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Retrofit of Residential Buildings in Europe

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Abstract: Recently, many cities in Europe are encouraging the recovery of the existing residential heritage. To maximize the benefits of these campaigns, a multi-purpose campaign of architectural, functional, and structural retrofit is essential. Additionally, a fast-changing society requires new living criteria; new models need to be developed to respond to the developing requirements of communities and markets. This paper proposes a method of analysis for 49 residential retrofit projects, a range of "best practices" presented through the definition of strategies, and actions and thematic packages, aiming at reassuming, in a systematic way, the complex panorama of the state of the art in Europe. Each project was analyzed using a data sheet, while synoptic views and tables provided key interpretations and a panorama of strategies and approaches. The analysis of the state of the art showed that lightweight interventions achieved using dry stratified construction technologies of structure/cladding/finishing are a widespread approach to renovation and requalification both for superficial/two-dimensional actions and volumetric/spatial actions. The study also highlights the leading role of the envelope within retrofit interventions. The retrofit approaches appear to reach the greatest efficiency when reversible, because only in this way do they ensure environmentally friendly actions with the possibility of dismantling. The intervention should improve the flexibility of the existing construction with a correct balance between planning for the present and planning for the future.

Keywords: social housing; building retrofit; building renovation; residential heritage; integrated retrofit; building envelope

1. Introduction

Interventions on built heritage are today necessary to upgrade the housing estate to current living and technological standards, due to the emergence of new social and cultural realities.

Along with the necessity to respond to the new housing demand—with different users, different uses, and different living styles—many cities in Europe are trying to promote urban policies against land consumption, encouraging the recovery of the existing heritage [1].

The first country to act in this direction was France, with upgrades of the performances and quality standards and promotion of maintenance programs, with the final objective to enhance the image of buildings and neighbourhoods.

Although research suggests that there are a number of "sustainable urban forms" [2] in Europe, the debate resulted in the promotion of the "compact city" model, a high-density mixed-use city with clear boundaries [2,3] and a good infrastructural system. To date, the model appears to be efficient in terms of transportation, at the same time promoting a sustainable use of land, containing urban sprawl [4] and preserving the areas in the countryside, while recycling the areas in the center [5]. Compactness and mixed use are also associated with diversity, social cohesion, and cultural development, while population density is able to support local services and businesses while granting a balanced exploitation of the infrastructural systems [6,7].

Some authors [8] evaluated the possibility to "manage the quality" of a building, introducing eight factors, namely performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality. Despite the relevance of each of these factors in defining the quality or the lack of quality of a building, rarely is the decision to intervene motivated by a single reason, being usually affected by interlaced necessities.

Indeed, the objective of a retrofit process should be a comprehensive and ideally endless extension of the lifespan of a building, through modifications of its physical, functional, architectural, and ecological characteristics [9–11].

There is more than one possible solution to intervene, and different procedures provide completely different results [12]. The selection of the most suitable strategy depends on several factors, such as the structural typology and technology of the buildings, its historical and functional importance, and the socio-economic issues connected with the presence of serious damages and obsolescence. Typically, the ratio between the costs and the final performance is determinant for the definition of the appropriate retrofit program.

Synergetic operations should improve the overall characteristics of the buildings, while reducing the ancillary construction expenses. Additionally, to maximize the benefits, a multi-purpose campaign of architectural, functional, and structural retrofit is essential. The hypothesis is that substantial and durable improvements can be achieved only considering the complex dimension of the problem, suggesting integrated and holistic interventions.

However, despite the many retrofit projects recently developed by European countries, only a few studies are directed toward fully integrated interventions. This is reflected in the research material currently available in the field of residential retrofit, which, although extensive, often considers only partial aspects related to building retrofit [13].This paper wants to fill this gap by proposing a method of analysis able to illustrate and summarize the different aspects involved within a retrofit project. For this purpose, 49 residential retrofit projects are presented, along with a range of "best practices" able to illustrate the complex panorama of the state of the art in Europe. The projects were analyzed by means of six thematic packages (later in the paper defined as fields), which aimed at summarizing the complex set of interventions and choices involved in a fully integrated retrofit. The thematic packages were construction, architecture, society, technology, function, and structure. The packages are further described and defined in Section 2.

Each "best practice" was analyzed and evaluated using a data sheet, while synoptic views and tables provide key interpretations and a panorama of strategies and approaches. Again, the method proposed is trackable in the literature [13], but mainly for single thematic packages.

The study finally highlights the leading role of the envelope within retrofit interventions.

2. Materials and Methods

2.1. Sample Size

The interpretation of the state of the art in the field of residential renovation started from the analysis of 49 European projects realized in the last two decades. The analysis took into account residential buildings retrofits, considering different typologies of housing and target users; few cases showed a substantial change of use, and this often corresponded to building reuse (Table 1; Figure 1). The sample size was influenced by the lack of available or reliable data, which limited the scope of the analysis.

