20th-Century architectural heritage adaptation to present climate challenges: Interdisciplinary methods for a rational intervention

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Abstract
By the end of the 1990s in France, the first labels have been created to distinguish the singularity of 20th-century architecture. However, a large part of its building stock suffers from energy deficiencies, and most of them need major retrofitting to align with today's habitability standards. If current technologies offer a wide array of devices that meet performance demands, their implementation does not always comply with heritage protection goals. As part of a transdisciplinary research project, our team studies the acceptability and feasibility of the renovation of various buildings of the 20th-century, using "the ventilated double-skin". The goal is to set renovation protocols that incorporate architectural and cultural evaluation in the technical analysis of energy and comfort needs. In this paper, we present our methodology and first results and aim to highlight the importance of complementary approaches to help inform sustainable interventions on this unique heritage.

Keywords
Modern architecture, Heritage protection, Energy transition, Renovation, Transdisciplinary research.

Introduction

Since the end of the 1990s, 20th-century architecture has been benefiting from a growing interest, and rightly so. Even though it does not always conform to the monumental and classical forms of architectural heritage in the collective imagination, it is nevertheless a monument of the industrialization of our contemporary society and transformation of our ways of living.

Twentieth-century architecture was conceived as a revolutionary gesture to challenge the established order, testing the limits of a new technicity offered by new construction methods and industrialized materials (steel, concrete, glass, etc.)[1]. In France, the creation of the "20th-Century Heritage" label, and more recently that of "Remarkable Contemporary Architecture", was a way for public authorities to recognize the singularity of this architecture by highlighting the innovation of buildings and architectural ensembles that are less than a hundred years old.

Fig. 1 Brive-la-Gaillarde Hospital, built in 1977 (left picture), and renovated by Vincent Espagno (Espagno Milani Architects) in 2014 (right picture), using a ventilated double-skin facade.Credits: Espagno Milani / Sylvain Mille

Even though new techniques "provided modern architects with unprecedented expressive and distributive opportunities", they did not necessarily guarantee "equivalent capacity of resistance and reliability over time"[2]. Most of the building construction of the era relied on mass production for time and cost optimization, which resulted in a built heritage that was ill-suited for the current climate evolutions and comfort standards. In addition, "the proximity in time of the twentieth-century architecture and the heterogeneous and prolific character of its production make its precise understanding, and thus its recognition as heritage as well as its preservation, complex"[3].

Today, the late recognition of this architecture presents a double challenge: on the one hand, its preservation as a civilizational heritage, and on the other, its adaptation to the needs of energy transitions. The current technological advances may offer technically powerful devices to overcome the deficiencies of comfort but their implementation does not always guarantee the respect of the protection goals. It is within this framework that our research project in the Nouvelle Aquitaine region was born, led by the GRECCAU and PAVE research labs of the National School of Architecture and Landscape of Bordeaux, as well as the Institute of Mechanics and Engineering of the University of Bordeaux. These academic groups have joined forces with actors from the industry (COVERIS) and innovation (NOBATEK INEF4) to investigate the acceptability and feasibility of the energy retrofitting of a group of remarkable and/or labeled buildings, using as a case study the integration of the "ventilated double-skin façade" (DSF) (Fig.1). This technological device has diverse forms of application on existing buildings, going from their encasing under glass to the radical transformation of their vocabulary and architectonics, depending on the goal of the intervention. The aim of our study is to develop a methodology to inform decision-making in the renovation of 20th-century architectural heritage through this device. Beyond the objectives of energy transition, the idea is to also investigate qualitative architectural, constructive, cultural, and

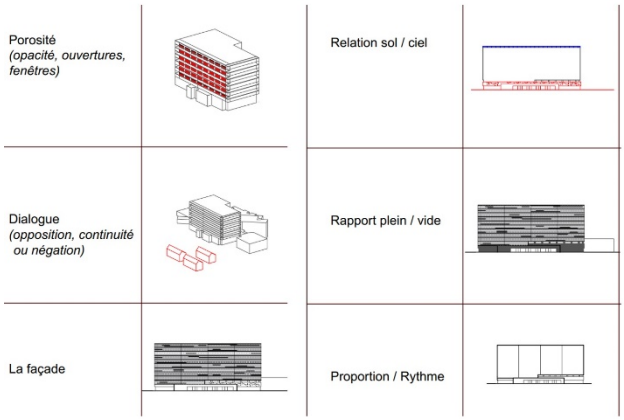

Fig. 2 An analytical chart of the relationship between the ventilated double-skin and the renovated building. Among the many chosen parameters for comparison: facade porosity, rhythm, proportions, ground/sky relationship, openings ratio, and more. Credits: PAVE research lab, 2022

