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A resilient refurbishment project for an Italian large sports hall

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ABSTRACT
In Europe the management costs and lack of flexibility of the sports halls, built in the second half of the '900, brought to the progressive abandonment of many structures. In this context the environmental, social and economic sustainable aspects of a refurbishment project of an Italian large sports hall, named "Palasport", are presented. It was designed by a group of architects and engineers and completed in 1962. It is located in the expo area of Genoa, a north Italian city, called "Fiera del Mare" and it plays a strategic role in the social community.

In the past it hosted several international events such as concerts, fairs, exhibitions and sporting events. Today the building is completely unused for several reasons, including the obsolescence of the mechanical and technological systems, the high operating costs, the lack of versatility and adaptability of the structure. For these reasons, it has been developed a project in the name of environmental, social and economic sustainability for a building that could attract different types of users during the day. The project is realized with the support of Building Information Modelling (BIM) methodology. The BIM is used to execute various simulations and scenarios to obtain the best possible results, to analyze functional, social, energetic and economic aspects. Furthermore, it is used to simulate Palasport in dynamic condition to understand its real behavior with dedicated applications (Equest, ElumTools). In the presented refurbishment project renewable energies are used: from the sun for the production of electrical energy, from the seawater to improve the performance of the Heat Ventilation and Air Conditioning (HVAC) system and from the wind to refresh the pavilion. This project makes the Palasport a flexible and resilient construction and adapt it to the future needs of society.

KEYWORDS
Resilient refurbishment, BIM applications, dynamic lighting simulations, thermal behavior.

INTRODUCTION
The urban fabric, mostly in Europe, is saturated and therefore it is increasingly the need to optimize existing heritage, improving its qualities and transforming the criticalities in new strengths. In the European cities often there are disused buildings because they are no longer able to meet the functions for which they were designed and the needs of the urban context in which they are located. The Genoa "Palasport" is certainly one of this kind of buildings, despite the historical importance it represented.
The Palasport, also known as "Pavilion S", stands in the Sea Fair of Genoa (Figure 1), whose urban design is attributed to the engineer Luigi Carlo Daneri. Today the fairground is developed among the following buildings: Pavilion B (designed by Jean Nouvel), Pavilion D (old place of University of Genoa), Pavilion C (exhibition places with historical and "experimental" tensile structures). The actual project of the Municipality of Genoa to transform the entire area offers an opportunity to return a sea view to the city and to relocate

the recreational activities in areas suitable for the performance of sports and nautical activities. This reconversion follows the design of the New Waterfront of Levante (masterplan by Renzo Piano) and combines the development needs of one of the most important industrial sectors of the city (naval repairs) with the process of modifying one of the most delicate and precious stretches of the entire urban coastline. The new places thus released will host, in addition to the navigable canals of the new marinas for pleasure boats, residential/receptive, directional, sporting and commercial functions; places and opportunities for meeting, exhibition, development and enhancement in the areas of leisure, sport and culture, with the relative parking spaces.


(a)


(b)