Table 1. Index of the data sheets related to the best practices.

Typology	Data Sheet	Project	Country	Year
Isolated	1	Aichinger house, Hertl Architects	Austria	2010
	2	Dovecote Studio, Haworth Tompkins	Great Britain	2009
	3	Gründerzeithaus M30, Peter Zinganel	Austria	2008
	4	House in Morchiuso, Castelletti & Viganò	Italy	2011
	5	House in a house, Fischer Naumann Partnerschaft	Germany	2005
	6	La ruina habitada, Jesùs Castillo Oli	Spain	2006
	7	Maison Saignelegier, Dubail & Begert	Switzerland	2013
	8	Studio Posehuset, Svendborg architects	Denmark	2010
	9	The White house, WT architecture	Great Britain	2010
	10	Villa Rotterdam, Ooze	Netherlands	2010
Terraced	11	Black Pearl House, Studio Rolf & Zecc	Netherlands	2010
	12	Casa do Conto, Pedra Liquida	Portugal	2011
	13	Didden Village, MVRDV	Netherlands	2006
	14	Heliotrope over elevation, Bang architects	France	2010
	15	Lude House, Grupo Aranea	Spain	2011
	16	M03 house renovation, BAST architects	France	2013
	17	Neo Leo, Luderwaldt	Germany	2006
	18	Over elevation in Rue Daumer, Le Bihan	France	2010
	19	Over elevation in Rue Delbet, Le Bihan	France	2006
	20	Passive renovation De Kroeven 505, Aramis	Netherlands	2011
	21	Peugeot blocks, Lucien Kroll	France	1995
	22	Symbiont, FloSundK	Germany	2004
	23	St. Johanns-Platz 25, 4056, Wenger	Switzerland	2003
	24	Tayson House, Kraus & Schoenberg	Great Britain	2008
Row	25	Bondy Loggias, Laurent Pillaud	France	2009
	26	Falconer Rehabilitation, Atelier Jens Freiberg	France	2009
	27	Fordsiedlung der LEG, GBR arkitekten	Germany	2010
	28	La Golette, Atlante SA	Switzerland	2011
	29	Leeuw van Vlaanderen, Heren 5	Netherlands	2005
	30	Minimum impact house, Julien De Smedt Architects	Germany	2008
	31	Republic housing complex, Castro & Denissof	France	2003
	32	Rue Daubin 26-27-29, Group 8	Switzerland	2011
	33	Square Vitruve, Atelier Du Pont	France	2013
	34	Stadthaus Dreiheiligen, Daniel Fuegenshuh	Austria	2007
	35	Surefit, Ipostudio	Italy	2008
	36	Treehouse Bebelalle, Blauraum	Germany	2010
	37	UFO, Florian Danner	Germany	2009
	38	Zwinglistrasse 9 and 15, Viriden + Partner	Switzerland	2003
Tower	39	Fahle House, KOKO architects	Estonia	2007
	40	La Chesnaie, Lacaton & Vassal	France	2014
	41	Le Bois le Prêtre, Druot, Lacaton & Vassal	France	2011
	42	Over elevation, Studio Albori	Italy	2007
	43	Torenflat, Frowijn de Roos	Netherlands	2010
Patio	44	Hellwagstraße 6-8, Lutter Heinz	Austria	2003
	45	Park Hill, Hawkins-Brown & Egret West	Great Britain	2011
	46	Spitalgasse 25, Wien 9, Lutter Heinz	Austria	2003
	47	Veilige Veste, KAW architects	Netherlands	2012
Gallery	48	Wijnand Nuijenstraat, van den Brink en Tupker	Netherlands	2007
Mixed	49	Dillenburgh, Heren 5	Netherlands	2010

