10. Analysis and evaluation of the implementation of sustainable criteria in the construction at protected environmental areas. Visitor Centre at the Bahía de Cádiz Natural Park

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Summary The visitor centre is located in the Bahía de Cádiz natural park at the San Fernando municipality. The complex is surrounded by high ecological value marshes called Santa Leocadia and is bounded, both on the south and west sides, by salt works zones. The buildings that make up the visitor centre treat with great care its own integration with the surrounding environments. The central image of the aggregate, which adapts to the plain and clear orography of the marshes, along with the use of sustainable architecture, has allowed a land once desolated and degraded by a wasteland to recover its value and integrate with the environment of the Bahía de Cádiz Natural Park. This research analyses the bioclimatic principles employed in the design of the building, checking the condition of the complex 10 years after its construction and getting results to confirm that this is an actually sustainable building. This research analyses the bioclimatic principles employedin the design of the building, checking the condition of the complex 10 years after its construction andgetting results to confirm that this is an actually sustainable building.

Keywords Visitor centre, Regeneration, Sustainable, Environment, Tide mill

1 Introduction

A visitor centre is an establishment where the user receives information about a specific tourist or natural area, through qualified staff and employing elementary communication and interpretation methods that promote the understanding and appreciation of the main values of the protected area.

The creation of basic user-greeting infrastructures at the key entry points of the natural park is necessary for the construction of a visitor centre. The building's layout must offer areas suitable for: user greeting, displaying of meaningful items,

dark areas for documentary showings, documentation and research areas, coordination centre for related activities and even a tourist office and rest zones.

The salt works customs from Bahía de Cádiz originated the first design idea of the Visitor Centre, as a way to remind about the ethnologic legacy of the bay. It's a synthesis and expression of the "gaditano" lifestyle. The environment is characterized by its great tradition in the salt industry, which dates back to the Neolithic. After them, Romans expanded the production by means of a studied engineering and a great constructive simplicity which has resisted through centuries and managed to keep the salt works form, looking natural and adapted to the marshes.

San Fernando's skyline also includes simple buildings. On the one hand, the saltworking houses, which serve for the extraction of salt obtained during the year and, on the other hand, the tide mills formerly employed to grind flour. These two kinds of buildings formed the layout of the bay's saltwork landscape.

The saltworking houses and its auxiliary dependencies were generally simple, white-coloured building. Houses usually designed with a single floor, built with materials from the area with shed roofs or rooftops. Humble buildings nowadays victims of the transformations suffered by the industry, increasingly abandoned. The mills, greatly adapted to the environment, employ a simple technology result of the evolution of hydraulic engineering and transmission mechanisms. In the main body of the building, we must differentiate two parts: the low part of the mill, namely the hydraulic part (generally built with stonework pieces of "ostionera" stone) and the building itself, whose construction was much more varied.

The energy needed to move the mill was obtained taking advantage of the difference in the sea level between the high and low tides. The most commonly used scheme was based on the usage of dammed water contained by a wall with floodgates. When there was a difference between the sea and dammed water levels, it was cleared through the flumes, that is, small sloped pipes that led the water with great pressure towards the prime wheel which, employing simple mechanisms, spun the grinders that crushed the flour.

Until the 19th century, the natural renewal of the resources was enough to ensure their productive continuity. The tide mills, with low environmental impact, made up a clever and rational form of exploitation of the natural resources; clean and profitable energy, safe, predictable, free and with simple technology. (AAE 2010)

2 The Visitor Centre

2.1 Aspects to consider

The design of the Visitor Centre for the Bahía de Cádiz natural park was subject to severe urbanistic terms, as the land is a segregation of a municipal plot, bounding at its south and west sides with saltworks, and at the north and west sides with the town hall's municipal land. The building, being a saltwork area, complies with the requirements demanded by the current normative of the Coast's General Direction, with the ones from the Bahía de Cádiz's Natural Park, with the ones from the Ministry of Defence, and with the San Fernando town hall's ones (see Fig. 1).

