Prototype Design of a Coloured Primary School (Sichuan - China)

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Abstract—**A school project is here presented embodying innovative spatial and technical principle aiming at children well-being, and urban and environmental sustainability.**

Index Terms—**Education, photovoltaics, school buildings, solar energy.**

I. Introduction

Primary schools play a key role for the educational and emotional growth of the children through playing. Nowadays, educational systems tend often to complicate formative procedures by piling activities over activities with not so encouraging results, trying to help children grow prematurely, in the hope to boost human intelligence beforehand by fostering competition as a value for society's growth.

More often than not, the result is that the act itself of playing is no longer a chance to discover the surrounding world and to gain further consciousness of things by direct experience, because it is accounted as an activity for “diversion” and escape. This dynamics lead children to be treated as miniatures of adults and their daily lives to be shaped like imitations of those of grown-ups, at the risk of producing work stress and fostering education ineffectiveness.

The key ideas in the here presented project are conceived to enable children to live, experience and shape their own world and to encourage them to gain knowledge by first-hand experience.

This objective has been pursued through a suitable integration between service architecture and adjacent exteriors. With this aim, the buildings layout has been designed featuring parallel bars of different lengths and depths. The idea here is to let buildings and space adjust themselves to different necessities by enabling them to assume different forms, lengths, widths, and even mutual relations within the lot. Exteriors and built forms challenge one another and fall into a reciprocal dialogue, thanks to specific spaces at their intersections further outlined by different heights.

This principle brings consequences to both urban integration and sustainability. One reason for this is that mechanical and technological systems are assumed to be at the very center of contemporary design and thus to require to be embodied in the visual composition, in order to enable architecture to radiate its own light and colors and dialogue with both people and the city. For this reason, all spaces in the project are marked by some symbolic Figs, typical of the toys world. The colors produce a new kind of furniture conceived to be like a toy, even before creating volumes designed to only contain things. And furniture takes on a dual meaning, becoming both a container and a toy able to contain other toys, like a sort of “matrioska”. Within this perspective, the remaining objects/toys here become a means of both relax and work - the very core of the project –; and the entire school complex is involved in this dynamics, by assuming shapes and colors of children' toys.

II. Architectural Means

Detectable from afar, the school stands out from its rural surroundings thanks to the movement of the roofing, obtained sometimes by the rotation of the photovoltaic panels, which track the sun during the day, and sometimes by the fixed shape of the roofing, which recall boat sails. Ultimately, these roof, which alternates higher to lower volumes, create horizontal and vertical lines combined together. This particular effect harks back to that image of a city seen epitomized in paintings from the XIII and XIV centuries’ right up to the early Italian Renaissance. [1] [2]

Another important inspiration for this design was the seaside colonies constructed along the Adriatic Riviera during the first half of the XX century. [3] In addition to that, a clear allusion has been made to two of James Stirling’s projects: the Olivetti Training School at Haslemere in Surrey, [4] and the South gate Housing at Runcorn New Town. [5]

In order to define a suitable integration between Architecture and Nature, where Nature plays a formative role in the life of a student, divided into play and discovery, the buildings’ layout was designed as a series of parallel bars of different lengths and widths.

Connections are carried out by various pathways, made of pavements grafted onto the intersection spots between the buildings, running in a longitudinal direction inside and outside each of the bars and creating a web of pedestrian passages.

A sort of coherence is kept between these linking paths and the ones running through within each building, in order to further highlight the fact that there is no actual distinction between buildings and Nature, but a continuity, which becomes a sort of artificial wrinkling of the ground. Furthermore, these passageways offer designed sights of the rural surroundings directed and framed by the buildings. This gentle wrinkling of the ground, together with the layout of the buildings, provides a harmonic fusion of the project with the horizontal trend of the rural landscape and, at the same time,

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defines spaces suitable for the students to play and study in complete safety.

There is no appointed main entrance in the school complex, but each of the paths of the web throughout the lot has its own access to the buildings through glass doors. This gives the spaces a flexible and transversal use, allowing the various features and functions to be used separately, including the spur-of-the-moment users.

The colors of the façades identify (from the outside for who approaches the site and from the inside for those who look out of the windows) each of the buildings' different functions:

1) First bar Flaminia side – light blue: laboratory, staff room, services
2) Second bar – red: primary and elementary school classrooms (3+5 sections)
3) Third bar – red: primary and elementary school classrooms (3+5 sections)
4) Fourth bar – yellow: services, infirmary, warehouse
5) Fifth bar – green: auditorium, gym, changing rooms
6) Sixth bar – orange: library, kitchen/canteen, changing rooms, services, warehouse (As it could be inferred by numerous text, chromotherapy is a science often use as a mean to resolve childhood issues such as interrupted sleep and academic performance.)