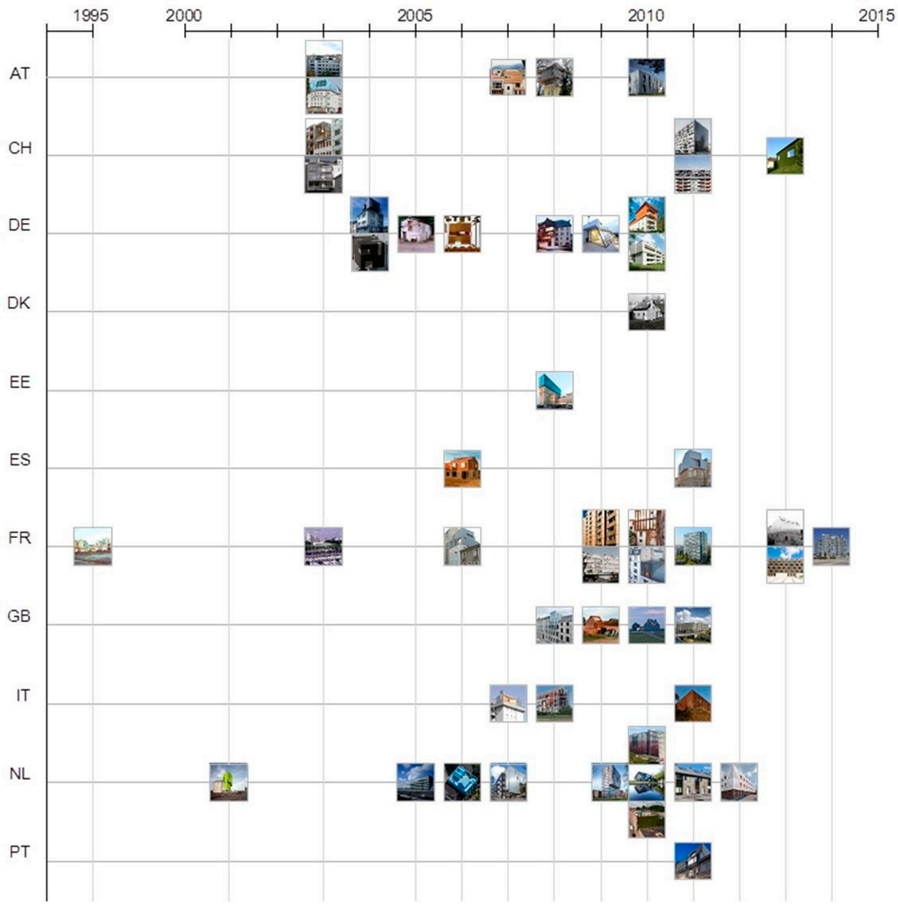

Figure 1. Locations and periods of the selected best practices.

The sample size was also dictated by the research design; the buildings selected provided a various range of options in terms of geographical distribution, year of intervention, and type of intervention. The study could be further expanded with the inclusion of other case studies; however, at this stage, the sample size already allows observing significant relationships and correlations.

2.2. Data Collection

Each project is presented through a data sheet (Figure 2) showing the main characteristics of the building, the design concept, and the consequent results. The data sheets were used to draft synoptic tables and analysis diagrams.

Each building is presented with a set of images of the post-intervention configuration, as well as general information, such as the location, the architects, the client, etc. The data were collected from literature using a desk research qualitative approach.

The data sheets were organized in relation to housing typologies; within this research, the housing typologies detected were: isolated house, terraced house, row house, tower house, patio house, gallery house, and mixed.

Another important descriptive factor was the "action" used, including superficial/two-dimensional actions, aiming at determining better environmental conditions through the application of additional layers to the envelope, or volumetric/spatial actions, intended as high-level three-dimensional transformations.


DATA SHEET N. 13

Action: volumetric/spatial

Contrast

A “village” over the roof of a traditional row house.

General data:

Project: Didden Village
Site: Rotterdam, Netherlands
Architect: MVRDV
Client: Didden’s family
Construction: end of the XIX century
Renovation: 2006
Typology: terraced house
Target: single family

Data collection:

The project explores the idea of rooftop densification realizing the expansion of the Didden family’s house and atelier, a traditional row house of dark brick (ARC.1, ARC.2, ARC.3). In a dense urban context, the vertical dimension is the only possible direction of development and the large rectilinear roof surface of the existing house is the only place to create new usable surface (ARC.3, SOC.2, SOC.3).
The project of addition looks like a plastic model over the roof of the building, an architectural prototype showing the new design concept at the same time adding a novel character to the skyline of the city (ARC.1, ARC.2).
Bedrooms are organized in separate volumes, miniaturized houses surrounded by streets, squares, trees and shared facilities creating an overhead village, mimicking the same logics of an urban settlement (SOC.3, FUN.2).
A clear parapet encloses the intervention and presents windows, which frame views of the landscape at the same time granting the privacy of the family (ARC.2, SOC.3).
All the elements are shaped as elementary geometries, so the staircases are cylinders that pierce the older roof floor to connect the new volumes with the existing kitchen and living room (ARC.3, FUN.3).
Prefabricated beams bear a concrete structure (STR.1) with an outer coating in sky-blue polyurethane (ARC.3, TEC.1), which covers and uniforms every elements of the new addition granting a complete and durable waterproofing effect and long lasting colour effect (TEC.1, TEC.2, TEC.3, CON.1).
Warm colours, such as red and brown, are used in indoor spaces where prefabricated birch plywood panels covers the vertical surfaces (ARC.3, TEC.1, TEC.2, TEC.3, CON.1).
Prefabrication process, both for structural elements and finishing, allows to maintain minimal costs and anyway lower than using traditional systems or of the equivalent ground price for a building (CON.1, CON.2, CON.3).

Summary:
STR.0) Structure > Medium strategy
ARC.0) Architecture > Heavy strategy
SOC.0) Society > Light strategy
FUN.0) Function > Light strategy
TEC.0) Technique > Heavy strategy
CON.0) Construction > Medium strategy

Material palette:

Prefabricated concrete with sky-blue waterproof polyurethane coating
Red painting
Prefabricated birch plywood panels
Vegetation

Figure 2. Example of data sheet.