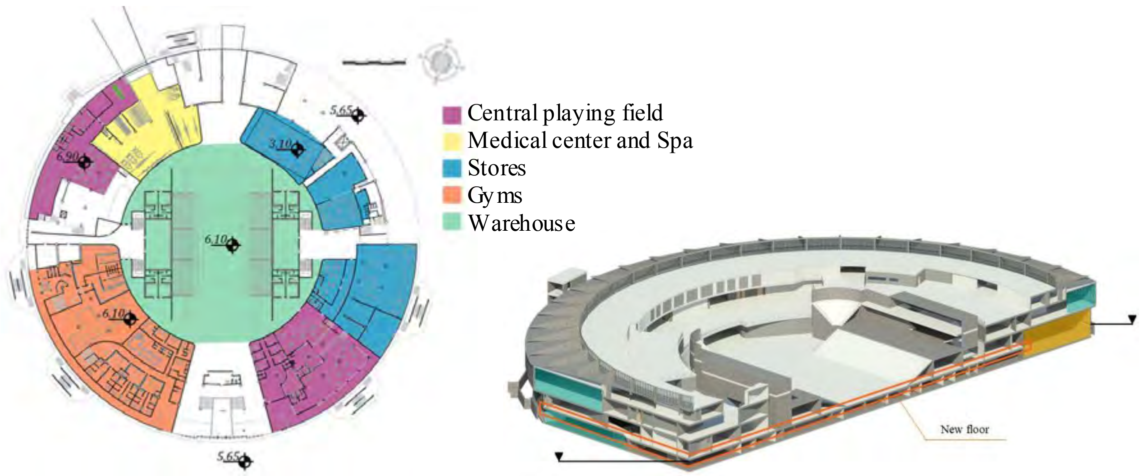
Figure 1. (a) The coast of Genoa; (b) The pavilions of Sea Fair of Genoa: S (Palasport), B (designed by Jean Nouvel), D (old place of University of Genoa), C (exhibition places with historical and "experimental" tensile structures) (Cenci, 2018).

The Palasport, object of this writing, has an area of 30.000 m^2, split in three different levels: the ground floor, just below the external reference quote, has a diameter of 160 meters and it's surmounted by two concentric ring galleries. The central zone with two grandstands with 2.000 seats has a large space at full height. From the inauguration, the Palasport is characterized by its great multi-functionality, hosting international sport events, concerts, exhibitions with great success. However, with time, the previous events were too sporadic to justify the high running costs; this aspect, with the age of the technological systems, has brought to a progressive inactivity of the pavilion. The project of the new functions and consequence design for the Palasport regeneration was based on the resolution of these problems and took advantage from the inclusion of different activities inside and outside, because inserted in the masterplan by Renzo Piano.

METHODS

The requalification project of the Palasport wants to give back the building to Genoa, making it the pivot of sports agonistic and amateur activities. So it was chosen to make a project table with CONI Liguria to understand the real needs of the sports federations, located in the Ligurian territory. This collaboration has brought to an optimization of the internal spaces in order to host the large number of sports activities, like as basketball, volleyball, tennis, boxe, rhythmic gymnastics, football, ping pong, badminton, etc. To cover the operating costs is necessary to include other collateral activities, for example commercial establishments, restaurants, conference rooms and entertainment spaces.

Thanks to the collaboration with sports federations it's born the need for a sport medicine center, agreement with CONI, to be included in the Genoese urban context. Therefore the project includes a large space dedicated to sports medicine in the building, that could become a landmark for all of Liguria.
The careful study of the spaces has allowed to insert a large number of activities, without precluding the possibility of hosting large sports events, exhibitions and concerts (Figure 2).



(a) (b)

Figure 2. The requalification project of Palasport, examples of project development in BIM mode: (a) first floor; (b) the new floor.

Thanks to the new floor at the same elevation of outside, the Palasport has four floor, so there was the necessity to design some new side stands, that can host 4.000 spectators. As previously stated, one of the standards on which this design is based is the versatility of the interior spaces; this has been achieved with the use of slight prefabricated walls to give greater freedom to the interior arrangement, that could change according to the needs of users. The independence of the rooms hasn't pursued only at the planimetric level, but also from the plan engineering point of view, especially under the thermal and lighting aspects.
For the outer casing only some interventions are necessary in order to keep the original characteristics of the Palasport as much as possible; furthermore, insulating and compartmentalizing the rooms it wasn't necessary to modify the roof and the vertical curtain walls to obtain good thermal insulation values.
The plant engineering aspects were addressed to minimize consumption; in particular, the lighting and thermal conditioning systems, incorporating renewable energies: infact the heat generation system was granted to seawater heat pumps, while the electrical requirements were partially satisfied by the use of photovoltaic panels.
All the simulations of this project have been performed with BIM technology. This type of design is based on a parametric modelling, born in the '80s, whose innovative aspect is the ability to report the changes made on an element, or some of its features, throughout the model, keeping it continuously updated, in function of the context changes too. Through BIM technology you can do a lot of operations, such as architectural, structural, plant engineering simulations, controlling temporal and economic variables too. For these reasons Building Information Modelling is considered a 5D technology.

