decade after the Exterior Conservation Intervention". In *Proceedings of the 6th International Symposium on the Conservation of Monuments in the Mediterranean Basin*, L. Aires-Barros and F. Zezza, Eds., CD, pp. 626-631. IST and Sociedade de Geografia, Lisboa, 2004.

even so, it became evident that some problems still existed. For example, on the west façade, a dark streaking was evident towards the south end that could be traced a broken spout of the drain from the round-walk terrace (Figure 2). This feature funnels water along the wall of the tower so that both soiling and biocolonization is enhanced along the water path. Also visible towards the center of this facade is the pipe that grounds the lightning rod passing through a hole in the round-walk. By 2015, similar staining was observed (Figure 2 right). Both these problems, which have relatively easy solutions, have as yet not been addressed but in the meantime further soiling has accumulated over the seventeen years that have gone by since the intervention (Figure 3).

When comparing the soiling shown in Figure 3 to that in Figure 1 it is evident that the east façade accumulated far more soiling than it had before the 1997 intervention and the reason can be found in part by the actual intervention. During Phase I of the project, structural problems were identified in the covered balcony on the south façade, such as cracks in four of its six columns and in eight of the twenty corbels supporting it. Furthermore, this balcony, as the round-walk terrace, had round holes in the floor that originally had served as defense for shooting arrows down to the enemy should they reach the bulwark terrace. In a previous intervention, these holes had been covered by wooden round blocks, which over the years, through expansion-contraction during wet-dry cycles, induced major or minor cracks in the surrounding stone. A monitor was installed on one of the most affected corbel and it was found that the crack was still active three years later. Therefore, to prevent further damage, the wooden blocks were removed from this balcony as well as from the round walk terrace. In the case of the balcony, the holes were sealed with round Lioz stone.

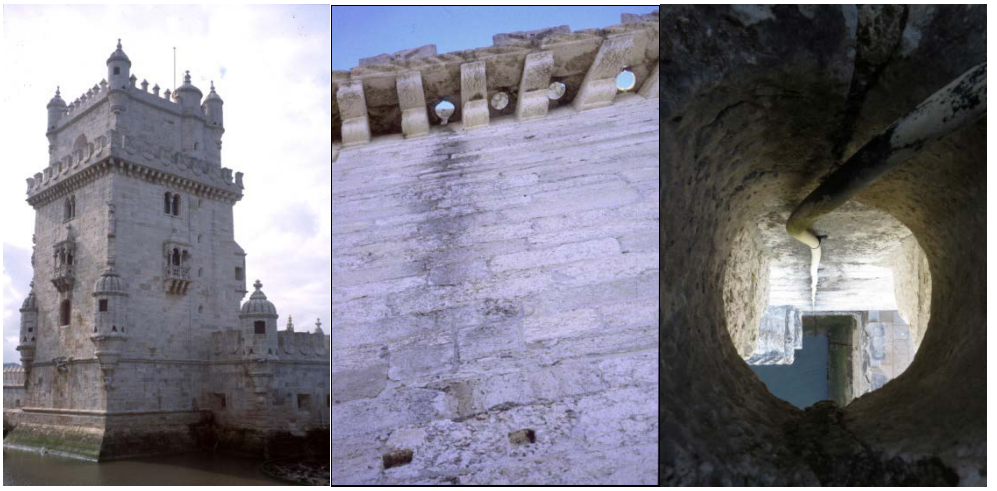

Figure 2. View of the north-west façade of the Tower in 2003 (left). A stained strip towards the south originates from a broken drain spout of the round-walk terrace (center). A lesser line closer to the center results corresponds to the pipe that grounds the lightning rod (right) and that by 2015 shows increased staining. Photos left and center, A.E.Charola, WMF-P; right, Angelo Silveira, DGPC – DEPOF archive.

Figure 3. View of the east and north façade of the Tower de Belem in 2015. Note the regular soiling pattern that developed from water running down the holes in the round walk terrace. Photo Angelo Silveira, DGPC – DEPOF archive.