2.3. Data Analysis

The data sheet also shows the “strategy” (Figure 3) of renovation individuated from a range of ten different possible approaches [14].

The ten strategies, and the relative symbols, are explained below, and they were deduced from a literature review and from the author’s analysis.

- Absorption: the intervention completely covers and absorbs the existing building or the new part is contained within the volume of the existing building.
- Continuity: the intervention presents no sharp rift with the language of the existing building in terms of shape, dimensions, or architectural features.
- Contrast: the intervention presents marked differences from the existing building in terms of shape, dimensions, and technological or architectural features.
- Filling: the intervention fills a gap between two or more buildings or between different parts of the same building.
- Integration: the intervention and the existing building collaborate and integrate to shape a new overall image and perception of construction.
- Parasite: the intervention forces the creation of temporary or permanent relationships with the host building in order to be completed.
- Rebalancing: the intervention acts as a counterbalance for the existing building, creating an overall equilibrium in the new perception.
- Remodeling: the intervention operates a substantial modification on the original building that results in drastic transformation.
- Selection: the intervention works through punctual and specified action to upgrade the features of the existing building.
- Stratification: the intervention acts as an additive layer, with different possible depths, modifying the original architectural features and performances of the existing building.

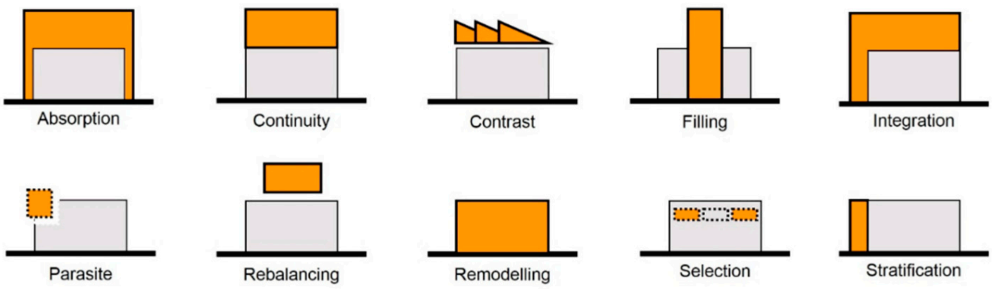

Figure 3. Strategies of interventions on residential heritage.

The second section of the data sheet summarizes the main findings concerning the design concept, the construction process, and the final results of the renovation project.

Within the text, each record is classified using codes related to six different fields: structure, architecture, society, function, technique, and construction. Each of these fields is further divided into three sub-fields (Table 2). The codes refer both to the existing building and to the results after intervention.

Table 2. Definition of codes and sub-codes.

Codes	Explanation
STR.0)	**Structure**
STR.1)	It describes the structural characteristics of the existing building and its extension; it comprehends the materials used, the structural scheme, and the static and dynamic properties of the construction.
STR.2)	It indicates every reference to the structural capacities of the building before and after the intervention or to the external constraints or structural threats, such as seismic or geotechnical constraints.
STR.3)	It represents the condition of obsolescence, the structural deficiencies, and the retrofit actions applied on the existing construction, in connection or not with the renovation intervention.
ARC.0)	**Architecture**
ARC.1)	It indicates all the details connected to the historical, environmental, architectural, and urban background of the existing building.
ARC.2)	It is connected with the recognizability and attractiveness of the area or of the existing building, considering also the perception and the visual relationships with the surrounding environment.
ARC.3)	It refers to all the design choices concerning the intervention of renovation of the residential building, which influence the architectural features of the building and, in general, its perception.
SOC.0)	**Society**
SOC.1)	It indicates the enhancements obtained, voluntarily or not, with the application of the intervention, also considering factors such as the social cohesion and security.
SOC.2)	It is used for every reference to the introduction of new supplies for the target users; it is also connected to the themes of densification and participation.
SOC.3)	It expresses the level achieved after the intervention of renovation in relation to the social sustainability and livability of the area.
FUN.0)	**Function**
FUN.1)	It indicates the provision of new services and facilities for a wider group of users, the new functional quality of dwellings, and their availability for a wider target of users.
FUN.2)	It individuates situation of mixed use, connected both to residential function and to other relevant functions, such as education, business, healthcare, etc.
FUN.3)	It indicates the improvement of connections and accessibility contributing to improving the attractiveness of a wider target of residents.
TEC.0)	**Technique**
TEC.1)	It is used in relation to the data connected with the use and choice of materials and technologies.
TEC.2)	It is related to the improvement in the energy performance of the building, to the use of natural energy resources, and new technical and technological equipment.
TEC.3)	It is related to the life-cycle assessment of the building, including the degradation, the aging, and the maintenance plans.
CON.0)	**Construction**
CON.1)	It is used to indicate the construction process and approach adopted in relation to the context of the existing building.
CON.2)	It is related to the cost of the intervention and to any method adopted in order to limit the expenses or to capitalize the action.
CON.3)	It explains the construction choices and the material used to limit the construction times and, thus, the nuisance for the inhabitants and the indirect cost connected.