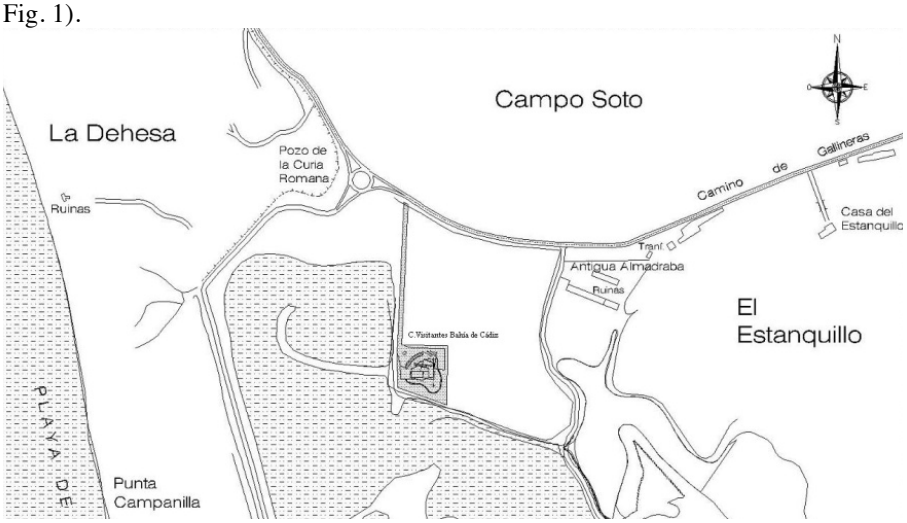

Fig. 1 Visitor Centre situation map

A special foundation was needed for the construction of the visitor centre due to the characteristics of the land, as the floor is not stable. The building is constructed on a dump 6 meters deep plus 8 meter over sludge field.

Another of the aspects to consider in the design of the building was the climateology of the place, as the area where the center is has high summer temperatures and strong easterly wind. In the case of natural lighting, light has always been linked to healthy and comfortable environments, however the light intensity of this region, lighting is an essential element to consider in architectural design.

2.2 Room layout

The plot has a surface of 10.109m^2, from which 1.044m^2 are for the main building, the rest being destined to parking and gardening.

The outline that the complex reflects presents the spatial organization of an aggregate of white volumes located on a central pond.

Fig. 2 Visitor Centre's general view

This image attempts to remind that of the tide mill (see Fig. 2). This design refers specially to the tide mill at the Arillo River. This mill is located in the Las Salinas' Natural Park, next to the national road IV. The central volume of the building with a single floor, contained the mill's grinder and spillway system (Barros Caneda J.R., Tejedor Cabrera A. 2000) .This construction is presented as a line-up of arcaded built in "ostionera" stone as a bridge which received the thrust of the tides. On both sides of the central warehouse, there are two two-storey annexed volumes which probably were used for grain storage. (IAPH 2012)

The visitor centre has a first white central volume raised over the salt water pond, which reminds of the mill's main building, referring the hydraulic part, and the tide's enter and exit floodgates (see Fig. 3). This main volume of the complex is dedicated to the expositive area of the centre.

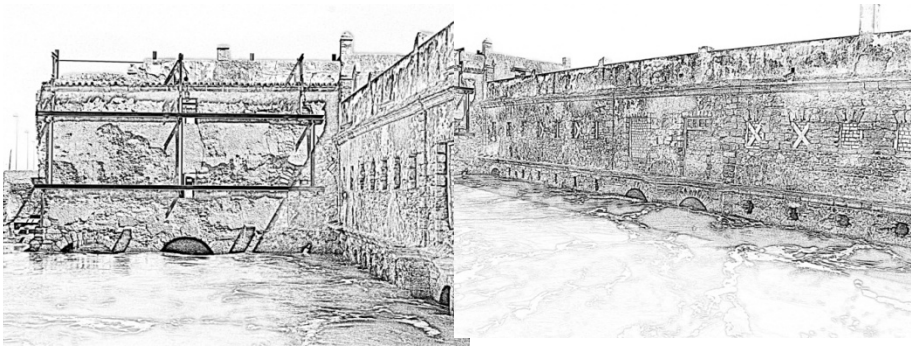

Fig. 3 Arillo's river tide mill. Central volume and auxiliary rooms

Fig. 4 Bahía de Cadiz's Visitor Centre. Central volume and auxiliary rooms

Both annexed, smaller volumes, which appear recessed and conform the main entrance, remind the rest of the rooms of the mill: the granary, the barns and the guard's house (see Fig. 4).

The building is conceived to give flexibility of use to the facilities in different volumes, the visitor centre has: reception, audio-visuals room, environmental interpretation area, library, Renpanet area, viewpoint, rest area, shop, restrooms and storage (see Fig. 5). The exterior has a parking area for fourteen vehicles and two buses, along with an environmental education point, terrace, panoramic ramp and steps to the viewpoint, entry pond, walking tour and bike path and native plants gardening.