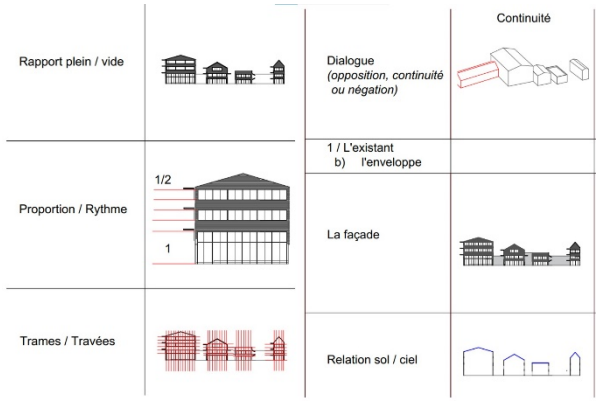

Fig. 3 An analytical chart of a panel of labeled Remarkable Contemporary Architecture buildings in France, to identify the feasability of their energy retrofitting using a ventilated double-skin facade. Credits: PAVE research lab, 2022

symbolic attributes. In this contribution, we review the methodological aspect of our research and highlight the complementarity of prospective and retrospective approaches for an innovative, sustainable, and reasoned intervention on this heritage.

Renovation and conservation with the ventilated double-skin

The ventilated double-skin façade is commonly called a "bioclimatic facade" for its energy performance attributes. It is a thickening of the building envelope that aims to improve the thermal insulation of the building using a passive system. The idea is to create a layer of air that generates a greenhouse effect in winter to warm the building, and a chimney effect in summer to ventilate and refresh the building naturally. Although the device is fundamentally technical, it is capable of adopting different architectural styles both for new buildings and as an addition to existing ones.

Methodological approaches to study the feasibility and acceptability of 20th-century architecture retrofitting by ventilated double-skin

The study is structured around the feasibility and acceptability of the integration of such a the ventilated double-skin through a variety of methods. On the one hand, we elaborated a multiscalar literature review of renovation projects using this device to identify in which types of building, program or environment it was applied, and to evaluate its real contribution in energy performance and relationship with the existing building. An architectural analysis was conducted to examine the physical characteristics of the building both before and after the addition of the double-skin (Fig.2). It is an analytical an purely architectural approach, ranging from the details of the building's envelope and structure, to its uses and integration into the urban environment.

At the same time, we are carrying out a similar architectural analysis of a panel of 20th-century buildings in Nouvelle-Aquitaine, which belong either to the mainstream production or are recognized for their "Remarkable Contemporary Architecture" (Fig.3). The goal is to evaluate the feasibility of their renovation with a ventilated double-skin. Through this prospective study, the idea is to identify remarkable typo-morphologies, compositions, and architectonics, which may or may not be suitable for the integration of the device, for technical, cultural, or spatial reasons. This work in progress should lead to recommendations that would complete the technical performance studies with a qualitative architectural understanding of that heritage.

Finally, based on a selection of case studies of ventilated double-skinned renovations in the Nouvelle-Aquitaine region, the aim is to understand in greater depth the discourse of the actors surrounding such interventions, by documenting them through in-depth interviews and project monographs. We review the arguments mobilized by the project owner, the architect, the project manager, the design offices, and the companies regarding the use of this device. These accounts retrace the genesis of the renovation project, the motivations behind the choice of the DSF, the type of analysis carried out beforehand, the desired dialogue with the existing building, and the difficulties faced during the process. Additional insights are gathered from the Advisor for Architecture of the DRAC Nouvelle-Aquitaine (Regional Office of Cultural Affairs). This external perspective helps to understand the renovation by technological devices within the global strategies of intervention on this architectural heritage. Interviews are planned in a later phase with the users of the renovated buildings in order to cross-reference the project's will with the inhabitants' experience in the broad sense.

"*Une mise sous cloche*"[4]: the case of the Peixotto Campus of the University of Bordeaux

In order to demonstrate the discourses of actors involved in such retrofitting projects using a DSF, we choose the case of the renovation of the Faculty of Sciences of the University of Bordeaux.

An iconic architecture

This faculty was designed under the direction of René Coulon in the early 1950s and was completed in 1963. According to the architectural historian Franck Delorme[5], Coulon wanted a new academic centrality, using rationalist architecture, which manifest as much through the rhythms and proportions of the facade as through the linear organization of the buildings around a large green belt running the length of the estate.