These codes allowed defining the level of success achieved by the interventions in relation to the six fields (Table 3).

Table 3. Definition of the levels of success.

Level of Success	Field	Description
Unknown strategy (0 points)	Structure	Unknown strategy
	Architecture	Unknown strategy
	Society	Unknown strategy
	Function	Unknown strategy
	Technique	Unknown strategy
	Construction	Unknown strategy
Ineffective strategy (1 point)	Structure	Lack of a primary step of evaluation of the capacity of the existing building and of the external constraints; ineffective selection or use of the structural materials.
	Architecture	Wrong or incomplete interpretation of the surrounding context; unattractive or inadequate selection of the architectural features.
	Society	Failure of the strategy for inadequate interpretation of the societal conditions and no participative process; degradation, crime of the area, and missing sustainability.
	Function	No additional services, new functions and/or accessibility patterns; no mixed use in terms of functions or target users; ineffective design and consequent use.
	Technique	Inadequate selection of the technology in relation to the performance and to the surrounding environment; missing attention on the sustainability of the project and on the energy performances; easy degradation of the elements.
	Construction	Management problems during the construction process, late delivery, and/or unforeseen indirect or direct costs.
Light strategy (2 points)	Structure	Evaluation of the existing structure and minor lightweight additions, both superficial and three-dimensional.
	Architecture	Minor modification of the architectural features of the building; relative attention to the existing context in terms of permanence of the same visual and physical relationship.
	Society	Interactions with limited societal groups; permanence of the same provision of dwellings and facilities.
	Function	Permanence of the same provision in terms of facilities and services; no new accessibility schemes.
	Technique	Absence of relevant enhancement of the performances of the building; the choice of materials relatively consider the maintenance, aging, and degradation processes.
	Construction	The construction plan is not specifically intended to reduce the construction time and costs.
Medium strategy (3 points)	Structure	Partial demolitions of non-structural elements for distributive reasons with no relevant modification of the existing structures; light addition on the roof with independent structure.
	Architecture	Increase in the interaction in the context of some modification of the appearance of the building.
	Society	Enhancement of the livability and sustainability of the housing estate.
	Function	Provision of new facilities for the existing users and societal groups; mixed use and new accessibility schemes for private users.
	Technique	Enhancement of the energy performance of the building with the introduction of new insulation layers or performing materials.
	Construction	Consideration of strategies to reduce the costs and the time during the construction process with the selection of particular processes, structures, and materials.

Table 3. *Cont.*

Level of Success	Field	Description
Heavy strategy (4 points)	Structure	The structure is modified consistently in order to carry new loads and elements or as a consequent of the individuation of environmental constraints.
	Architecture	Significant interaction or modification of the context provoked by the intervention.
	Society	Provision of housing for a wider societal group, often mixed, with new pattern of sustainability in the area.
	Function	Provision of facilities and new services for a wider societal group, often in correlation with mixed use or target, new accessibility patterns for the users.
	Technique	Use of prefabricated technologies, dry technologies, and/or lightweight technologies. High increase in the energy performance of the building connected with the use of natural resources.
	Construction	Exploitation of prefabricated construction techniques and application of innovative strategies to limit the construction time and costs.
Radical strategy (5 points)	Structure	Substantial demolitions and modifications of the existing structure with addition of new consistent structural elements.
	Architecture	Radical modification of the interaction with the context and/or substantial change of the architectural appearance of the building.
	Society	Consistent strategy of modification of the living standard of the area, sometimes developed with a participating design process; new users and societal groups are considered and involved.
	Function	Provision of new spaces, facilities, and services, often in mixed use. The accessibility results are substantially modified.
	Technique	Prefabricated and high-performing technologies are used to achieve the best environmental performances. New strategy for the production of energy with the use of natural resources.
	Construction	The construction process has radical positive effects on the reduction of costs and time; the realization of the intervention does not influence the life of the inhabitants and their activities.

The final section of the data sheet provides information concerning the materials and the solutions used.

The information obtained is collected in material palettes relative to structural solutions, cladding and finishing, and details. The palettes can be seen as part of a catalog, an instrument that can be progressively updated with new technological solutions or materials, in this way becoming a dynamic and adaptive tool.

The final objective of this operation was to keep a margin of variety in the final solutions, relieving the designer from the choice and giving the occupant more freedom in the definition of the parameters and performances of the dwelling.

3. Results

The retrofit approaches reach the greatest efficiency when reversible, because only in this way do they ensure environmentally friendly actions with the possibility of dismantling. The intervention should improve the flexibility of the existing construction with a correct balance between planning for the present and planning for the future.

