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### **Les Pavillons des Boulingrins, example of parametric ephemeral architecture. 3d cladding modelling with re-usable criteria.**

**C.Valderrama, M.Plocikiewicz, J.Ocampo, F.Cottaz**

Technical and Marketing Department  
Acieroid, S.A.  
e-mail: magdalena.plocikiewicz@acieroid.es

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#### **Abstract**

The aim of this paper is to verify how 3D industrial modelling help to accomplish the re-usable and dismountable metallic envelope. Les Pavillons des Boulingrins, situated in the heart of Monaco, is a remarkable example of ephemeral architecture based on parametric design integrally developed within 3D digital mockups. Designed by Richard Martinet and Chérif Jahlan the pavilions, recalling stones modelled by the river, fit in the non-interruptive way into the Monegasque gardens and historical heritage surroundings. The project is composed by 5 buildings with “Lego designed and executed” envelope where all the pieces may be integrally assembled and dismantled on site. The re-usability of all the steel structure and complex metal claddings was previously verified in the workshop. Over 5000 envelope puzzles were controlled by means of 3D mockup combined with QR numerical control in order to assure its perfect fitting on site. Les Pavillons des Boulingrins design and execution was based on accurate thermal performance, sustainability and life-cycle concept. The building skin is a custom- designed composite honeycomb panel with its thermal, acoustic and water-tightness demanding parameters. 3D modelling and industrialization significantly reduced the construction process and in consequence the carbon footprint left. The surrounding trees were carefully removed to be re-planted again in its original place, once the works finished. The construction materials and intervening workshops and companies were also selected within the environment respect criteria. Les Pavilions des Boulingrins project is an example of adaptable, temporal and respectful design combined with agile, technological, precise and sustainable execution process.

## 1 Introduction

The origin of the Pavillons des Boulingrins, situated in the heart of Monaco, close to the emblematic Casino and surrounded by the Monegasques gardens, was the reconstruction of the luxurious commercial centre. Richard Martinet and Chérif Jahlan designed a very singular, asymmetrical design based on the stone river concept. The project was conceived as the example of ephemeral, parametric architecture made of re-usable pieces and planned to be dismantled on site, after 5-6 years.

Acieroid noticeably participated into that project as a specialized engineering and construction firm to develop and install the complex steel construction and the metal cladding solution.

