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BUILDING FUTURE Lab.: a great infrastructure for testing

Corrado Trombetta, Martino Milardi

Università Mediterranea di Reggio Calabria, Dipartimento Architettura e Territorio, Building Future Lab.

Abstract

The great infrastructure for research "BUILDING FUTURE LAB." created by the Università Mediterranea di Reggio Calabria through EU funds PON-MiUR (8.6 M€), represents a technological innovation for Testing Advanced building performance. The BFL exceeds the traditional transfer method of constructive experiences, and strives to achieve a transfer of technology and skills-based testing for the definition and certification of performance. Within this project there are some patents in investigation; on this occasion will be presented the patent of a new "Apparatus for testing the water permeability of samples of facades of buildings".

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Keywords: Laboratory; Advanced Testing; Sustainability; integrated and dynamic tests;

1. Introduction

Through the PON Call no. 254/Ric. 2011 Progetti di Potenziamento Strutturale, was funded for 8.6 M €, the project from Università degli Studi Mediterranea di Reggio Calabria Arte e Territorio (dArTe) Department called: BFL - BUILDING FUTURE Lab. The BFL is assumed that the building of the Future pass by the opportunity to overcome the traditional method of transferring constructive experiences in order to achieve a transfer of technology and skills based on the Innovative Testing. The project proposes the avant-garde technology, is divided into 8 sections for 5 Operational Objectives. The operative sections are strongly related and provide dynamic "TEST relating to the Sustainable Energy and Environment; Testing Our leathers and components, through the "TEST MAT&COM" subsystem building through the "TEST LAB", "TEST CELL" and the "TEST ROOM" is morphological systems through the "TEST DIMORAProject&Co", structural systems through the "TEST DINAMICA" and buildings in use, through the "TEST MOBILE"; buildings in extreme conditions, i.e. with foundations on the water, will be tested through the "TEST WATER"; completes the "COGNITIVO Lab." defining committed to the innovation of the project. The analysis and assessment of the sustainability of innovation will be carried out in view of the life cycle, according to the three aspects of which can be traced back today the issue of

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sustainability: environment, social context-historical, cultural and economic resources. In this way the project will move in line with the framework UE. The heart of the proposal is the phase of Testing Advanced solutions under investigation, through the use of the compendium of machines consists of the Test LAB, the Test ROOM and the Test CELL, a technology you will work with advanced equipment, systems borrowed from the world aerospace and aeronautics, for verification of dynamic performance, simulation and monitoring of the actual behavior of the "technological systems". Imagine a portal of more than 16 meters on each side, on which to test portions of the building envelope innovative with contemporary evidence and testing the ROOM and the CELL (See fig.1);. These days we are starting the assembly, with the company REXROTH, Robert Bosch Group, MokeUp the TEST LAB to be operational, with the rest of BFL, then dell'IBPC2015. [1]

The BFL is a candidate to become Accredited Certifier for the Energy Consumption and Environmental Sustainability; a significant program of training of the staff (Postgraduate MASTER) completes the scenario of an ambitious, but practical and feasible to be poured into a company SPINOFF will be accompanied in the conceptual definition of new products and components. Within this project there are some patents in investigation; IBPC2015 represents an excellent opportunity for the presentation of the first patent of the project, namely concerning a new "Apparatus for testing the water permeability of samples of facades of buildings".

From this scenario [2], it seems clear that the pressing need to control performances of the building, evidenced by the increase in regulations on the international scale, constitute a key role in activities aimed both at testing and at the certification of technical assets to innovate. For the types of tests that can be performed and the classes of rules that the BFL checks, it can be rightfully placed within the international scenario of testing laboratories that today are leaders in this type of activity, such as the Architectural Testing York, Pennsylvania (USA) and Wintech Engineering of Telford, Shropshire, UK.

However, when compared to the general characteristics of the current laboratories, the BFL is placed at a different level for two particular aspects:

1. It consists of three sections, which cover a greater range of testing and offer greater flexibility in both the combination of the casings and in the possible integration between the tests, a characteristic that gives a broad spectrum of possible experiments. These sections are the Test LAB, for tests on mokeup casing; the Test CELL for tests on layers of vertical and horizontal surfaces; the Test ROOM for testing the quality thermohygrometric indoor;
2. The sections have facilities, equipment and the latest generation of sensors designed to allow:

- Increased speed in the operations of preparation to the tests, because of equipment housed on the structure permanently; - Increased adaptability of the Test Box, as a result of mobile structures and retractable; - Possibility of simultaneous tests on mokeup of different "origins" for benchmarking; - Wider test surfaces available, because of large structures; - Ability to check more certifiable performance on the same mokeup (e.g. UNI EN 13830 - Curtain Walling. Product Standard, April 2005 and UNI EN 12152: 2003 - Curtain walling - Air permeability - Performance requirements and classification, as well as, ASTM E283 - 04 (2012) Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen; - Ability to have environmental certified simulations and stress accelerated; - Wide range of possibilities for experimentation due to the interchangeability of equipment and the integration with other instruments of the sections of the laboratory, e.g.: Test MAT&COM, Test MOBILE Lab, Test Dimora, etc ...