The traditional "room" gave way to "fields", able to promote higher permeability in both private and collective life. Some recent studies verified the benefits of providing more space but lower specification, giving more options to define the use over the time [15]. Another option is to design spaces with adjustable configuration or equipped walls able to rationalize the space in different ways over time, within a permanent or a temporary structural frame.

Superficial or three-dimensional stratifications, contrast, and rebalancing interventions—mostly relative to volumetric addition on the roof—were found to be the most recurrent strategies used (Figure 4).

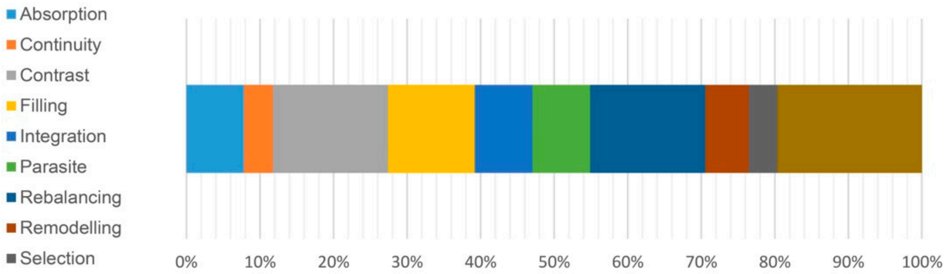

Figure 4. Percentage of recurrence of the strategies.

In most of the cases, new space and expansions were obtained at the same time, improving the energy performance of the buildings.

The additions and modifications were realized with dry and lightweight construction technologies; thus, in most of the cases, the inhabitants could remain in their dwellings for the entire construction process, and the existing structure was able to bear the new loads without major modifications. In this way, a relatively limited amount of resources could solve a complex set of problems, spanning from architectural to technical and structural.

Another relevant result was the level of success obtained in the different fields of action (Figure 5). For the field of technology, 67% of the projects scored equal or more than four points, corresponding to heavy and radical strategies, followed by architecture, with 63%, and construction, with 61%. This result was consistent with the research methodology adopted, which proposed a sample composed of "best practices" in the domain of building retrofit. On the other hand, only around 30% of the projects scored equal to or more than four points for the fields of society and function.

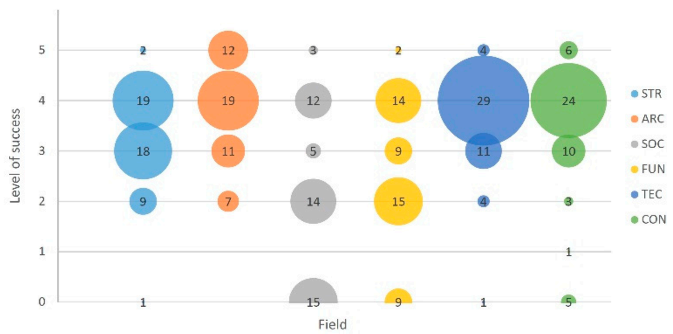

Figure 5. Levels of success for the different fields of action.

The maximum value that each field could reach was 245 points (five points for radical strategies multiplied for 49 projects) with the highest values recorded for architecture and technique. On the other hand, the society field reached only 108 points with a great margin of uncertainty in the design program (Figure 6).

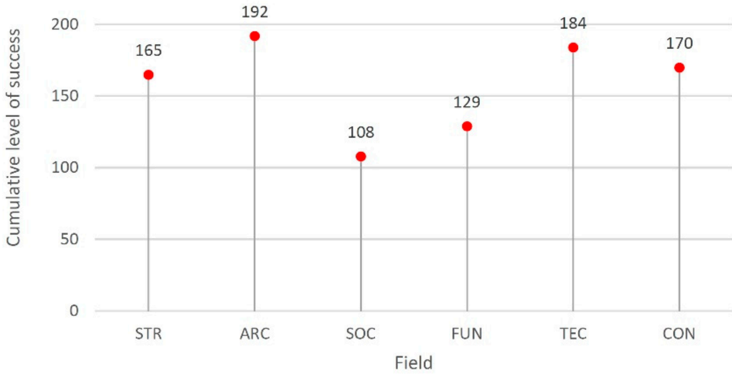

Figure 6. Cumulative level of success for the different fields of action.

This underlines how the approach to building regeneration, also shown in these key examples, is still unripe.

An example of a synoptic table used to categorize the case studies is shown in Figure 7. The tables are classified in relation to the retrofit strategy used and they contain information regarding the building typology and the level of success of the approach used.

