INTRODUCTION

Building - high quality and low energy consumption - schools (particularly kindergartens) are a priority of the many governments in the world. In Italy, e.g., more than 50% of school buildings do not correspond to current spatial, functional, energy and seismic standards and urgently need to be renovated, expanded or replaced. In some regions of Germany it is an urgent need to build many kindergartens to ensure every child a place to spend the day while its parents work. Even in most developing countries (Africa and Southeast Asia) the humanitarian interventions are focusing their field of action on the creation of schools: e.g. Zambia needs immediately 10,000 classrooms. Moreover, in many countries, there is also the need to provide temporary school buildings (quickly realizable and totally removable) to be used after natural disasters or during the redevelopment of existing schools.
Furthermore, an investigation carried out a few years ago by the U.S. Green Building Council (USGBC) has estimated that in the U.S. "*more than 55 million students spend hours every day in buildings with poor ventilation, inadequate lighting, inferior acoustics and antiquated heating systems*" (www.usgbc.org). Because of this, USGBC started a study called "Greening America's Schools - Costs and benefits" which concluded that *"Greening school design provides an extraordinary cost-effective way to enhance student learning, reduce health and operational costs and, ultimately, increase school quality and competitiveness"* (Kat, 2006). Based on these research results and with the aim of promoting the development of energy-efficient schools, 2006, USGBC launched LEED for schools. These new suite of rating systems recognizes the unique nature and educational aspects of the design and construction of schools. Also the U.S. Department of Energy has promoted a program called *"EnergySmart Schools"* that shares "*best practice and technologies for achieving significant savings in both new construction and school renovation*". This program also provides tools and training for school planning, financing, operation & maintenance, and energy education. Moreover, the ASHRAE has just published an *"Advanced Energy Design Guide for K-12 School Buildings"*.

OBJECTIVES AND METHODOLOGY

On the basis of the above considerations this research aims to develop an easy to build, flexible and reversible constructive system for the building of high spatial-functional quality, good technological-constructive standard and excellent energy efficient school buildings located in different climates. The idea of designing buildings in different climatic conditions was born from a faculty exchange between UNICAM, Italy and Cal Poly, USA in which 2nd year architecture students have been involved in the design of energy-efficient school buildings located in different climatic zones in Italy and in USA (Rossi, 2012). Based on this very positive didactic experience it was decided to accept "the challenge" of designing in different climatic conditions also for this research, particularly for the design of a very versatile constructive system.

To achieve this goal, the research has been organized into the following phases:

1) Detailed analysis of: A) spatial, functional, energy and seismic standards for school buildings in different countries, B) types of learning and teaching and their impact on the design of the spaces, C) materials and constructive systems with lower environmental impact and suitable for use in reversible processes, D) Climatic conditions and indoor comfort standards in three cities chosen as case studies, E) passive and active energy strategies and devices efficient in different climate.
2) Development of a constructive system in cross laminated timber.
3) "Try and test" of the spatial-functional, technological-constructive and energy-environmental performance of the developed constructive system in different climate through appropriate tools.
4) Optimization of the constructive system on the basis of the results of the "try and test" phase and development of the final system.
5) Application of the system in 3 case studies: Helsinki-Finland, Rome-Italy and Nairobi-Kenya.
6) Evaluation of results of applications.

DEVELOPMENT OF A CONSTRUCTIVE SYSTEM FOR SCHOOL BUILDINGS

With the intent to develop a constructive system for the building of energy efficient (temporary) schools located in different climatic conditions, particular importance has been given to achieving a high level in three categories of performance: spatial-functional, technological-constructive and energy-environmental. In this paper, for reasons of space and in relation to the topics of the conference, more emphasis is given to the last one.

assembly method), air change rate, occupation, internal loads etc. to internal comfort level, energy demand and energy balance of the entire building. With the intent to minimize the use of active systems, passive solar analyses (fig. 6) are one of the most interesting intermediate results of this research for the appropriate use of devices like greenhouses, evaporative cooling etc.

All the simulations carried out in the three case studies have shown a high level of environmental comfort and an extremely small internal energy demand for heating, cooling and lighting in relation to the climatic zone. Kindergartens designed in Helsinki and Rome achieve the standard "near to zero energy building" (with the use of passive devices and active systems like photovoltaic and solar collectors). Moreover, in all three buildings PMV has values between -1 and +1 even in periods with extreme climatic conditions (Helsinki in winter or Nairobi in summer).

CONCLUSION

In conclusion, tests (design application, static and dynamic simulation) conducted in this research have shown that the developed reversible constructive system (applicable in temporary schools) combines good spatial-functional and technological-constructive qualities with a high level of indoor comfort and a low energy consumption for heating, cooling and lighting. Moreover, the system resulted extremely efficient also in very different climatic conditions, thanks to its easy adaptability to different configurations and strategies.

This work was born in a school of architecture as a graduate thesis presenting an environmental research scenario for locations with peculiar climate and performance needs based on the final better judgment from the design team. From an educational operative perspective the work of comparison between different performance responses is an open-mind attitude to stimulate the research in sustainable construction methods.

The architectures' primary role is guaranteed as the method gets a lot of dedicated input information to lead in the design phase. Each information can have a particular importance in processing the ideas from a sketch or from a detailed commission request, (for example from a local government program).

The collaborative role of building physics became not abstract or simply theory, but is addressed to be an useful cooperation design technique.

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