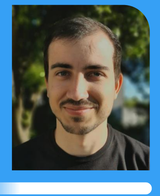
The Habitable Envelope: A Paradigm Shift in Building Renovation



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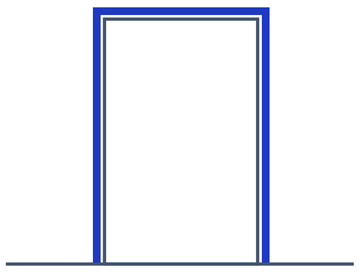
PRESENT

Currently, with the climate emergency and in accordance with the Sustainable Development Goals for 20230, it is necessary to reduce CO2 emissions and make buildings more sustainable and energy efficient. Studies show that to reduce the energy consumption of buildings, it is necessary to act mainly in their envelope, where energy losses are more significant.

Current Practice
ETICS System

In Portugal, the current strategy to reduce energy consumption consists of the replacement of existing window frames (high-performing windows) and the application of the External Thermal Insulation Composite System (ETICS). Although this system improves the energy efficiency of buildings and is relatively easy to implement, it only intervenes in the “skin” of the building, not addressing other potential existing problems.



ENERGY EFFICIENCY ✓ STRUCTURAL STABILITY ✗ ARCHITECTURAL RENOVATION ✗

Housing stock

The majority of the Portuguese building stock was constructed after the 70s. These constructions, often clustered in degraded urban suburbs, present more anomalies and lower construction quality due to the lack of legislation and technical knowledge. Moreover, these buildings are characterized by extremely high operating energy and living discomfort, and with high seismic vulnerability.

Methodology

Using all the information collected in contrast with the onsite assessment – information from residents, drawings, and photography – it was possible to gather information about the constructive system, the function and uses of the buildings, and the quality of life of the residents. This information will provide us with an overview of the building's characteristics, enabling us to propose suitable solutions for the future.

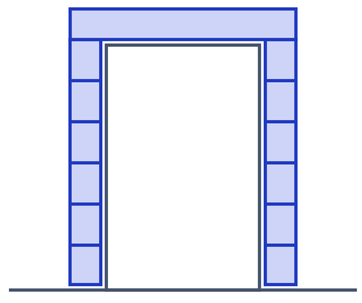
		BUILDINGS						
		A	B	C	D	E	F	G
CONSTRUCTIVE SYSTEM	CONSTRUCTION YEAR	1983	1998	1979	1988	1988	[1968]	2004
	NUMBER OF FLOORS	4	4	4 ; 11	4	2	3	2
	GRID LATERAL SPAN [m]	4.90 2.30 – 6.10	2.70 – 3.90	2.30 – 5.00 1.30 – 2.80	2.40	5.20		2.25 – 2.70
	GRID TRANSVERSAL SPAN [m]	4.85 – 6.25	3.20 – 4.30	1.00 – 4.80 1.30 – 4.20	2.80	3.10 – 3.80		5.20 – 5.95
	STRUCTURE	Solid RC slabs and walls	RC columns and beams	RC columns and beams	RC columns and beams	RC columns and beams	RC columns and beams	RC columns and beams
	EXTERIOR WALLS	Concrete blocks	Double brick masonry	Double brick masonry	Double brick masonry	Double brick masonry	Resistant brick masonry	Double brick masonry
QUALITY OF LIFE	THERMAL INSULATION	------	EPS (3cm)	------	------	------	ETICS System (only in 2 façades)	Roofmate (4cm)
	HOUSING CONDITIONS	Insalubrity Insecurity	Insecurity Lack of hygiene	Living discomfort	Living discomfort	Living discomfort	Insalubrity Insecurity	Insalubrity Insecurity
FUNCTION AND USES	ACCESS SYSTEM	Outdoor galleries	Central	Central	Central	Direct	Central	Direct
	DISTRIBUTION	Linear	Left-Right	Concentric	Left-Right	Direct	Left-Right	Direct
	GROUND FLOOR	Housing	Housing	Commercial areas	Garage	Garage	Housing	Housing
	ROOF	Not accessible	Not accessible	Not accessible	Not accessible	Not accessible	Not accessible	Not accessible
	PRIVATE AREAS (average per dwelling)	10.40 m2	10.87 m2	10.13 m2 10.22 m2	9.19 m2	11.40 m2	8.61 m2	10.16 m2
	SOCIAL AREAS (average per dwelling)	14.24 m2	19.12 m2	21.36 m2 23.35 m2	15.68 m2	19.19 m2	14.85 m2	21.12 m2

FUTURE

The development of a prefabricated wood-based system emerges as an innovative proposal to optimize the rehabilitation of reinforced concrete buildings, contributing to a more resilient and eco-friendlier built environment. Through this research, we believe it is possible to drive significant change in the construction industry in Portugal, offering a promising future for the retrofitting of buildings.

Proposed System
Habitable Envelope

The Habitable Envelope consists of a wooden exoskeleton attached to the exterior of the existing building. The main goal of this system is to create a new exterior envelope that improves energy efficiency and structural safety, while incorporating new spaces and uses into the interior of the dwellings. Moreover, it is possible to renovate the architectural image of the building in a low disruptive manner, as this intervention is carried out from the exterior.



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PROBLEM	PEOPLE'S NEEDS	SOLUTION
SARS-CoV-2 pandemic	Flexible and new programmatic areas — Teleworking, Video conferencing, Outdoor spaces	Exoskeleton
Buildings with poor quality of construction	Quality of life and well-being — Thermal and acoustic comfort, Indoor air quality	Habitable envelope
Environmental problems	Sustainability — Natural, renewable and ecological materials	Wood

OVERVIEW	OUTCOMES	
BUILDINGS CHARACTERISTICS	RENOVATION PRIORITIES	
- Buildings do not meet current needs (thermal, constructive and seismic) - Different number of floors (significant variation) - RC structure (columns and beams) - Exterior walls in double brick masonry	- System suitable for different seismic zones - Structural solution suitable for buildings with different numbers of floors (2 – 11) - Structure appropriate for the grid span of existing buildings - Possibility to remove infill walls	STRUCTURE
- Lack/absence of thermal insulation - Buildings with issues of insalubrity, insecurity, and living discomfort	- Appropriate thermal and acoustic insulation - Façade suitable for the urban and geographical context	LAYERS
- Shared accesses with other residents - Ground floor used for housing or garage - Gable roofs, not accessible, and with no usage - Minimal areas and rigid spaces	- Enhance community life (vegetation/common spaces) - Address/mitigate the issue of privacy intrusion (ground floor) - Explore the roof to create new common spaces/housing/ventilation and lightning - Greater flexibility of housing (teleworking/winter garden/outdoor spaces) - Maximize solar exposure and natural ventilation	SPACES

TASK 1
Assessment of the RC building stock and Literature Review

TASK 2
Constructive and architectural potential of the envelope

TASK 3
Prototype: experimentation, construction and testing

TASK 4
Parameterization of the proposed systems using BIM

Conclusions

In Portugal, it is still very common to consider building renovation solely as a solution for energy efficiency. However, it is crucial to seize the opportunity to intervene in a building not only to reduce energy consumption but also to enhance structural safety and provide new flexible spaces suitable for the living conditions of residents.

Future Work

The next tasks involve developing a wood-based prefabricated system that responds to the needs of buildings (constructive performance) and the needs of people (functional and spatial performances). In this regard, identifying and characterizing the Portuguese building stock is essential to propose adequate construction and spatial solutions.

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