RESULTS
In the BIM's mode several dynamics simulations are used to verify the project hypotheses for energy efficiency and comfort conditions. In particular, are conducted: lighting simulations,

thermal-hygrometric simulations (for energy efficiency and indoor thermal-hygrometric comfort); irradiation analyses (for renewable energies production) and wind flow analyses (for indoor thermal-hygrometric comfort).

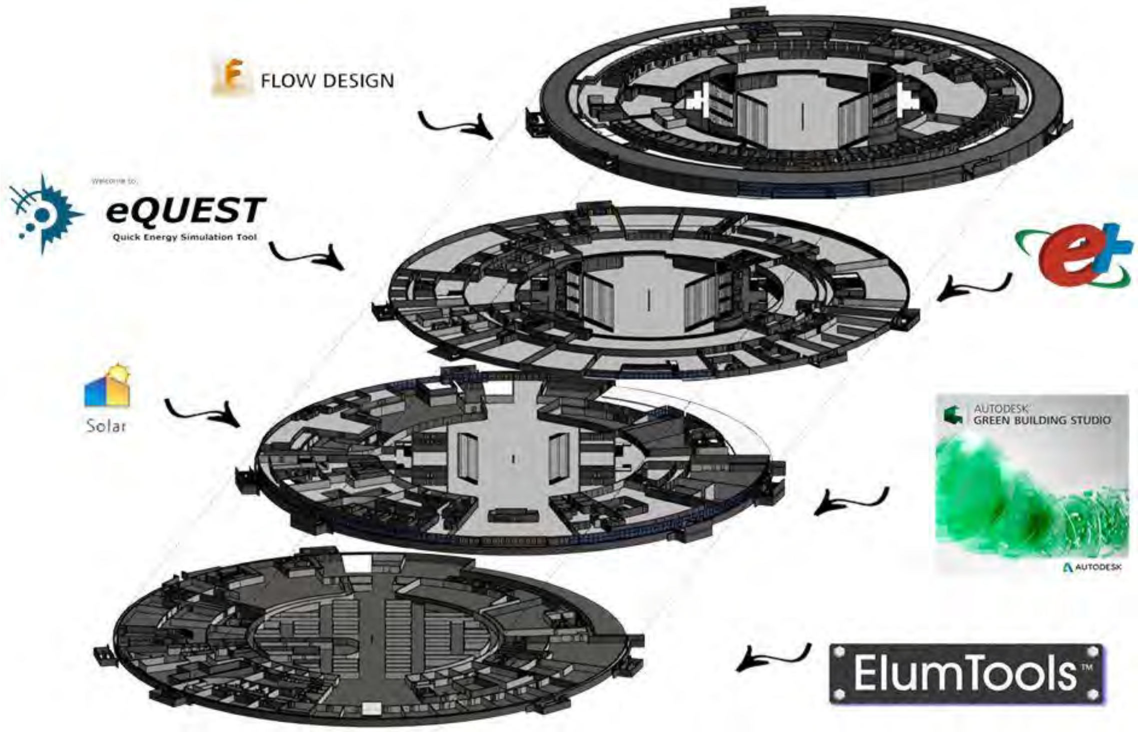


Figure 3. Used tools for dynamic simulations: lighting simulations (ElumTools, EnergyPlus), thermal-hygrometric simulations (Green Building Studio, Equest), irradiation analyses (Solar-Autodesk) and wind flow analyses (FlowDesign-Autodesk).

The first topic was the lighting project, with the purpose of obtaining the maximum illuminance value, respecting the quality parameters required by current legislation (UNI EN 12464-1:2011), namely: general uniformity, glare, color rendering and color temperature.

