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Façade retrofitting: from energy efficiency to climate change mitigation

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Abstract

Since climate changes are now evident, it is not only important to achieve high level of energy efficiency, but also to think about retrofit actions in order to mitigate the natural hazard impacts and to make buildings resilient. The paper focuses on climate change effects in summer and investigates how it is possible to reduce them through façade retrofitting solutions (external insulation, PCM, green wall, cool materials) in Mediterranean climate. The goal is to develop a set of climatic resilience indicators for opaque envelopes in order to consider resilience ability against climate change, both inside and outside of buildings.

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Keywords: Energy efficiency; energy refurbishment; sustainable energy development; resilience; climate change mitigation; green wall; cool materials

1. Introduction

The European Directive 31/2010 and its targets for 2020 has become effective through the enactment of national laws and regulations. However, they impose complex obligations for existing buildings towards NZEB and do not take into account other actual problems. It is not only important to achieve high level of energy efficiency, but also to think about retrofit actions in order to mitigate the impacts of natural hazard. This issue has been neglected for several years, especially in building sector, but these events are becoming more and more influential and frequent. For this reason, the idea of resilience in buildings is developing [1] and represents the measure of their ability to recover from or adapt to an unfavourable condition, event or change in building use [2]. Resilience is a complex challenge at any

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scale, including the scale of building systems. In other words, buildings have to be able to survive and maintain their own functionality [3] and performances even in an uncertain future. Moreover, environmental degradation is accelerated by climate changes and global warming and by increasing frequency and severity of the linked disruptive events. Buildings are highly responsible for the global and local climate change [4] but, at the same time, they have to withstand to these events in terms of performances and dynamic reaction.

As regards the study focuses on climate change effects in summer and on how it is possible to reduce them through façade system retrofit (in particular opaque envelope) in Mediterranean climate. Indeed, the facades play an important role in urban context because the surface area of facades overcome roof and, sometimes, street area for huge amounts of square meters. Moreover, each side of a building façade should perform for the environment that it faces: inside and outside [5]. Most of the facades in the existing building stock need retrofit, but current practices do not require enough attention in de-signing systems that adapt to changing external conditions. Therefore, it is desirable to predict the needs for future retrofit, satisfying principles of resilient design. In particular, facades have to mitigate increasing or decreasing temperatures in the future, even if it is obviously that this function has to be supported by the whole building - plant system. The influence of facades needs particular analysis both at building and pedestrian level.
The aim of the research is to create an assessment tool thanks to a set of climatic resilience indicators for different building facades in order to take into account resilience ability against climate change, both inside and outside of building. This new holistic approach integrates both the energy efficiency requirements of buildings and resilience to climate effects at urban and building level.

2. Method

Since facades are crucial elements to ensure energy efficiency and indoor comfort, but also to mitigate urban heat island phenomenon, it is studied a methodological approach that takes into account these two different dimensions and allows to analyse how the facade system can contribute to enhance resilience in both buildings and urban neighbourhood. In particular, the opaque building envelopes are studied considering different solutions also with dynamic behaviour to withstand and react to very hot temperatures.

Therefore, it is important to define a set of climatic resilience indicators in order to evaluate the degree of increase in resilience and to tackle the reciprocal interactions between existing buildings and urban climate. In fact, the interaction between buildings and the atmosphere is not limited to the wind field and shading: technological solutions and materials chosen for façade affect the radiative behaviour towards neighbourhood and the heat stored in walls or transferred between the inside of a building and the outside atmosphere. The characteristics of facades define also the external surface temperature of walls, which consecutively influences the external air temperature [6]. Moreover, the envelope behaviour in summer can increase or decrease the use of air-conditioning systems that affects energy consumption in buildings and urban pedestrian comfort.

The comparative analysis of different technological solutions concerns the assessment of summer resilience to climate change of buildings in relation to urban effects. In this field of study, it is identified the need: to reduce the inside and outside temperature in summer. Hence, in relation to this goal (criterion), an index about resilience to the increase in temperatures is defined through multi-indicators. Therefore, resilience indicators for opaque envelope are singled out. They can be divided into direct performance indicators and indirect ones. The direct indicators have a direct effect on neighbourhood microclimate; the indirect indicators have effect on reducing energy consumption and on the heat rejected by air conditioning system to external environment. The performance indicators with urban indirect effect are: Operative Temperature, Wall Heat Gains, Sensible Cooling. The performance indicator with urban direct effect is External Surface Temperature. These indicators are chosen in order to evaluate the dynamic behaviour of building in summer. The performance measure for each indicator (with the relative unit) is defined in relation to a base case that can be a traditional retrofit solution (Table 1).

The methodological approach is validated on a case study of residential building in an urban context of a Mediterranean city. Different retrofitting actions regarding building facades are applied: XPS, XPS+PCM, cool finishing layers, green wall. These solutions are chosen because they can be responsive to the disruption event linked to the hot peaks of temperature in summer. At the same time, they have to comply with the energy efficiency regulations: in fact, the energy improvement is a prerequisite for the comparative evaluation of retrofit solutions. The dynamic simulations are carried out through the software DesignBuilder/Energy Plus in the hottest period of the year.