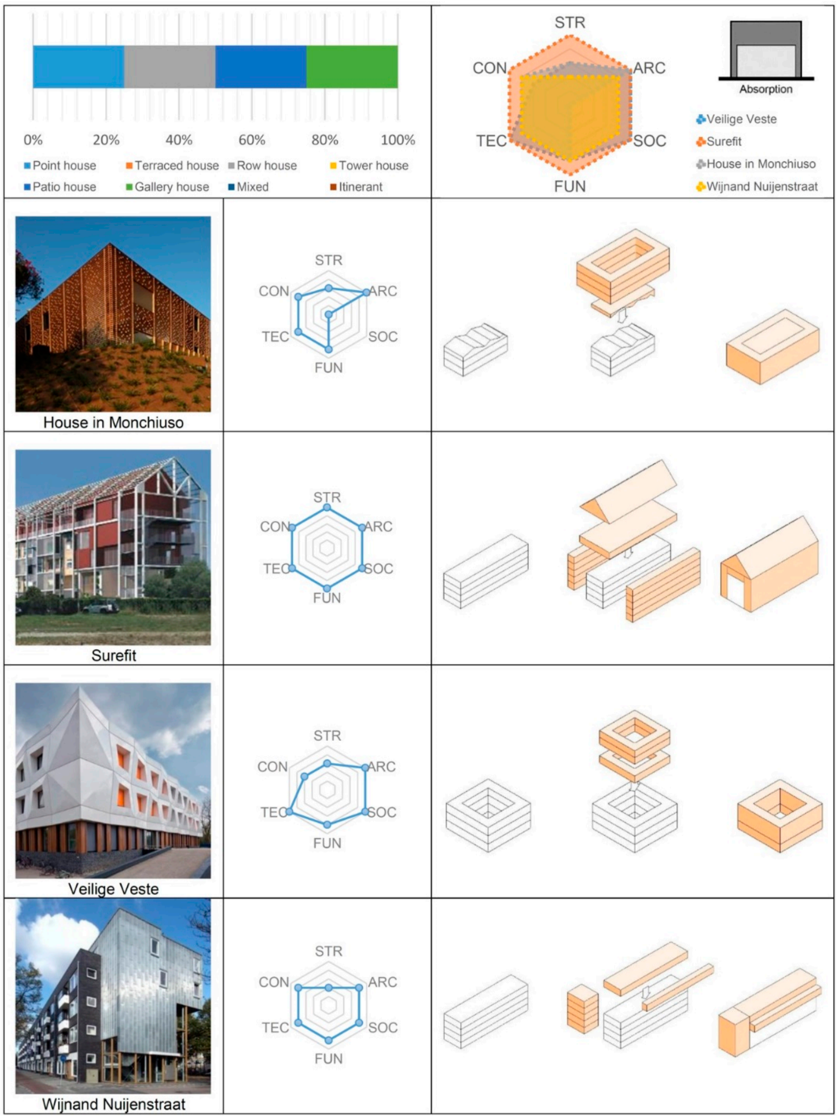

Figure 7. Example of a synoptic table.

These synoptic tables constitute a catalog of best practices which can be used and expanded by designers and architects.

The use of synoptic tables is not uncommon in researches concerning building retrofit projects [13]. However, as already mentioned, most of the data currently available in the literature focus only upon partial aspects.

Finally, the study helped produce material palettes, which can again be used as a design tool and as a catalog of choices for the dwellers (an example in Figure 8). These material palettes are classified into different categories, namely structure, cladding and finishing, and details.