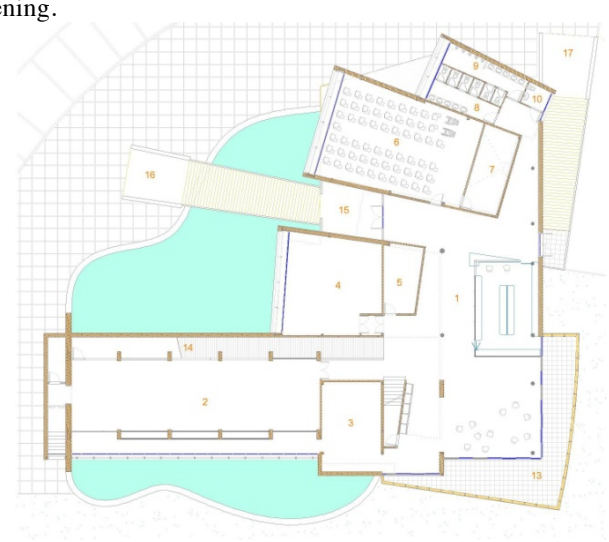

Fig. 5 Distribution: 1 Information lobby, shop and rest area. 2 Environmental interpretation area. 3 Renpanet room. 4 Library. 5 Storage. 6 Projection room. 7 Storage. 8, 9 y 10 Restrooms. 13 Terrace. 14 Ramp to the viewpoint. 15 y 16 Access gateway. 17 Auxiliary entry.

2.3 Construction system

The construction period was 18 months and the whole budget including: adjustment, liquidation, fees, geotechnics, interpretation and VAT was of €3.024.008.

The supporting structure is formed by metal and concrete pillars, with an armed slab basis structure. The foundation was made of precast concrete piles with stiffening slab.

About the cover, it is inverted in the exposition room and the viewpoint. In the annexed volumes corresponding to restrooms, library and audio-visual room, there are deck-type light sloping roof. The building has a false ceiling made of biodegradable coconut fibre.

The exterior walls are made of thermal blocks and interior divisions between different rooms are made of double air brick. The East elevation is fully coated with "ostionera" stone facing, being the rest of the elevations coated only on its base and the rest thereof coated in monolayer continuous white.

In the south elevation, the expositions room's facade was projected as a whole metal exterior carpentry tiling to glaze and foment natural illumination. This carpentry is protected from the impact of sun rays during summer through solar panel slats. The slats from the volumes corresponding to the audio-visuals room, restrooms and library are made of wood chips of TREX-type recycled plastic. This closure is made of phenolic board sandwich panels and VIROC with internal isolation (see Fig. 6).

The terrace area has been protected by metallic carpentry of weathering steel with slats of the same material, some of them being foldable from its upper horizontal axis (see Fig. 6).

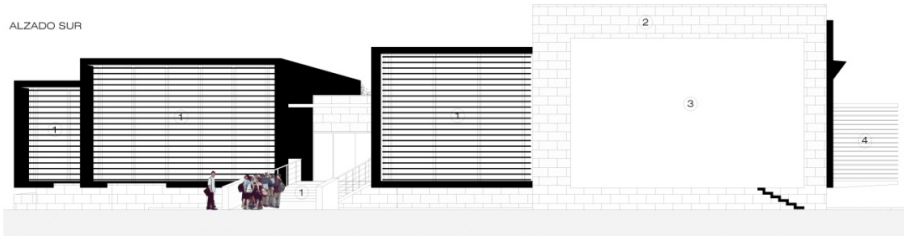

Fig. 6 Materials: 1. Fixed Lamas conglomerate recycled plastic and wood chips Trex type. 2. Stone "ostionera" e = 3cm pieces of 60x40cm 3. 4. Coating monolayer white lattices formed by folding Corten steel slats

The dump, over the years, causes small movements due to the settlement of waste in it, for this reason the exterior urbanization of the building was made with concrete tiles, in sepia colour, over a sand layer with a 5cm dirt filling. This decision has achieved that, in its 10 years, the floor has not been cracked.

The plot is delimited by a closing of pinewood logs, recessed 3m into the land in a cutting with a visible height of 1m, to achieve the least possible visual impact.