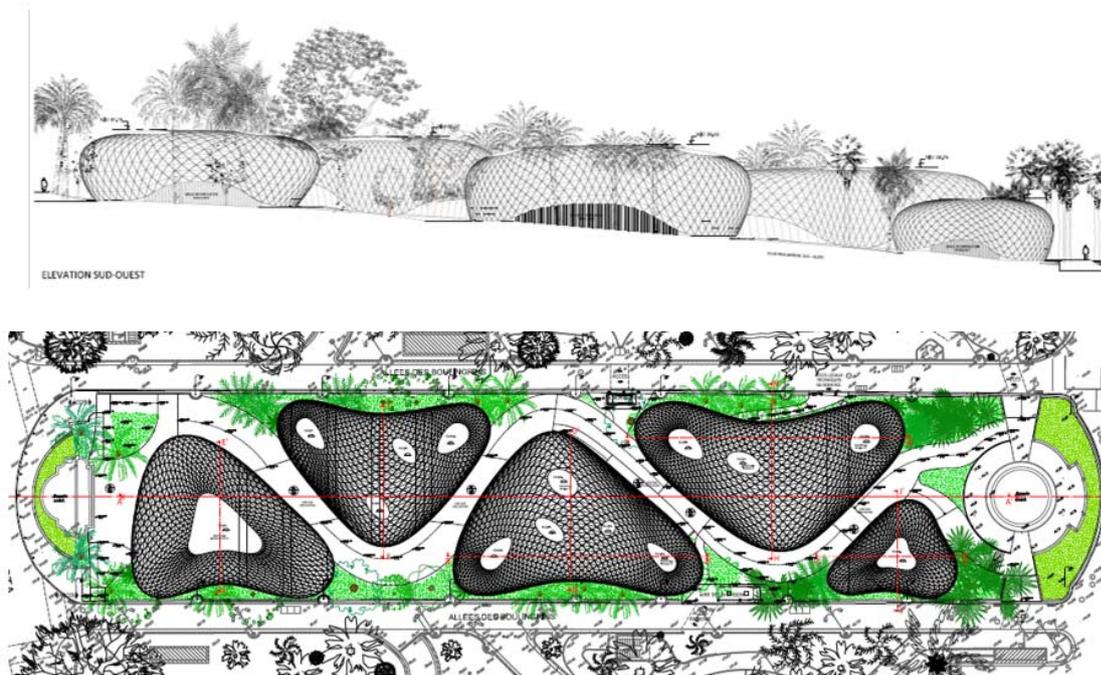


Figure 1: Richard Martinet- Affine Design architectural concept

## 2 3D concept and project design

In order to meet the parametrical and re-usability requirement, the approach was to develop the project integrally in 3D. The complex geometry of the structure and double skin cladding were settled using different software support, like Autocad, Rhinoceros, Solid Works, Tekla and specially Catia where 95% of the 5000 singular pieces were defined. The main challenge for the Pavillons des Boulingrins project was to develop a modular system to permit the installation and posterior dismantling on site. The basic project, designed by Setec and T/E/S/S engineering office in Rhinoceros, was transferred by Acieroid into Catia, the software principally designed for the automation and aeronautic sector. To guarantee the possibility of dismantling the “Tetris®-like design”, the modular self-supporting system of steel structural segments was developed. To meet that requirement, adequate geometries, dimensions and weight has been calculated.

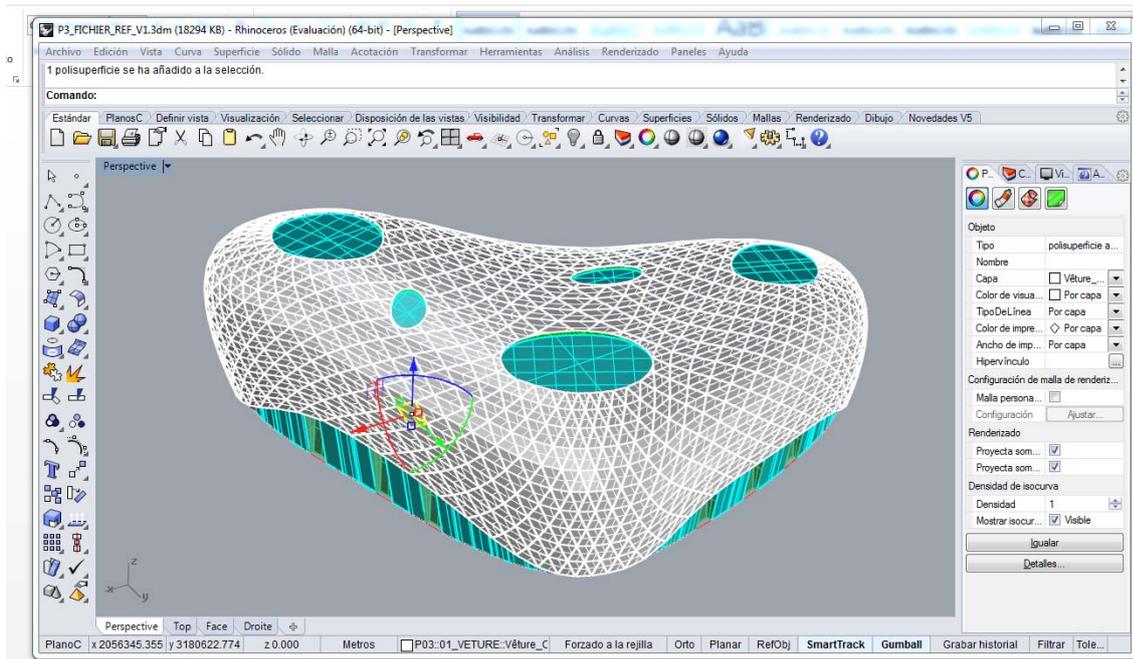


Figure 2: T/E/S/S Rhinoceros structural design

## 2.1 Mockup design and execution

In order to bring the project into reality, Acieroid, previous to any contract agreement, decided to realize the mock-up in its facilities. The 8 meters high and 4 meters width, the pieces of “stone” allowed our client to touch what would be the future landscape of the Jardins des Boulingrins.

We were convinced that we had to go further and solve a priori all the possible hotspots. When the client decided to contract Acieroid, the bigger slice of building was executed, taking into account all the remarkable points. This was the basis for the boutiques industrialization to ensure that each piece of the building, once arrived to Monaco, can be properly assembled.