III. Constructive Simplicity and Speed

From a technical point of view, the generative concepts of the project are lightness, speed of assembling and disassembling, and ecological integration. With this aims, the supporting structure of the buildings is conceived as a frame composed by laminated wood elements sized to resist seismic stresses while freeing interiors from imposed limitations.

The external cladding is composed by precast insulated panels, some of them provided with linings for possible waterworks and other aligned with the multilayered glass and steel walls.

Suspended wooden panels ceilings host the ventilation and the electrical systems.

The dry joints and light prefabricated components that have been adopted allow for security and speed in the building process. It has been esteemed that a total of about 400/450 workers is necessary for the entire construction process, from the building to the technical systems.

IV. Low Impact Materials

Low-impact materials play a key role in the project's conception. The main key points here are the following.

1) Laminated wood load bearing frame.
2) Wooden slabs. The 5-meters-spanning structure is covered by a wooden modular panel, assembled beforehand through "dry" techniques, and including box section bars hosting an easily inspectable, insulated slot for wiring. Both vertical partitions and the slab insulation are made of natural and recyclable materials, while in the ground floor a concrete slab is covered by a modular double floor system which is left the space needed for wiring and waterworks.
3) Low-impact vertical walls, consisting in a double gypsum 2 cm panel, 24 cm cavity for technical systems, two 10 cm wooden fiber panels, one inner, one outer, with a 6-cm-thick multi-layered insulated panel between them and an envelope of recycled 80 x 115 laminated plastic panels.
4) Envelope termo-setting HPL paneling walls. HPL panels are high pressure, full-height laminated elements which offer a high resistance to mechanical stresses. As an alternative to HPL (thermosetting recycled - and endlessly recyclable – resins) materials, the used of CPL - cellulose based materials treated with thermosetting resins is here allowable and even encouraged.

V. Technical Considerations about the Sun-Tracking PV Units in the Proposed Design Solution

Each building roof features expressive box-like shapes supported by a steel structural frame, which host photovoltaic panel units. A device provided with sensors allows the rotation of these systems in order to track the sun and receive the maximum possible amount of energy.

The load bearing frame is anchored to a rotating platform laid upon highly resistant wheels provided with appropriate bearings and pivots and conceived to require a very low maintenance since presenting a very low number of movable and fault-prone parts.

As extensive study of tracking solar panels allowed us to incorporate the most up-to-date technology on the market into the building's architecture. Each roof solar energy system is composed by about 100 sqm of exposed panels and has a double rotation gear - horizontal and vertical - so to adapt themselves like sunflowers to the position of the sun. Some of these rotating systems include solar water heating panels, thus making the buildings fully self-sustaining.

The tracking solutions which has been adopted for the photovoltaic units allows for an increase in energy production (compared to a fixed panels solution) ranging from about 25% to 50%, depending from climates and sun tracking strategy.

The increased efficiency of the considered tracking system are higher at lower latitudes for climates characterized by predominantly clear skies, and at higher latitudes, due to the efficient tracking in the summer early mornings and late evenings.

The construction solutions that have been taken into account for the side walls of the PV rotating units are conceived to make the shadowing effect of the side walls negligible even in clear sky conditions (in which the direct radiation component is small and therefore the sun-tracking benefit is low) and prevalence of direct solar radiation. This is made possible by (a) the adoption of a clear, diffusely reflective, opaque metal finish for the interior face of the walls, aiming to reflect to the PV panels a radiation amount just slightly smaller than that shadowed by the opposite wall, or (b) of a partially translucent and partially reflective sheets for the walls' surfaces.

Fig. 1. Overview of the architectural concept.

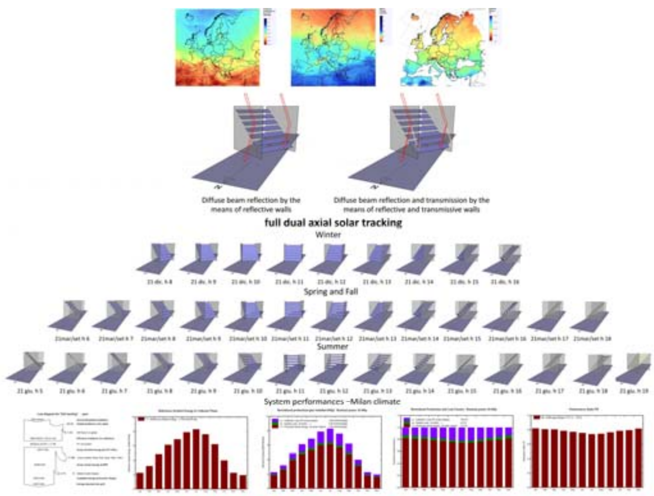

Fig. 2. Synthesis of the main technical features for the PV panelling system.