3 Building's sustainability

The implementation of the resources established by sustainable architecture was made possible thanks to, among others, these factors:

- **The landscape regeneration of the environment.** The visitor centre project, with a constructed land over 1000m2, was based on the regeneration of a landscape marshes area desolated by an old dump.
- **The recovery and reuse of its infrastructure.** The centre's design has been prepared for a potential future change of use, being a, easily-recoverable complex and with highly recyclable materials. The system employed in the foundation and the structure of the building makes it easy to disassemble and allows the construction of another complex in the future.
- **The usage of native materials.** The choice of native materials to keep the environment's aesthetics, as lime mortal or local "ostionera" stone. This kind of rock is made up from sandstone and fossilized sea remains and is characteristic of the Bay's shore. It is extracted from open-pit quarrels in areas such as Cádiz. One of the current main environmental problems has to do with the distance and transport of the materials used in construction. CO_2 emission levels produced by the combustion of fossil fuels derived from oil prove it. The usage of native materials, not only gives great ethnologic value, but also considerably reduces the emission of polluting gases.
- **The usage of native species.** The usage of native species such as the "mastic" and "taraje" in the landscape decoration seeks obtaining an extensive, low-maintenance, gardening, adapted to the environment, reduces considerably the amount of water needed for its growth.
- **The usage of recycled materials.** It is worth noting, first of all, the usage of some architectural resources that made possible the employment of recycled and environmentally friendly materials, as the usage of wood for the pergolas or the use of a material called "Trex" for the placement of slats and pavement with wood finish. Trex platforms are made up with 95% recycled materials, such as plastic bags, wood remains and sawdust. Also, their fabrication process includes the most possible respect to the environment.
- **The use of materials aging nobly.** Corten steel used in carpentry is a material because of its chemical composition, it is not affected by corrosion because in its initial phase, a well adhering oxide layer that is impermeable to water and steam is formed. It prevents oxidation of the steel continue into the piece, so it is not necessary to apply any other protection as its own oxidation, voluntarily and controlled, protects the part against atmospheric corrosion (See Fig 7).

Similarly it happens with the use of TREX type materials discussed above. Except for the dirt produced by the environment, the material is intact.

Fig. 7 Use of Corten steel. The photograph on the left is taken during the execution of the work in 2006. The image right on a visit in August 2016

- **The employment of passive methods in the complex.** The correct orientation of the projected spaces in order to take advantage of the natural conditions has been essential in the project's design.

  There are various examples in the complex, ranging from opaque facades that protect from the strong wind, to white surfaces on the points where the sunlight is stronger.

  There also exist simple constructive solutions to fight the poor orientation of the east and west glazed facades through the usage of overhangs in the windows, or the protection of the shadow cast by solar panels.

  The usage of natural ventilation helps lowering the buildings' high temperatures in summer. To that end, it has been necessary to study the distribution, the shape of the exterior openings and its location. The usage of crossed ventilation with windows or air vents in high and low parts, make the usage of cooling systems unnecessary even in august. Hot air evacuation in the high area of the central volume improves due to the chimney effect produced. This phenomenon originates by forcing the creation of a fresh air stream from the pond's water that enters the building to replace it. The same way, by closing the windows in winter, a greenhouse effect is produced, heating the room automatically (see Fig. 8).

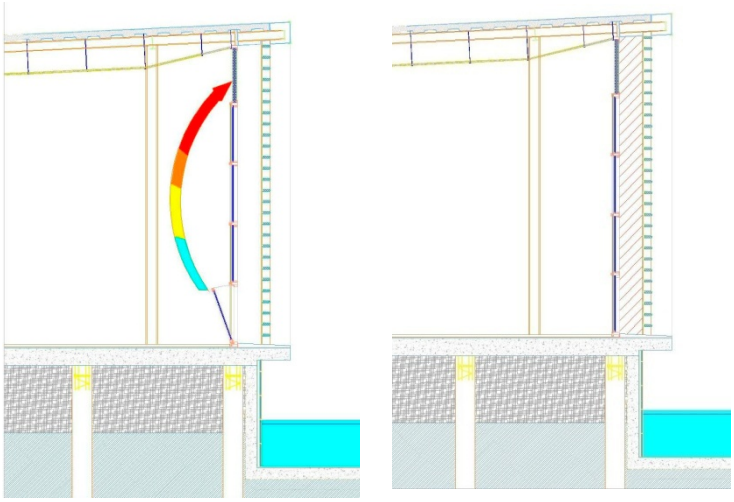

Fig. 8 Summer natural ventilation scheme. Greenhouse effect in winter.

Already in the implementation of the volumes it is seen the need to create healthy environment while avoiding at any cost the entrance of sun rays on hot months. For that reason, the great glazed facade favours the entry of natural lighting but avoids excess heat through the usage of slats and horizontal overhangs. This way, we achieve not only huge energy savings, but also an intelligent proposal for the placement of solar panels (see Fig. 9). Likewise, the usage of zenithal lighting its constant in the complex across different volumes, since having multiple heights allows the light to penetrate and reach the darkest places.