It is interesting to note that the north façade is still the one showing most soiling, which can be attributed to the vehicular traffic beyond the railway tracks though it appears to be less than it was before, owing to its restriction close to the Tower. This is followed by the east façade, where a streaking pattern developed from water flowing through the holes of the round-walk terrace, which was not evident previously (Figure 1). The west façade shows an intensification of the two previously mentioned streaks, while the south one is still the cleanest as these façades benefit from the regular cleaning from SW driven rain. This same soiling pattern had been originally found as previously reported[13].

ONGOING PROBLEMS

One of the key problems, already present at the time of the exterior conservation intervention is the deterioration of the interior renders. In particular, those that cover the vaults of the first and second level rooms of the Tower, i.e., sala do Governador and sala dos Reis, especially on the north side and that resulting from water infiltrations as discussed in more detail by Costa Silveira and Carvalheira[14]. Further studies are being undertaken to locate the origin of these infiltrations and to find alternative solutions for the eventual replacement of the cement based renders with a more compatible formulation to the underlying stone vaults.

Another one is the mentioned sealing of the terraces, starting with the more urgent Tower terrace that is currently being planned for quick implementation so as to minimize the time it will be closed to the public. This hopefully will be followed by addressing the drainage of the round-walk, while the bulwark terrace appears to have less problems.

[13] Aires-Barros, L., Basto, M.J., Córes Graça, R., Dionisio, A. ¨Patologias da pedra usada na Torre de Belém e análise das águas de limpeza". In *Torre de Belém-Intervenção de conservação exterior,* pp. 57-67. IPPAR, Lisboa, 2000.

[14] Costa Silveira, A., Carvalheira, E. "Torre de Belém. As intervenções realizadas e os novos desafíos". In Proceedings *Torre de Belém 500 years Sphera Mundi Art and Culture at the Time of the Discoveries.* 2015.

OTHER IMPROVEMENTS

During the subsequent seventeen years, several other improvements were carried out as described elsewhere[14]. Among them, improvement of the drainage system in the bulwark ground floor light-well prior to removing the plastic cover installed over it; replacement of window and door frames; and, the upgrading of the electrical system. Others focused on improving the circulation of visitors' through the Tower and their safety, as for example, the replacement of the access gangway by a new designed wooden footbridge; the visitors' flow management system for the single narrow spiral staircase; installation of new public restrooms; and signage and information improvements including an audio-visual station installed on the fourth floor of the Tower to give a brief historical introduction on the Tower of Belem to visitors, both Portuguese and foreigners.

CONCLUSIONS

The exterior conservation intervention of the Tower of Belem carried out in 1997-98 successfully addressed many of the problems. However, it did not address all the problems identified, among them, the sealing of the horizontal surfaces such as the Tower terrace, the round-walk, and the bulwark terrace. Subsequently identified problems, such as the broken drain spout of the round-walk, were not addressed, since other issues had to be given priority.

What has become evident over the past seventeen years is the significant increase in visitors that the Tower receives. Since the new century began, over half a million people visit the Tower per year. This corresponds to an average of about 1370 visitors per day, i.e., nearly 200 visitors per hour. The number of visitors has been increasing at a rate of 1% per year, which corresponds to an increase of 5000 visitors per year. During 2014, 530.903 visitors were counted and each one of them erodes part of the historic material of this monument. To mind comes the spiral staircase that suffers tremendously from the increased number of visitors going up and down it,

independently that they pose a tremendous hazard to public safety, should any accident happen. Meanwhile, measures are being considered to allow access to handicapped visitors which will definitely have an impact on the presentation of this historic monument.

In an age where visual documentation has been developed to unexpected levels, it may be the time to reconsider the values that this monument has and how new documentation techniques may help in making the monument available via digital technologies to a wider audience than the one that can physically visit it.

As a military structure, the Tower was only minimally decorated and its most visually impressive details, such as the carved figures under the bartizans, e.g., the rhinoceros, are only visible from the exterior. Climbing the Tower to reach its top terrace is more a search for an iconic visit and the view from it, than to see what is of interest in its interior. The discomfort that visitors undergo by waiting in long and slow queues somehow do not appear to be compensated by the experience gained in the visit and do not compensate the wearing down inflicted to the monument. A new approach to deal with these issues needs to be urgently developed: a new information center —as discussed elsewhere[14]; external visit circuits; new multimedia support systems; and, any other potential tools should be considered and implemented as an alternative to the current daily massive invasion of visitors.

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