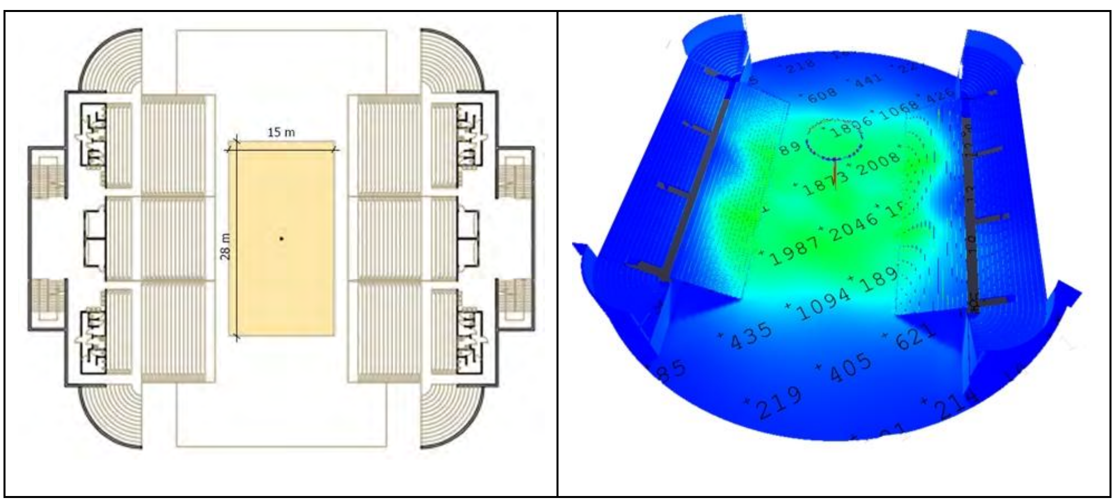


Figure 4. Examples of results for lighting simulations in lux.

The next step was the insertion of a control system for many applications: to optimize the luminous flux of the luminaires, according to the specific requirements of the regulations for the different activities, to keep the best visual comfort, to have, overall, the greatest energy savings possible.
The thermal-hygrometric project was studied using dynamic energy simulations, in order to analyze in detail the Palasport behavior and needs. As an example of the conducted dynamic analyses, the hourly values of the energy demand are shown (Table 1). In this case the dynamic simulation permitted to determine the exact peak load for heating and cooling through which the heat pump was sized.

Table 1 - Peak load values.

Peak loads	
Heating peak load [kW]	-1896.6
Peak cooling load [kW]	2926.7

Consequently, a seawater source heat pump (SWHP) was chosen which harnesses the Mediterranean sea thermal energy as a means of generating renewable energy. Three modular SWHP were, therefore, assumed to be used (Table 2).

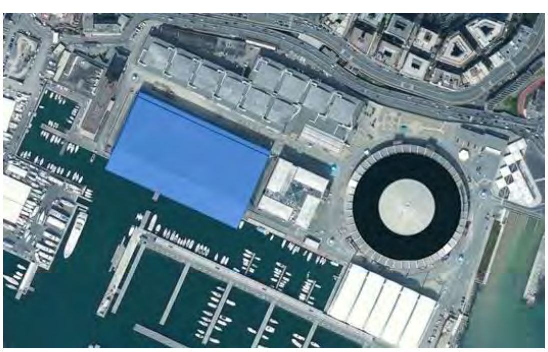
Table 2 – SWHP Specification.

