The Fortress of Sagres (Portugal) - an heritage and restoration practice

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1. A Strategic Location

1.1. The Origin of the Portuguese World Discoveries

The Fortress of Sagres is located at the most southwestern part of the Portuguese coastline and it is a legend that lives in most people’s minds. More than 300 km south of Lisbon, the 30.0m tall rock cliff, protruding into the Atlantic Ocean was the basis for the Portuguese Discoveries program, initiated by Prince Henry, the Navigator, son of King Dom Joao I of Portugal and the Queen Dona Filipa of the House of Lancaster.

The young Prince during several years adjourned a remarkable group of mathematicians, cosmographers, navigators, naval engineers, merchant entrepreneurs, and in Sagres and in the nearby village of Lagos designed the Portuguese expansion through the world. The Sagres promontorium was considered a symbolic stronghold and, in the XIVth cent., a 15.0m tall masonry stonewall fortress was built in this location.

The historical background that still attracts thousands of visitors every year may be summarized on the following important facts:

(1) V-VI millennium B.C. - archaeological Neolithic artifacts;
(2) Ist cent. A.D. - the Roman historian Plinium describes for the first time the Sacrum Promontorium;
(3) 779 A.D. - martyr Saint Vincent relics are buried at the Monastery of the Crows;
(4) XIIth cent. - Saint Vincent relics are transferred by boat to the Lisbon Cathedral, under the order of the first Portuguese King Dom Afonso Henriques;
(5) XVth cent. - Prince Henry, the Navigator builds a saw-tooth fortress to defend the Promontorium;
(6) 1573 - King Dom Sebastiao adds two new ramparts to the initial Prince Henry fortress;
(7) 1587, the british pirate Francis Drake surveys and attacks the Fortress;
(8) 1581-98 – under the Spanish King Dom Filipe I rule a new tower is built over the barbican;
(9) 1621 - Napolitan Military Eng. Alessandro Massai designs a new plan to upgrade the Fortress;
(10) 1640 - the Portuguese King Dom Joao IV orders the construction of a new Fortress; and,
(11) 1793-94 - the new Fortress is completed under the French Vauban system.

1.2 The Recent Events and the Needed Intervention

After several years of neglect, on the occasion of the 500th anniversary of Prince Henry decease (born in Oporto, Mar. 4, 1394 and died in Sagres, Nov. 13, 1460), the Fortress of Sagres experienced a major rehabilitation process with several buildings and the chapel being restored. Under the custody of a
Fig. 1 - The Fortress of Sagres: a. the Sacrum Promontorium and the Fortress of Sagres - west side; b. the Main Entrance t north elevation; c. the Praça-de-Armas, the giant Rose-of-Winds and the Chapel - view from southeast
Government’s heritage agency, this monument underwent a large construction/maintenance program in the early 1990’s in order to be restored for the 1998 Oceans Lisbon World Exhibition. This program comprehended the construction of a new visitor’s center building and an exhibition hall new building. However, lack of maintenance, poor restoration/ construction techniques, time pressure and a very aggressive environment resulted on a even faster degradation rate that the one that it was previously observed, on the following upcoming years, Fig.1. This Portuguese monument is one with the largest number of visitors and, in the summertime, it may easily reach the peak value of 16,000 persons a day. The national Tourism Agency recognized the importance of having this heritage building under good conditions to respond to the increasing visitor’s pressure. The Ministry of Economy (Tourism Agency) and the Ministry of Culture (Heritage Agency) implemented a joint global renewal program, after the first phase restoration process yielded excellent results. This work presents the two phase Fortress of Sagres restoration techniques and some innovative approaches being adopted. Major concerns exists related to the water action through the earth filled wall core existing between the two exterior stone masonry walls and the archaeological quest to understand the inner structure of the Fortress walls. The possibility of identifying Prince Henry’s original saw-tooth stone masonry walls location and the subsequent additions led to the use of the integral sampling method. This method was first used in 1971, for rock mechanics studies (tunnels, dams), and it was proposed for the first time in this Fortress of Sagres restoration project. The second important aspect is to provide adequate drainage from the inner core avoiding that the water pressure builds up against the mortar layers and bursts the wall finishing.