2. Methodology

Why not using assessments by theoretical calculation or laboratory? The laboratories for testing of the components (for example to measure the thermal transmittance, spectrophotometric or to conduct tests on the optical properties of the glasses) give the possibility to perform accurate and repeatable tests, but there is to say that they are steady tests, without the consideration of the variability of the behaviour of the material which depends on the variability of the boundary conditions, and therefore from the real condition in which the subject is. [3]

Therefore it looks clear that the most obvious solution is to control and measure the behaviour of the new component on a real building: this involves, however, considerable difficulty of control of the whole building (for example, the construction details, the behaviour of thermal bridges, the air movement, the heating and cooling systems and the variability of the internal conditions related to climate variability external); numerous studies

conducted on existing buildings have shown that the desired results on the behavior of a specific component are not reliable and thus not sufficient to properly define the thermo-physical characteristics.

The division “Test LAB - Test CELL - Test ROOM”, which we called "Catalogue of Open System", which we both designed and realized with the Robert BOSCH REXROTH group, aims to build and enhance a comprehensive testing system that has a high degree of control of the internal, external and boundary conditions, of a specific constructive system and with a measurement instrumentation, which may be the solution to overcome the criticalities and to enable the use of DEFINED parameters and characteristic of the component subjected to specific conditions.

3. Discussion: The Catalog of Open System.

The Test CELL has the aim to test parts of the facade and roof, both opaque and windowed. From the formal point of view, the solution with a rectangular plan, classically used to define the interior, is the best suited to carry out the test components of plans. From the constructive point of view, the Test CELL has a bearing structure, insulated, with walls characterized by a transmittance equal to 0.35 W/m2K; We decided not to create an adiabatic test chamber because from the European experiments it was shown that the adiabatic turns out to be a weak point on the measurement of the behaviour of the component to be tested: the internal environment in fact would tend to overheat and measures would be biased. To minimize overheating of the Test CELL a superstructure of ventilated walls and floors is provided, the cover also it ventilated. The structure is made to help reduce thermal bridges which otherwise would favour the thickening of the carriers of heat loss, giving considerable measurement errors. The internal surfaces are coated with tiles that support the sensors capable of measuring the heat flow and thereby control the walls in order to better interpret the behaviour of the component test. The test chamber is then appropriately controlled and equipped by instrumentation, able to check the components under dynamic conditions, to assess the characteristics and the opportunity to use or improvement to the architecture in the Mediterranean climate. The Test CELL is therefore a certified test lab good for outdoor materials and technological solutions related to the concept of the high thermal mass building, the use of advanced systems of fixtures, the facade cladding and roofing, systems solar shading as sunshades, blinds, shutters, etc. Today new technological solutions can be used though their thermal behavior under dynamic conditions needs to be tested first. The proposal to use a Test CELL under outdoor conditions is also useful for the testing of the dynamic behaviour of new building components. The design solution of the test chamber described is innovative compared to the solutions tested and adopted in the past, both from a technological point of view and from the point of view of the conditions of use: it is intended to be built on a swivel base, able to verify the performance of the facade component in different orientations; it is composed by two levels in order to compare and test the conditions of the attics or to test components on pitched roofs; the test chamber is both non adiabatic and appropriately shielded to reduce the effects of overheating due to direct solar radiation. Serving as a tool for the measuring and the evaluation of new building components, the Test CELL also allows to test combinations of products of different companies to check the actual performance of technological solutions and innovative construction, trying to quantify the benefits deriving from the optimization of the 'use of thermal mass and verify possible proposals of algorithms for the adjustment of the calculation of daylight factor in the Mediterranean countries. The results of the tests on the component will allow the development, and then the validation of the algorithms and computational codes in dynamic conditions, giving the possibility to simulate the behaviour of the new building component in other climatic zones and different scales of building. The scientific results will bring useful discoveries to the research area also promoting innovation in the products of housing construction with potential scientific importance at a national, European and international level.

