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Author: Martino Milardi, Mariateresa Mandaglio

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New Scenarios of Building Performance Control for Climate Change in Urban Areas

MARTINO MILARDI¹

Mediterranea University of Reggio Calabria

MARIATERESA MANDAGLIO²

Mediterranea University of Reggio Calabria

Abstract

In recent years the issue of climate change has become increasingly developed and widespread, bringing with it a greater awareness of the impacts it causes. This is based on the current emergency highlighted by numerous studies regarding the impacts of construction on climate change. It is well known that the construction sector requires the development of methodologies and tools to limit the impact of climate change on the urban system and mitigate the phenomena arising from the dynamics of the built environment at small and large scales.

The study of climate and its changes is, therefore, an emblematic example of the intellectual challenge posed by complex systems today and how technological innovation and experimentation are the ideal tools for grasping their behavior.

In particular, the effects of climate change are becoming more evident on buildings that face the greatest risks of damage from pluvial flooding, heat waves as well as frequent episodes of tornadoes and water bombs.

It therefore becomes essential to implement adaptation strategies to make cities and buildings more resilient by seizing the opportunity to increase their quality levels.

The current theoretical and design research activities concern the study of innovative and dynamic solutions to limit those phenomena that being macro stress the city but especially the buildings in a very intense form.

Through an adaptive design approach, the aim is to direct experimentation toward the realization of a dynamic building through the study of the new building-context relationship, that is, not the one resulting from the requirements-performance sequences, but the current ones of phenomenon-response and therefore, according to the fields of innovation concerning the new types of adaptive envelopes.

This approach is also to be related to the needs for measurable control, because of the flow exchanges between different environments such as, precisely, that which is determined between the building and its context that interdependently influences the microclimate of the urban space.

Keywords: *Adaptive Building Envelopes, Advanced Testing, Building react with Climate change, Performance Evaluation,*

Introduction

The current regulations on the set of requirements to be met, by contemporary building envelopes, as well as the new housing needs regarding users' expectations of comfort, seem to be no longer only related to the demand for energy efficiency or guarantees of durability, but to new performance fans to be offered, concerning technical systems increasingly aimed at integration logics. This complexity is to be related to the needs for "measurable" control, because of the flow exchanges between different environments such as, precisely, that which is determined between the building and its context through the envelope.

Therefore, it becomes essential to put in place adaptation strategies that must arise as a priority from the knowledge of the vulnerability and fragility of the territory and the environment, the first step for the enhancement of the resilience capacity of that given context; at the same time from the assessment of the potential risks generated by the modifications and criticalities of the system, which are indispensable for adaptation actions; from the identification of the priorities of interventions both at the urban and building levels, as well as of the territory, putting in place those the strategies consequent to the knowledge of the place and the assessment of the criticalities that characterize it.

Therefore, bringing the reasoning back to the built environment, the degree of vulnerability that characterizes it is further increased by the physical, functional and performance status determined by the different conformations of urban fabrics and the morphology of the settlement, the correlation between the building and the reference context as well as construction techniques, surface characteristics, the presence of vegetation and permeable soils (D'Ambrosio and Di Martino, 2016).

For the purposes of resilient behaviors at the building scale and considering how much external surfaces therefore affect the quality of the urban environment, research efforts are now moving toward curtain walls with adaptability characteristics such that they respond efficiently to the dynamic and complex context at the same time are can absorb the effects generated by it (Milardi, 2016).

Architecture is therefore no longer seen as a classic static system, in which forms fit together to produce buildings made alive exclusively by the people who use them, but, on the contrary, as a dynamic system that changes in response to its environment and the needs of its users, a living system: in essence, it is architecture itself that comes alive.

To adaptive urban design belongs the concept of the city as an urban ecosystem complex, metabolic, traversed by flows of energy, environmental resources and waste production. Within it, settlement patterns, buildings and open spaces play an important role through the related surfaces (envelopes, roofs, pavements and surface treatments) that act as an interface with the external environment (Pacteau, 2016) in continuous energy exchanges.

Background, Scientific Innovation

There is growing evidence that climate change requires substantial modification of building design approaches to make urban systems more resilient to climate change.

Evidence of climate change, particularly the stresses brought about by intense rainfall and high temperatures, implies the need to implement pathways of adaptation and reduction of possible risks, through policy measures of mitigation, adaptation and resilience.

The research has two main objectives. The first concerns orientation toward adaptive design to ongoing climate change; the second, the definition and development of guidelines that identify a protocol for analysis, assessment, and possible mitigation intervention. Adaptation highlights unavoidable effects in terms of changes in temperature, precipitation, desertification, salinization of soils, changes in mid-sea and biodiversity gradients. This results in the need for design techniques, standards and policies calibrated to different possible scenarios.

Climate policies at the local scale for a long time have focused predominantly on "protection" and mitigation, particularly by promoting the deployment of renewable energy sources for sustainable development and "climate protection."