2. The Fortress of Sagres
2.1. The Fortress Access - the State of Conservation
Sitting on the top of a gentle hill, the nearly 300m long Fortress, with a 7.0m tall stone masonry wall is strategically placed transversely to the 30.0m high rock isthmus formation pointing south through the Atlantic ocean stormy waters. The access to the Fortress is made through a broken line path which meant to deter the invading troops as long as possible. After crossing the main gate, a 30.0m long access tunnel had to be walked through which ended in a hollow 8.0m high tower with a barrel vaulted ceiling. Along this path, the defending troops could use the several ceiling air vents (“mata-cães”) to stop the invaders by shooting their rifles through the openings. Finally, going through the tower door the visitor reaches the large assembly parade - the “Praça-de-Armas”, bordered by the surrounding buildings (former military barracks), the rose-of-the-winds and the chapel, see Fig.1. The state of conservation after ten years of neglect and an aggressive climate was very poor. The rainwater would infiltrate through the terraced stone roofs and large water stains, clay mortar cover spalling, and mould growth thoroughly on the walls and ceilings could be observed. The existing stone elements bordering the large window tower and the entrance gate portico also needed
urgent repair measures. In 2004, the Fortress administration decided to take urgent measures to rehabilitate the Fortress and a two phase approach was adopted. The first phase was focused on the main entrance – the access gate and the tunnel. The second phase was more extensive and costly, because it would focus on the 300.0m long walls, ramparts and ravelins. This two phase approach was chosen because of the large construction costs being involved and to take different approaches to the north and south wall façades.

The first phase would serve as an experimental program to identify possible shortcomings and pitfalls in this global process. In the first phase (2004), the diagnosis, the adopted methodology, the construction techniques and the technical assistance provided by the designer yielded excellent results, see Figs. 2, 3 and 4. These results have been consistent during the past five years.

In 2004, after a careful diagnosis study, the designer was invited to develop a major plan for the restoration of this interior access path. A better assessment revealed that the major source of problems originated from the roof terraces – lack of waterproofing through the stone slabs joints, inexistent or clogged water drains, and materials deterioration. The interior tunnel and tower had limited ventilation due to the intentional opening’s blocking with stone and mor-
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tar. This resulted on an accelerated interior space material’s degradation. The designer strategy was multiple: (1) use traditional materials and techniques; (2) restore the old ventilation system and protect the interior from excessive stormy rain with contemporary glass solutions; (3) remove the terrace stone slabs, waterproof the existing stone vaults and replace the cover; (4) remove the interior deteriorated cement mortars covering the walls and ceiling vaults and replace with a more permeable lime mortar; and, (5) clean and replace deteriorate the existing stone elements placed around the architectural elements – large window, airshafts, entrance gate portico. A detailed archaeological, architectonic and historical survey was deemed necessary, see Fig.5.

2.2. The Fortress Walls - the Phase 2 Conservation Process

Previously to the Phase 1 intervention (2007), to rehabilitate the access tunnel and main tower, an extensive mortar covering layer detachment (approx. 5.m x 30.m) was observed on the exterior wall surface. This historic icon degrading image was further accelerated and prompted the national authorities to take required action to restore, into acceptable conditions, this major touristic attraction. A joint financing program between two different public agencies was assembled in order to develop the adequate studies to rehabilitate the

Fig.3 - The Phase 1 - Main Tower restoration process (2007): a. main tower - existing roof; b. main tower with drainage and ventilation

Fig.4 - The Phase 1 restoration process (2007): a. main tower - entrance gate; b. tunnel - exterior drainage (gargoyles)
Fortress walls. The design team proposed a “Phase 2” intervention methodology based on the previously acquired experience: (1) diagnosis; (2) intervention methodology; (3) design plans, tender bid documents and technical specifications; (4) public works technical assistance and support. It is worthy to underline that nearly ten years before the Phase 1 intervention, the designer ran long term in-situ lime mortar wall tests and samples were collected from the tunnel and tower walls and tested at the University of Minho, in Guimaraes, north of Portugal.