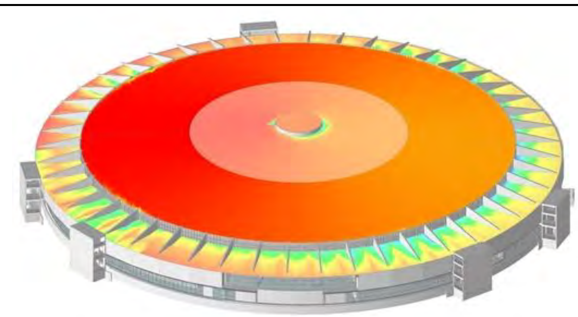
Heating	
Rated Heating Output [kW]	1188
Power Consumption [kW]	242
Coefficient of performance (COP)	4.89
Evaporator water flow [m^3/h]	205

Cooling	
Rated Cooling Capacity [kW]	1061
Power Consumption [kW]	204
Energy efficiency ratio (EER)	5.21
Evaporator water flow [m^3/h]	185

In this way, the winter requirement is satisfied thanks to the use of only two SWHP, achieving savings in terms of electricity consumption. The third, therefore, would be used during the cooling season or in case of failure of one of the other two.

BIM simulations were used to sizing the renewable energy systems too; in particular, for the photovoltaic systems it has been planned the use of CIS panels, composed with copper, indium and selenium. These panels have an excellent efficiency, so we can ensure a greater production than the use of traditional photovoltaic panels maintaining the aesthetics of the Genoese roofs.





Total surface [m^2]	Average irradiance [kWh/m^2a]	Minimum irradiance [kWh/m^2a]	Maximum irradiance [kWh/m^2a]
10393.1	1287.87	1197.6	1376.42

Figure 6. Photo insertion of photovoltaic panels and annual irradiance on Genoa “Palasport”.

To fully exploit the context in which the building is located, it was decided to use natural ventilation to condition the premises during summer, checking beforehand the intensity and the direction of the prevailing winds. The natural ventilation takes place through the opening and closing of windows controlled by a Building Automation system that conveys the air inside the building, in function of outdoor and indoor temperatures and wind's characteristics.

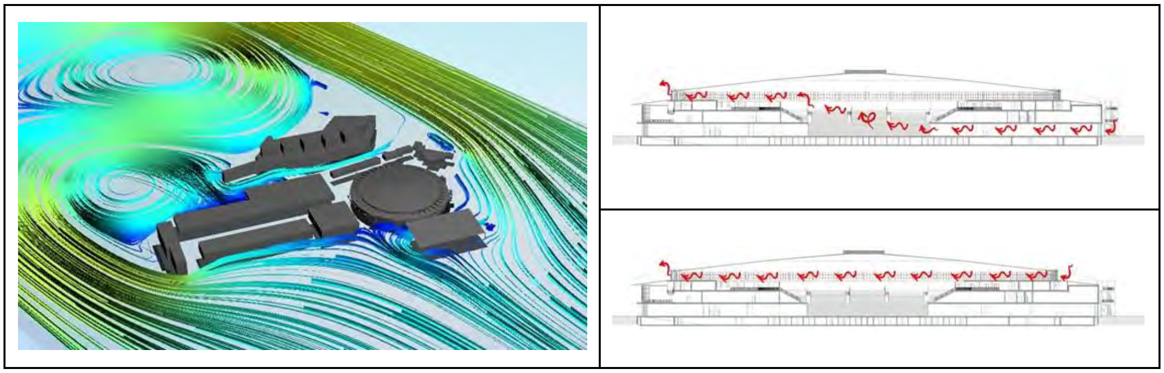


Figure 7. Analysis of the summer wind regime and the schematic dynamic natural ventilation.

DISCUSSIONS

Building automation is a fundamental element in this project: thanks to it, it's possible to control the ventilation, the heating system, according to the individual indoor use destinations, monitoring the thermal-hygrometric conditions of each rooms, the lighting requirements with presence and twilight sensors and the optimization of photovoltaic panels.

CONCLUSIONS

In the end we can say that the design solutions chosen in the project, such as the subdivision of the rooms, the plant engineering independence, the use of sea water to refrigerate the heating system, the use of LED technology for lighting, natural ventilation to counteract the heating in summer and the Building Automation, have led to an important reduction in operating costs, that are equal to about 200.000 €/year. This amount is in particular due to electricity consumption which is further reduced by 40% thanks to the use of photovoltaic panels, making the Palasport sustainable from an environmental and economic point of view.

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