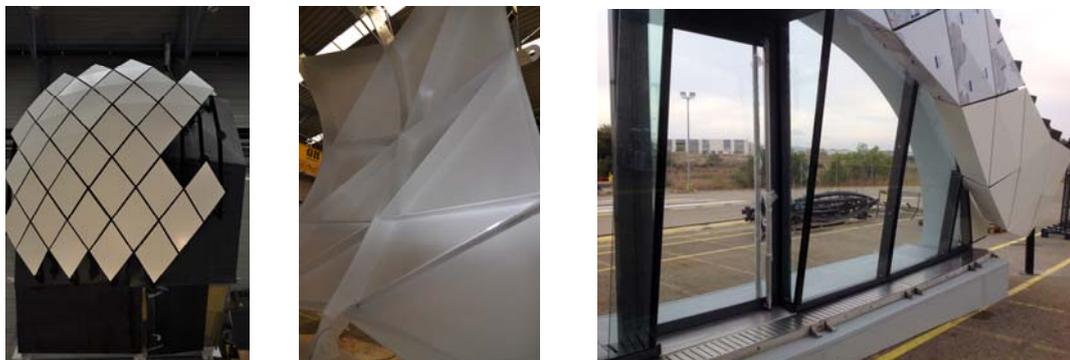




Figure 3: Mockup images, realized in Acieroid workshop

## 2.2 Cutting and manufacturing of the pieces

The Pavilions are composed by the following elements:

- Principal structure designed and manufactured by modules, called *coque* which incorporates waterproofing and insulation elements to guarantee tidy and clean mechanical fixing on site
- Curtain wall cladding, named *vitrine*, placed on the ground level to accede the pavilions
- Roofing skylights to guarantee natural illumination
- Ventilation zone covering the facilities of each pavilion
- External skin, called *veture*, composed by rhomboid scales, made of honeycomb aluminium panels white lacquered

All these parts were 3D designed with customized geometry and alternative fixing solutions for different elements.

First step was to module and manufacture the steel structure, mechanically fixed and made of self-supporting modules to facilitate the manoeuvrability by cranes. The structure was manufactured in the specialized workshop where the correct and parallel pre-assembly of different modules was assured.



Figure 4: Steel structure assembly in progress



Figure 5: Fixing of waterproofing and insulation elements to guarantee the rapid assembly on site

### 2.3. Topographic control in the workshop

Over the *coque* geometry, the external waterproof pavilion skin is fixed by means of light structure composed of steel rings and platens. That light structure is topographically verified in the workshop to assure the fixing points coincide, with the tolerance margin, with 3D design.

All the manufactured elements are meticulously referenced to define its exact position in every pavilion on site.



Figure 6: Topographic control of the structure elements in the workshop

### 3 Singularity of cladding

The singularity of metal scams which compose the external skin of the pavilions, consist of the uniqueness of each piece. The façade puzzles, 3D designed, are made from aluminium honeycomb panel where each rhombus has different measurement and angles, where the fixing to the principal structure is obtained by means of specially designed and injection moulding pieces, adjusted to obtain the singular pavilions geometric shape.

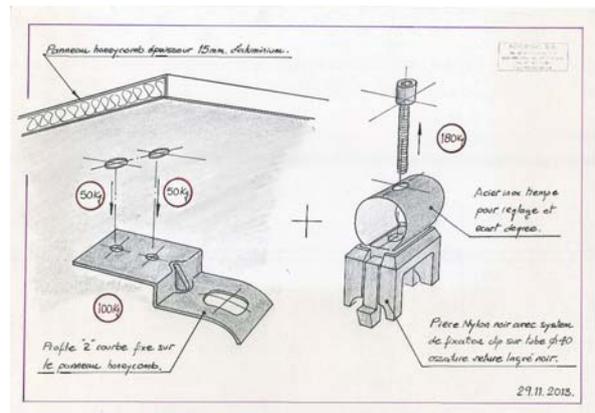


Figure 7: Cladding fixing using specially designed pieces

#### 3.1. Thermal and acoustic structure and cladding parameters

In order to assure the correct thermal and acoustic performance of the structure and claddings, different calculus and assays in factory were performed.