The Test ROOM, adjacent to the service room, is the real testing environment, and has the dimensions of a room-type, in which the wanted thermal conditions are recreated. The walls on the two sides and the internal partition wall are adiabatic and with high resistance to air, while the fourth wall is removable to be replaced with the different components to be tested (test component). The second level has an additional interchangeable component: the cover element. The growing attention to the environment, energy conservation and thermal comfort in buildings leads to the research of new solutions for systems and different types of facade. So during the process of designing and building energy models, the provision of a useful means to study the parameters and alternative solutions is crucial. However, such models should always be validated by measurements. For this purpose, measurements of

temperature, relative humidity and consumption are becoming increasingly important. This section of the laboratory proposes a Test ROOM with different types of installations and thermal facades, which are monitored in terms of energy consumption and environmental conditions. Such solutions are becoming increasingly useful, as they allow various interesting control strategies to save energy.
The Test ROOM will be analysed by means of experimental measurements and two software tools for dynamic simulation [4]. The model evaluates the temperature, the direct solar radiation and the heat loads due to the presence of people, machines and lights and the thermal inertia of walls and roofs. The Test ROOM will be monitored in terms of environmental and energy consumption; so that it is possible to evaluate the reliability of the simulation models. In order to understand the relationship between the parameters involved, the energy consumption measured in the test ROOM will be compared with the results of the dynamic simulation. The experimental set consists of a Test ROOM, where a number of advanced solutions for facades will be made in collaboration with innovative environmental systems. The Test ROOM will be managed and monitored in terms of energy consumption, temperature of the facade and internal environmental conditions. The system of supervision and control (Building Management System-BMS) will record with time interval of minutes, the air temperature, the relative humidity inside, and the direct sunlight transmitted inside (pyranometer). The temperatures of the facades in 3 heights will also be monitored, in terms of each of several layers of glass, the ventilated cavity and sunscreening. The BMS will also manage the installations, monitoring the flow of water and ventilation, discharge and recovery, both for heating and for cooling, allowing the real-time calculation of the power used, and consequently the energy consumption. Illuminance measurements will also be made. The experimental data allow us to make a direct comparison between different solutions, exposed to the same climatic conditions and provide a reliable basis of experimental data for the calibration of predictive models simplified and detailed. All the different types of facade taken into consideration will be continuously monitored in terms of energy consumption, ambient temperature and humidity and the temperature of the surface through the facade, the temperatures of the air cavity and solar radiation transmitted through the glass. In addition, the measures can be carried out in daylight. A weather station shows the weather from the roof of the building. (See fig. 5,6)

Fig. 1,2,3,4: the TEST LAB of “The Catalog of Open System”; currently under construction in Reggio Calabria, Italy (ready on 2015)

The Test LAB. The realization of a large test chamber is crucial to test the real capacity of the facades, which is in fact aimed at verifying the compliance with legislation and performance levels of MOCK-UP of curtain walls, which consist -as defined by UNI- "structural elements of vertical and horizontal, connected together, and anchored to the supporting structure of the building and buffered, to form a continuous thin wrapper which ensures, by itself or in conjunction with building work, all the normal functions of an outside wall, but that does not assume the

characteristics of the load-bearing structure of the building". Once defined, the MOCK-UP in 1:1 scale of the facade up to 12 meters high and 12 meters in height, is built in the test chamber and it undergoes a series of tests, defined by European regulations which establish the question whether the statement on performance expectations. The range of tests identified by European legislation covers a wide range of functions required to the facade; below there are listed some of these tests, the methods used to carry them out, some technical features of the equipment, in addition to the current European standards. The following tests are required by the UNI EN 13830 -Curtain Walling. Product Standard, April 2005 (permeability; Water tightness under static and dynamic conditions; withstand wind; Impact strength; proof of horizontal displacement). These may be accompanied by other evidence regarding the acoustic performance, the thermal transmittance, the durability and fire resistance, the permeability to water vapor [5]. (See fig..1,2,3,4)