The large scale of the project did not prevent Coulon from paying particular attention to the meticulous design of the envelope. The main facades are emphasized by a central motif and symmetrically punctuated by overhangs and regular openings that accentuate their horizontal lines. The stairwells are highlighted by concrete screens that follow the gable and subtly reveal the corner design. Finally, the austerity of the orthogonal lines is softened by the pinkish color of the bushhammered concrete and the crushed gravel-washed concrete panels.

A ventilated double-skin to improve comfort and "conserve the identity" of the renovated buildings

The buildings of the campus have been progressively challenged by the changing climatic conditions of our time, to the point where they have become unable to ensure the comfort of their users or reasonable energy consumption, which led to the renovation project. According to the representatives of the University of Bordeaux, as the project owners, they have displayed a strong ambition to be part of sustainable development in all its components from the beginning, with the need to obtain from the competing design teams serious commitments on the

Fig. 4 One of the buildings of the Faculty of Sciences of the University of Bordeaux after it was renovated from 2012 to 2016 by the design team : Bouygues (construction company), AUA Paul Chemetov (lead architect), Martin Duplantier Architectes & Ronald Sirio (architects), Franck Boutté Consultants (engineering consultants / design office). Credits: AUA Paul Chemetov.

future energy consumption. A "global public performance contract" was launched, and among the five proposed renovation projects, the one led by Bouygues (constructer), Paul Chemetov (lead architect), and Franck Boutté Consultants (engineering consultants) was selected (Fig.4).

If the renovation by ventilated double-skin was not included in the University's needs, the device was nevertheless the only one to promise unprecedented energy performances and the preservation of the architectural identity of the campus. Both the engineering consultants and the architects initiated the idea to design a "transparent box" for the buildings. The see-through double skin was then "enhanced" by the technical contribution of the engineers who sought to use it as a powerful "thermal machine". The other competing design teams only proposed outer insulation which threatened to completely erase the character of the existing buildings.

The decision to renovate with a ventilated double skin was unanimous. Beyond the goal of protection and the promise of energy performance, the installation of the DSF could be done in an occupied site, which partially compensated for the high cost of such a device. While, according to the client, the ventilated double skin meets the need to preserve the campus while modernizing it, it did not quite live up to the promised performance. The technology had not been sufficiently tested on renovation projects, and numerous technical failures revealed that the system did not perform much better than exterior insulation while costing more. However, it remained the most adequate option, as it balanced the energy transition goals with those of heritage conservation.

A technical solution rather than an architectural one?

When asked as a specialist in "Remarkable Contemporary Architecture" label, the advisor for architecture of the

DRAC Nouvelle-Aquitaine expressed a more mixed opinion about the argument of "transparency" which would imply erasure of the device for the sublimation of the existing building. For her, the renovation by ventilated double skin changed the original design with a solution that was more technical than architectural. She added that the architectural stance of the renovation project should be "owned" more as "*l'oeuvre sur l'oeuvre*"[6] than as immaculate conservation.

However, the ventilated double-skin has the added advantage of being reversible, which allows the technology to be tested in the long term, and the existing architecture not to suffer from the possible technological obsolescence of the device.

Conclusion

This ongoing study of the acceptability and feasibility of the 20th-century architecture renovation has the ambition to reveal the subtleties of a qualitative approach to this heritage, which should unconditionally support the technical solutions of energy retrofitting. Finally, the analysis of the discourse of the renovation projects' protagonists around the renovation by "innovative" devices put forward both the willingness to preserve this underrated heritage while upgrading its habitability, as well as the balance that remains to be achieved to reach an optimal dialogue between the existing buildings and the much-needed comfort and energy consumption upgrades.

[1] Fanelli, G., & Gargiani, R. (2008). *Histoire de l'architecture moderne : Structure et revêtement*. PPUR presses polytechniques.

[2] Giuliani, M. V., & Bucchignani, V. (2000). Preservation through change : Renovating modern architecture. *Journal of Architectural and Planning Research*, 17.

[3] Masse, S. (2022). Du patrimoine du xxe siècle à l'architecture contemporaine remarquable. *In Situ. Revue des patrimoines*, *47*, Article 47. https://doi.org/10.4000/insitu.34765

[4] A French expression for « putting under a bell », meaning protecting an artefact by keeping it safe and intact.

[5] Delorme, F. (2011). Faculté des sciences de Bordeaux, René-André Coulon architecte. *In Situ. Revue des patrimoines*, *17*, Article 17. https://doi.org/10.4000/insitu.932

[6] Literally meaning "a work of art over another work of art".