- steel structure calculus
- calculus of rainwaters drainage
- assays for the fixing pieces between *veture* (steel structure) and the honeycomb panel
- calculus of the charge descend

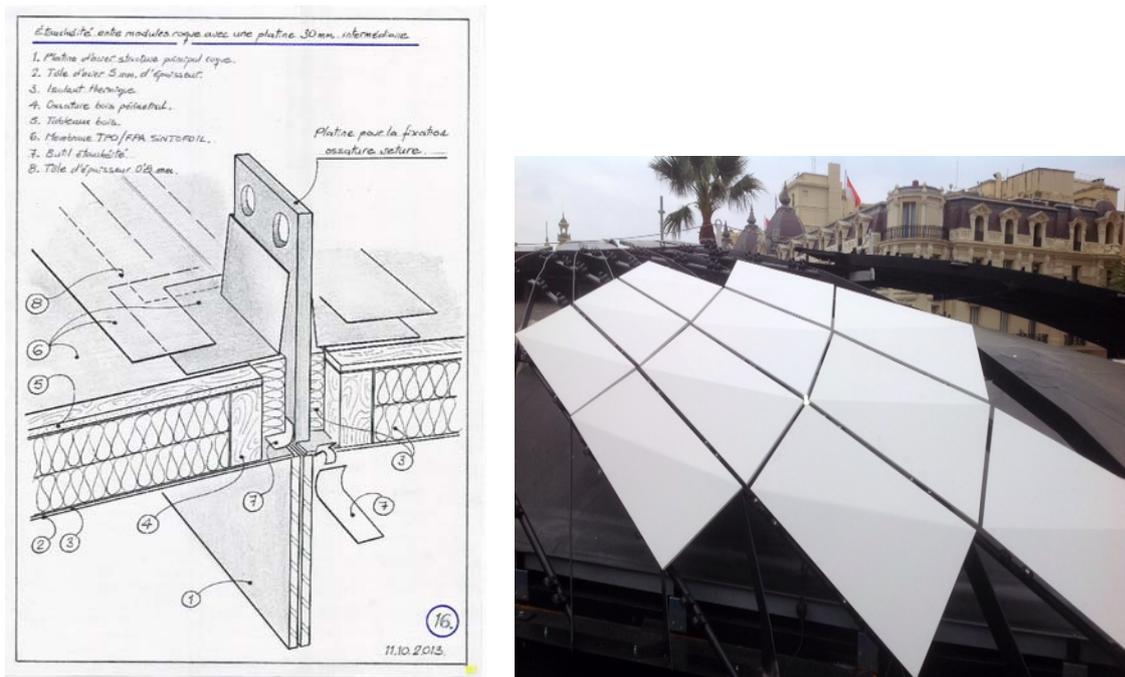


Figure 8: Cladding details and composition

#### 4 Logistics and on site process

Due to the traffic and transport restrictions within Monaco Principality, all the materials, as well as truck entrance, were submitted to strict controls. The space for the material stockpile in front of the Monaco casino was also restricted so that the logistics was based on the exact “just in time” supply process with the QR numeric control of the pieces. The production and logistic coordination was very precise and daily reviewed. All the irregular pieces were packaged individually in order to avoid any deformations during the transport.

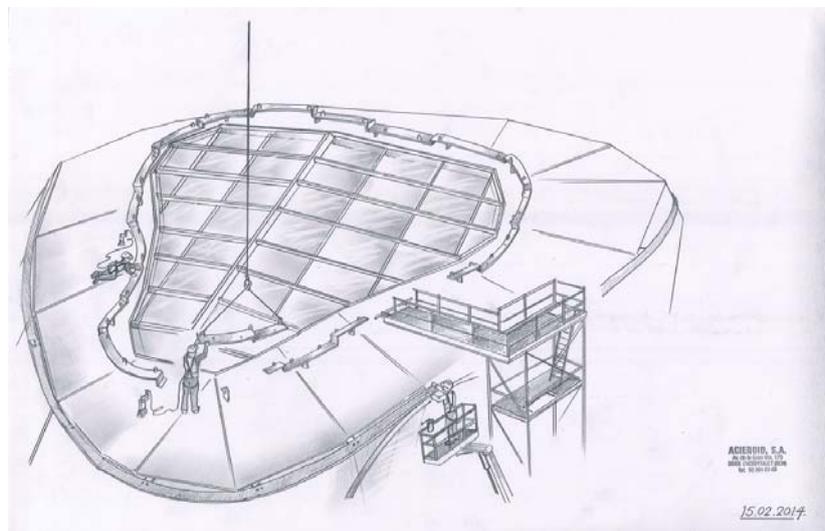




Figure 9: Pavillons des Boulingrins, assembly on site

#### 4.1. Assembling on site

The great particularity of that project is the previous industrialization of all elements what implied the very strict control of all the pieces without the margin of error. The achievement of that goal was possible due to the 3D modelling, topographic control during the manufacturing and numeric QR control in the workshop and on site.