4. Early result: The Patent of a new "Apparatus for testing the water permeability of samples of facades of buildings"

The current regulations on the requirements to be met by the part of contemporary building envelopes, as well as the new housing needs and the expectations of comfort of the users, are not only related to the demand for energy efficiency or guarantees of durability, but to new ranges of performance to offer that concern technical systems increasingly oriented toward a logic of complex integration both from the point of view of both stratigraphic and plant. In this light, the role of test performance verification is strategic for all actors in the construction industry, manufacturing, commissioning, and utilities [6]. In particular, due to the complex characteristics deriving from the profound innovation that has "hit" the field of the building envelope, new Test mode protocols are required and, consequently new equipment that can offer a spectrum of investigation in line with the aspects tracked by innovation. This paper briefly describes the patent for the "Apparatus for testing the water permeability of samples of facades of buildings". The apparatus of the invention, is constituted by a frame, on one side of which a sample of the facade to be tested is fixed, and by a grid on which there are nozzles, which with the input of pressurized air, spray water on the mock-up facade. Obviously, the pressure value is defined on the basis of thresholds regulations and unified standards of performance, for the purposes of the certifications to be manufactured or experiments to be implemented. The apparatus is also equipped with a handling system of the grid, with a working position located in front of the mock-up to try, and with a rest position behind the frame on the opposite side to that on which the sample is located. The grid on which the nozzles are arranged, and the system for moving the grid, consists essentially of a transmission chain with meshes with rider support of the pipes in light alloy. The grid, on which the nozzles are arranged, flows over the frame elements and, therefore, is obliged by the handling system to be arranged at a predetermined distance from the sample to be tested.

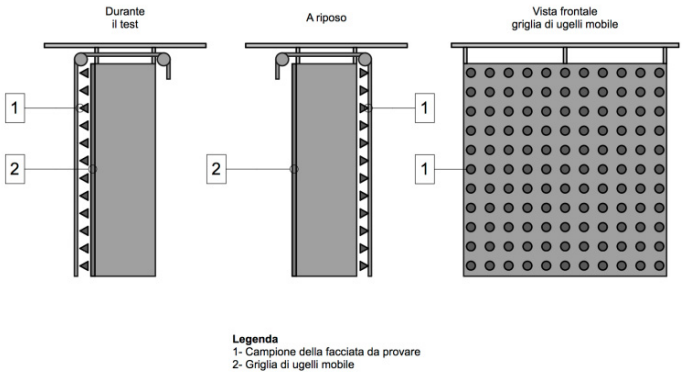
The nozzles are powered by light alloy pipes, arranged parallely to each other at predetermined distance in order to respect the rules governing the trials of tightness and the combined action of rain and wind. The pipes are connected on each side with a distribution column that has many branches, as there are tubes to be fed by means of connecting sleeves. In this way it is possible to use the equipment for different surfaces depending on whether you feed the two sides or only one or if one feeds a reduced number of tubes. The pipes are fed by a water system with pumping system that provides for the collection and recirculation of the water for carrying out the tests and its reuse for other test cycles; The water system includes a collection sump covered under the wall of the sample to test, a collection tank of the first rain of the square, and a drain towards a sedimentation tank and storage from which water is drawn to supply for testing. The apparatus of the present invention allows carrying out tests on samples of water permeability of facades without having to move the device on the wall to test. The sample of the facade, even if of a considerable size 10,00 x 20,00 meters (larger sizes are also possible), is easily installed on the frame; the said sample is located, in this equipment already positioned at the distance specified for the tests according to the standards required by the official European regulations or international adjustments, so further adjustments are not required. The tests are repeatable in times that are significantly shorter than those that occur using equipment currently available on the market. Furthermore, the technical solution does not pertain to the criteria of fixed test modules, but is made to be collected and positioned on the same test structure. The solution offers the possibility to make a greater number of tests, to make them more flexible through deferrable modularity, to ensure greater

variability to the test conditions, to offer enhanced possibilities for experiments because of their different nozzle configuration for water permeability tests.

The invention provides a semi-automatic solution of positioning of the nozzles on the front facade. Briefly, the nozzles are lowered from the top downwards through the system type "damper ". The technical solution pertains not to the criteria with fixed test modules, but is made to be collected and positioned on the same test structure. The invention offers the possibility to make a greater number of tests, to make them more flexible through deferrable modularity, to ensure greater variability to the test conditions, to offer enhanced possibilities for experiments because of their different nozzle configuration for testing water permeability. The grid with the nozzles, in rest conditions, is made to slide in the back of the frame, or in a location free of interference with other equipment and without increasing the space required for the admission of the test apparatus. In relation to the types of equipment included in the state of the art of these test procedures, the present invention allows numerous advantages and also allows to overcome difficulties that could not be won with systems currently present on the market.

5. Conclusion

The BFL is a candidate to become Accredited Certifier for the Energy Consumption and Environmental Sustainability and like a center for the testing of technological solutions, high-performance energy. SpinOff it will soon make available a catalog of innovative technology services thanks to patents that have been developed.



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