Fig. 9 Solar panel. View from the inside and the outside of the building.

- **Optimization of energy expenditure.** The project invested on the lowest possible energy usage, removing the need of an elevator with the creation of wide access ramp. It invested in the implementation of installations that use renewable energies: the usage of a wind turbine was essential due to the great energetic potential of the Bahía de Cádiz. The wind turbine is used to put into operation a pump that maintains the pond full of water from the saltworks.
  The usage of photovoltaic cells in panels in the centre produces around 10.000 kW/h every year, equivalent to the power consumption of two San Fernando homes. The usage of low-consumption illumination (LED) and electronic devices optimize energy usage.
  Likewise, the centre is provided with a purifier which cleans the wastewater generated.
- Finally, **the functionality principle.** It was necessary to make the administration of the complex possible with a single worker, able to manage the whole building from its workplace. This was achieved thanks to the design and equipment of the building, which allows to control access to every entrance of the building from that workplace.

4 Results and conclusions

In order to achieve a truly sustainable construction system, it is necessary to break the routine and bad habits acquired over decades of waste of natural resources. It is necessary to make a general behaviour modification, give up bad habits and constructive and make society aware that is needed an architecture that respects the environment and apply the necessary criteria for it to be truly effective.

To solve the problems of adaptation and respect for the environment, there are more keys each time they get, using different architectural resources, maintaining a conciliatory relationship between architecture, nature and landscape. This is mostly due to the uniqueness of the applied architecture, the proportion and harmonious available volumes within the environment, but also the types of materials used for its construction, the way these are used and the choice of colours.

In the visitor centre of Bahía de Cádiz Natural Park it is easy to discover the cordial relationship between the natural and ethnological environment of the place and its construction. The integration of the building in the context of the salt works area has been achieved through the reinterpretation of traditional salt industries houses and their tide mills in the design of the building itself, that is the key to achieve this purpose. The relationship with its environment is one of the essential principles of sustainability, achieving it represents reaching a significant expression of a people's identity, a testimony to its history and a manifestation of the richness and cultural diversity.

On the other hand, in relation to the construction system, the building has durable materials, which have been aging nobly in the last years. They are easily reusable materials, recyclable, removable and low maintenance. Even some of them come from quarries and nearby geologic formations of the building, thereby reducing emissions of greenhouse gases but the transmission of cultural values and awareness of social is achieved not only about the use of resources their environment.

The fundamental principles of sustainable architecture are not only material innovation of high environmental technology and / or lower consumption of electronic equipment, but design buildings that demand little energy. Take advantage of climatic conditions and available resources of the environment to make, as far as possible, that the interior of the buildings were comfortable places. Bioclimatic study of the project has demonstrated the efficiency of its design by calculating solar orientation and passive cooling method. So much so that on a visit in the middle of August, the use of cooling systems in the set are not perceived necessary.

As a result, it is observed the difference between the theoretical energy consumption of the building, in absence of the bioclimatic measures employed (6,500 kWh / month) and the actual energy consumption, according to invoices issued by the electricity company in the year 2015. In the average theoretical calculation, there were considered the necessary frigories (RITE 2007) to acondition the whole site, and the energy consumption in lighting. It can be seen that the actual consumption is considerably lower than the theoretical (see Fig.9).

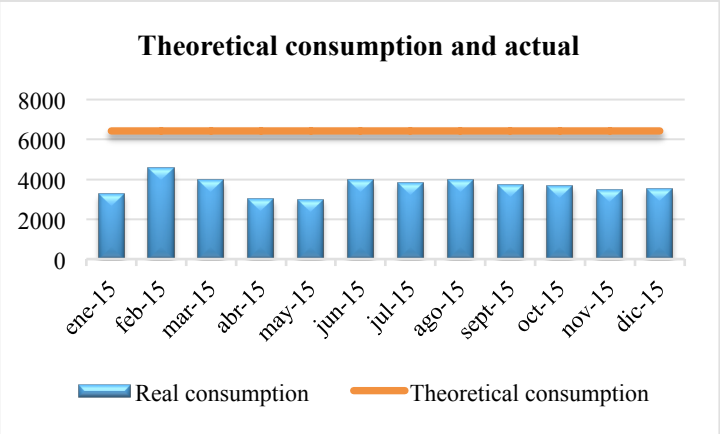

Fig. 10 Comparative actual and theoretical energy consumption

Under these premises, and keeping in mind the need to generate the least possible impact generate the least possible impact on the natural environment in which it is located, a sustainable building XXI century inspired by the ancient buildings of Cadiz, is conceived.

5 Mentions and References

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