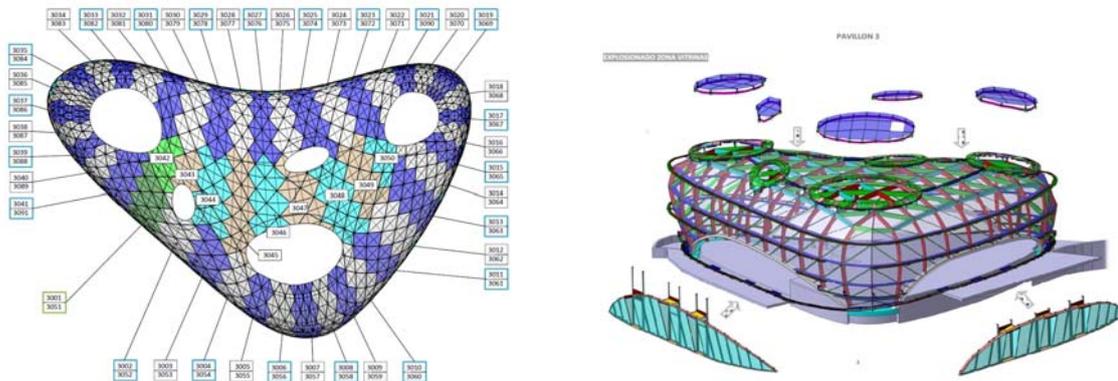


Figure 10: Numeric seams control and position control for skylights and *vitrines*



Figure 11 Sequence of assembly on site

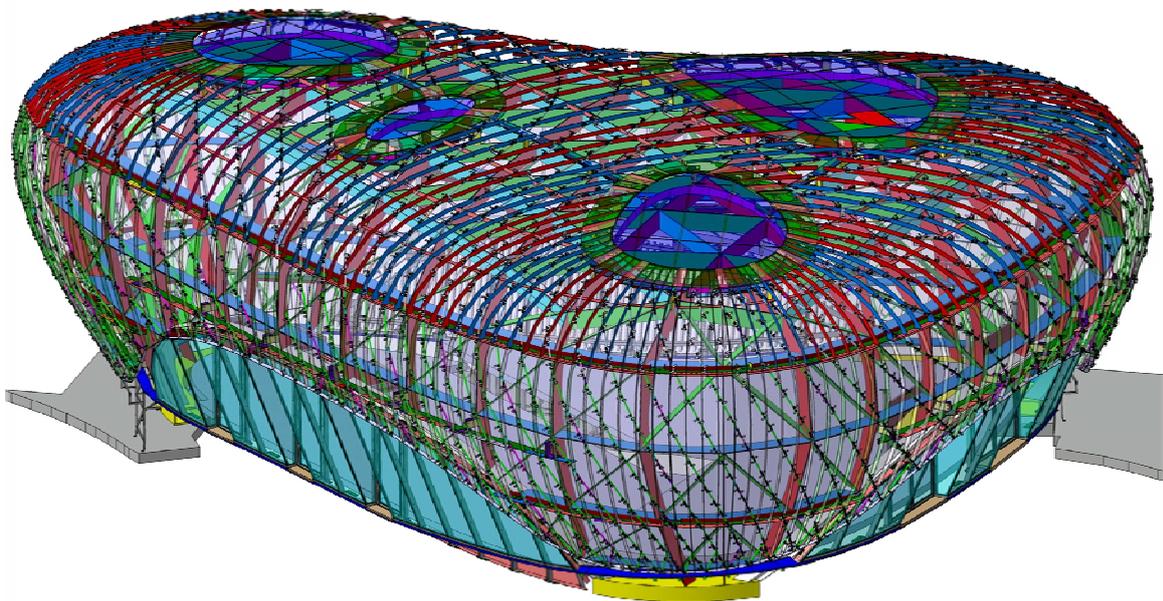


Figure 12 Catia perspective including all elements

## 5 Final findings

Les Pavillons des Boulingrins, based on parametric design, is a sustainably ephemeral architecture project. The re-usability criteria was respected by means of the special design which permits the total recyclability of the buildings. During the site execution all the trees of the park were carefully removed and placed into its original location again. Adjusting the timing of the execution, the carbon footprint left was minimized and all the designated resources optimally used. The technical parameters of cladding applied, its thermal and waterproof performance categorizes the project as energy efficient.



Figure 13: Pavillons des Boulingrins, Monaco

### **Acknowledgements**

We would like to appreciate the involvement of all our partners to make altogether that wonderful project reality. Nevertheless, the special acknowledgments goes to our client Société de Bains de Mer to trust in Acieroid.

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