This tests performed on the interior Saint Barbara rampart walls showed the importance of severe local climate conditions on four different lime mortar compositions durability. The strong wind gusts, the heavy rain and moisture conditions, and the steep temperature variations in this promontory could be hardly forecasted in the design office. These harsh climate conditions may occur altogether during the same day and make the local building conditions difficult to carry on by the construction crews. During the Phase 1 construction stage, the designer proposed to the contractor to run additional mortar tests in the same location. Improved admixtures with pozzolanic cements and other accelerators proved to be an adequate measure to get a reliable surface finishing, for these long Fortress walls.

The Phase 2 proposed methodology to restore the Fortress walls was: (1) to remove carefully all the external cement base mortar layers capping the underneath lime mortar layer with technical assistance (archaeological survey, sample tests, photographic/digital recording, chemical analysis); (2) to correct the top surface slope to provide effective drainage during heavy rain / storm weather conditions; and, (3) to drain the interior saturated earth fill wall core. The proposed procedure to drain this interior core was unique and tried to answer several intriguing questions. The use of the method for integral sampling of rock masses was first developed in Lisbon, at the National Laboratory of Civil Engineering (LNEC),[Rocha M., Serafim J.L., 1971].

This method uses a two-phase drilling process that allows to collect a total (integral) sample from the Fortress walls. The exterior stone masonry wall surfaces, the interior compacted earth fill can be sampled and the different construction phases identified. An archaeological real interest exists to find the possible location of Prince Henry’s saw-tooth masonry walls, the XVIIth century King Filipe of Spain ramparts and ravelins. The remaining inclined void would be lined with geotextile drainage pipes that slowly drain the earth core. This water removal from the interior Fortress core will reduce the water pressure on the exterior wall surfaces extending the lifetime horizon of the mortar finishing.

3. Final Observations
Since the mid- XIVth century, the Fortress of Sagres is a major icon linked with two hundred years of Portuguese world sea discoveries and technical innovation. In recent years, two major public works interventions were carried on this monument- the first, in the late 1950’s, the 500th Prince Henry Commemorations; and, the second, in the late 1990’s, with the 1998 Lisbon World Oceans Exhibition. Although traditional construction methods were used in the first
Fig. 5 - Different recorded surveys through the ages: a. 1587 - Francis Drake; b. 1617 - Alessandro Massai; c. 1794 - Francisco Cardenal; d. 1873 - José de Vasconcelos (Vauban style); (below) e. 2004 - architectural survey - access tunnel and main tower - roof plan and N-S cross section elevations
intervention (e.g. lime mortar finishing layers), the latter intervention exhibited long lasting durability problems, soon after it was concluded. The designer’s proposed methodology took a long term in situ testing and observation approach regarding the mortar admixtures to be used in these monument walls. The initial tests were run in the mid-1990’s, in the Fortress inner walls - the Saint Barbara rampart, using lime mortar with different compositions. The results were not satisfactory due to aggressive environmental conditions combined with permanent erosion. The first intervention was the chapel building where a lime mortar admixture with pozzolanic cement proved to be an excellent way to restore building exterior façades finishing.

For the Fortress walls, a two phased methodology was adopted in order to get the best results from the public funds. First, the access tunnel and the main tower provided an excellent full-scale test and a long time observation sample with data recording during the 2004-07 period. The use of the same type mortar admixture, as in the chapel, has shown an excellent performance, combined with the effective tower and tunnel terraces drainage and interior ventilation.

The second phase proposal (2008) was not yet initiated due several different factors. Although these shortcomings may arise, it is important to focus on the final results to be attained on a unique monument under harsh environmental conditions. This study purpose is to present the use of stone, repair techniques and design approaches to restore a national monument which represents a major symbol for the European heritage and culture. The use of innovative techniques, e.g. the integral sampling method, may allow a deep insight into the construction techniques during the past six hundred years vis-à-vis with improved draining performance.

References