The project has been optimized to possibly adopt two alternative groups of sun-tracking solutions for the adjustable PV units. The appropriateness of these groups of solutions depends from expenditure and efficiency targets. The first solution is based on a full dual axial sun-tracking strategy requiring that the panels position is updated every quarter of an hour on both axes, and controlled by a closed-loop sensor-based sun-tracking control. This tracking and control strategy is more costly the alternative ones, but produces the most efficient results, since it manages to always give the PV units an optimal position, depending from the proportions of direct and diffuse solar radiation, as monitored by real-time feedback, for instance by increasing the horizontality of the panels when diffuse radiation is prevailing. It is therefore a particularly advantageous solution in the cases in which the diffuse radiation component is strong in the sky, as in the foggy winter climates for instance or in the hot-humid climate in the world year-round. The simulations run for a number climates confirmed that this tracking solution is consistently the most efficient one from the point of view of energy production.

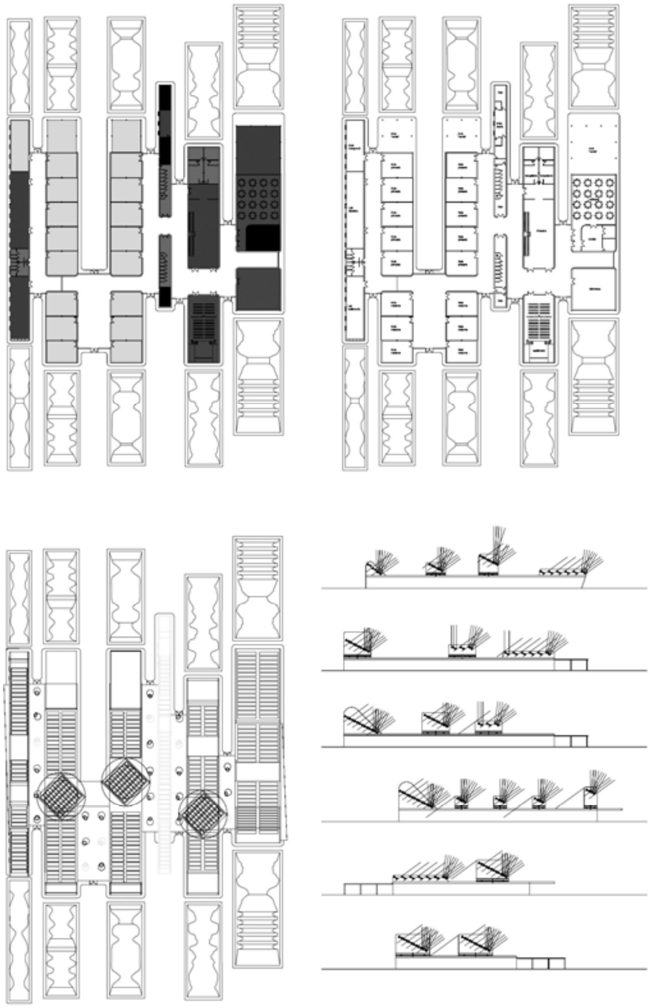

Fig. 3. Floors and elevations of the building.

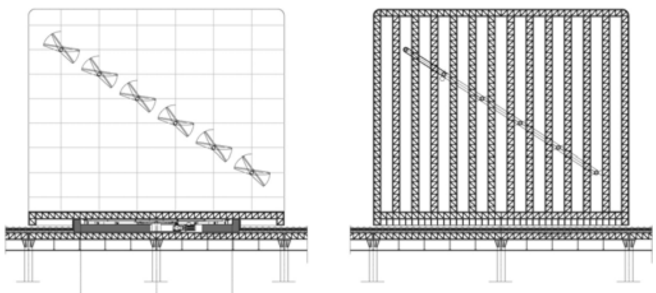

Fig. 4. Sections with rotating panels.

The second solution is characterized by a hybrid - hourly and seasonal - dual axial sun-tracking strategy. The dual axial movement is on the vertical plane it is here rarefied, happening every one hour and a half when the sun is up; while the movements of the horizontal axis are scheduled on a seasonal basis. This solution is likely to be of interest, because it shows a just non-dramatic efficiency decrease (ranging from about 3% to 6% depending from climate types) if compared with the full-tracking solution and it also comes at lower expenses and likely higher mechanical durability.

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