These policies have brought, especially at the local level, often contradictory results and, above all, has limited the innovative action of climate proof policies to only voluntary instruments, in many cases promoted under community-funded initiatives and projects.

Specifically, therefore, it is intended to develop a protocol not only for the analysis and evaluation of the major environmental criticalities, but also to identify possible interventions and actions in order to draw up a document that is as operational as possible. A document, which is always being updated, that assumes the function of a tool capable of addressing the consequences of climate change and that contains possible concrete actions and can provide for possible forms of monitoring the results. From rising seas to warming temperatures to hurricanes and tornadoes, the impacts of climate change are getting worse and worse. Knowledge of climate extremes and their variations is of particular importance in defining adaptation strategies and assessing impacts on building envelopes understood as vulnerable elements to the stresses of climatic phenomena. This requires that the design of façades, especially for critical or sensitive environmental areas, be preceded by analyses aimed at understanding the environmental dynamics that influence the behavior of the envelopes and performance verifications through simulations and tests to assess the adequacy of their responses.

In this context, the Building Future Lab's TCLab Testing laboratory [Fig.1], set up at the Mediterranean University of Reggio Calabria, enables the analysis and verification of the 'real' performance of large-scale facades through American and European normed and experimental testing activities. Mandatory façade performance tests, such as air permeability, water tightness, and wind resistance, which are applied to

full-scale models of façades, allow obtaining preliminary information on system performance prior to the assembly process. A strength of the testing activities is thus to offer, to designers and engineers in the field, guarantees on the reliability and compliance of the data and results, with important spillovers to industrial research, where there is an extraordinary increase in innovation on the functionality and adaptive responses of the components.

In this regard, ongoing research is working on processes and technologies to control performance due to building-context interactions that influence the climate change vulnerability of urban space and its resilience. In addition, through the contribution as mentioned above of the Building Future Lab's TCLab Testing laboratory, appropriate tests will be developed for the experimentation of building solutions for energy-efficient and adaptive surfaces, verified in the design and prototyping phase; the laboratory will support the experimental capacity, methodological rigor, and tenor of the results that can be obtained, due to the possibility of verifying steps and intermediate results through measurements, testing, and regulatory verification.

Specifically, this research will define protocols to guide and control the architecture process in building-context relationship controls through the definition of batteries of indicators and parameters that can be measured through available technology. Protocols that will derive from laboratory experiments through specific tests derived from the observation of various phenomena arising from climate change.

Quantifiable performance indicators and effective strategies for the design and evaluation of optimal adaptive façade performance under climate change will then be identified. This is in order to understand what kind of transformations could be produced through knowledge and monitoring of the elements that make up the context and the relationships between them through precisely a panel of indicators.

Vision and Conclusion

The experimental content of the current research, strongly characterized by the operational possibilities of Building Future Lab's TCLab Testing laboratory, allows to test the level of adaptability to climate change of technological solutions and materials by performing simulations of bioclimatic and microclimatic conditions in urban environments and their related effects, which can be measured, certified and evaluated in terms of industrial spin-offs. The opportunity to carry out such a wide range of tests and simulations, in an environment consistent with UNI/EN, ASTM and AAMA standards, directs the technological spin-offs of research toward innovative, performance-tested and verified technical solutions.

Through instrumentation that reproduces on mock-ups of envelopes, extreme climatic stresses, it is possible to study not only the performance responses of the envelopes but also to measure the resilient characteristics of the envelopes. This, allows to a large extent to configure the various scenarios of building adaptivity by directing design decisions toward the

options most congruent with the different reference contexts and relationship. Therefore, experimental tests will be developed on different types of facades, opaque and transparent in order to identify the behavior of facades in extreme climatechange situations, specifically heat island, heat wave and pluvialflooding.

The procedure developed starts from the analysis of the reference urban layout type by recreating, in the laboratory, the boundary conditions of the building. The location of the laboratory, together with the machinery and equipment present will, in fact, allow the on-site reproduction of different types of layouts. The test chamber, in fact, is located externally giving the possibility to interact directly with the external climatic conditions and offering the opportunity to model them in relation to the required need.

In this light, the role of phenomenological detection tools and, above all, centers that carry out testing activities assume particular relevance. The operational approach based on measurement testing and performance evaluation in a simulated regime seems to be strategic for all actors in the building sector, designers, production, PA, client, enterprise, user, etc. In particular, precisely because of the complex characteristics resulting from the profound innovation that has affected the envelope field in recent years, unified testing protocols also require new modalities and equipment capable of offering investigation spectra in line with the aspects traced by innovation.

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Figure 1. Reading from left Test Lab



Figure 2. thermal Chamber, 15x12x4.5 m, or trying make-up with the AAMA 501.5-07



Figure 3. Fan capable of generating wind speeds equal to ~ 200 Km/h in accordance to the standard AAMA 501.1-05 “Standard Test Method For Water Penetration Of Windows, Curtain Walls And Doors Using Dynamic Pressure”, and all the other test with wind speed