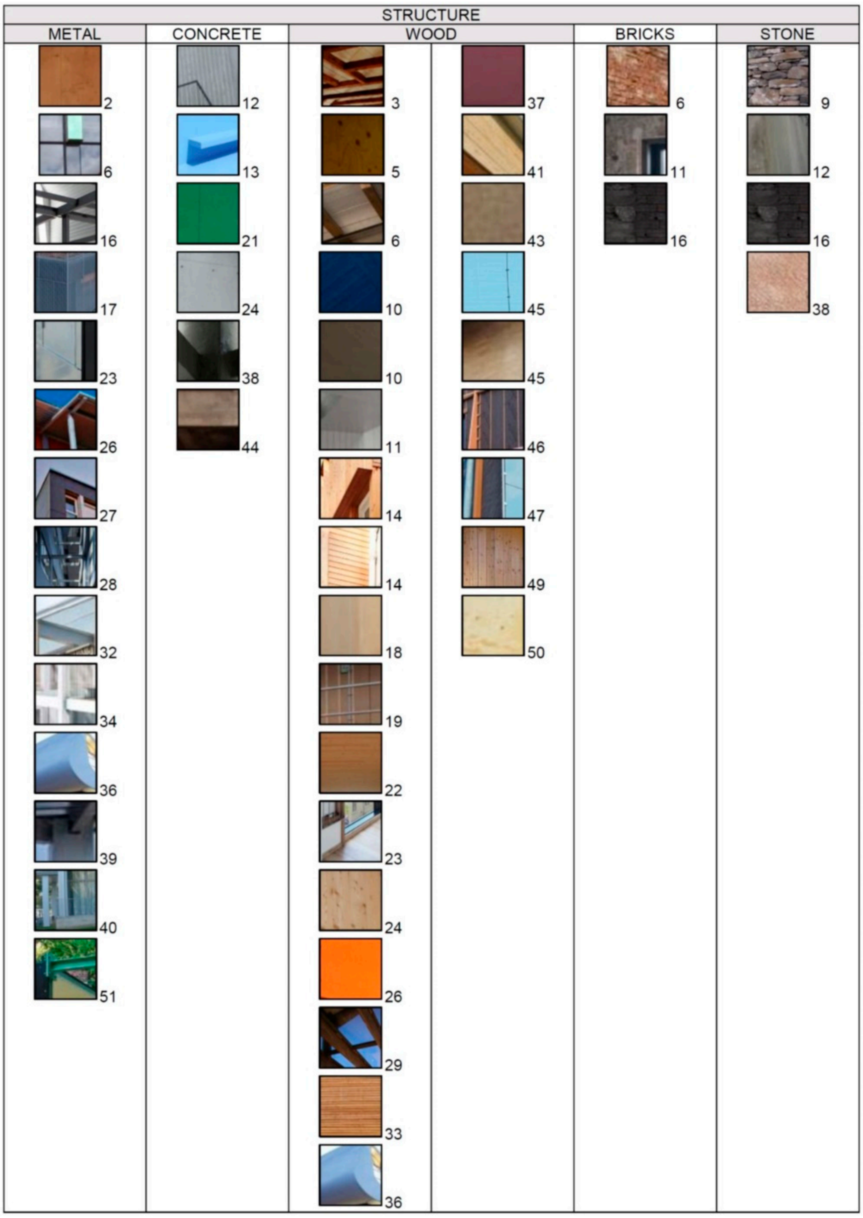

Figure 8. Example of a materials palette.

A comprehensive overview of the results can be further consulted in Scuderi [16].

4. Discussion

The retrofit theme is complex, encompassing a number of parameters such as architectural design, construction, and energy efficiency, along with political support and incentives, socio-financial effects, and user behavior.

Technical problems, for instance, manifest sometimes with a level of damage able to affect user satisfaction. Other common reasons for dissatisfaction are the size of the apartments or the inadequate layout of the dwellings, due to the standards and requirements consistently changing over time. With the shift in the age profile of the European population [17], accessibility and the elimination of architectural barriers are also important issues to address. Consequently, transformation strategies may also incorporate elevators, usually absent in buildings constructed before the 1960s. Financial motives are also fundamental, since obsolescent and neglected properties, with low social image, can consistently increase their value if upgraded [18]. An action can improve the appearance, the performance, and the efficiency of a building, increasing its attractiveness and, thus, the rent prices. Investing in energy efficiency renovation, for instance, has an appealing payback time, thanks to the benefits given by a reduction in expenses. Finally, the structural vulnerability of the building also consistently affects the necessity for transformations, because of pre-existing elements and the eventual additional components to ensure the safety of the construction.

Therefore, successful strategies should consider all of these factors, even if the final scheme is often determined by user-oriented visions rather than by simple technical demands.

A change in user typology is already happening because of the disaggregation of the traditional family, for different forms of social mobility and for the emergence of modern forms of nomadism. This phenomenon opens new considerations regarding current building and urban standards, which need to be updated in order to respond to the requirements of an unspecified group of users that changes over time and belongs to different social and cultural realities.

It is fundamental to recognize that the loss of the performance capacities of a building and, consequently. its degradation are part of the natural life process of a construction [19]. Friction within this model occurs when the event is not predictable or it is far below the acceptance criteria or the expectations of the users. In some of these cases, consistency of the expected lifespan can be assured through maintenance works [20].

Life-cycle extension is often more sustainable than replacement [20,21], which must be considered as the last resort, and it is also coherent with the conception of the building as a set of different layers [21,22], each one with a different useful life. The lifespan of a structure, for instance, is from 30 to 300 years, while the envelope can last only 20 years, due to reasons connected to architectural style and energy performances. This means that the external elements conclude their natural degradation process when the structure is still completely sound. In these cases, components with a shorter lifespan can be replaced or upgraded to contribute to the overall life-cycle extension of the building [19].

If the buildings are not conceived anymore as static and unmodifiable objects, the interventions of modification should not be expensive in terms of time and economic and material resources; the design of the intervention should promote velocity, lightness, safety, and recyclability [23], in addition to reversibility and flexibility.

The interventions require specific technological resources, finalized to the realization of additions, not intended to just cover missing parts, but also able to give an answer to the evolution of the needs of users.

It is a design philosophy alternative to demolition and reconstruction, not defining the destiny of the built environment but allowing, stimulating, organizing, and encouraging the evolution of building technologies toward long-lasting solutions.

The analysis of the state of the art showed that lightweight interventions achieved using dry stratified construction technologies of structure/cladding/finishing are a widespread approach to renovation and requalification both for superficial/two-dimensional action, aiming at determining better environmental conditions through the application of additional layers to the envelope, and volumetric/spatial actions, intended as high-level transformations. These types of intervention overcome the necessity to relocate the dwellers during the construction process, and they are less problematic for the structural capacity of the existing building.

Additionally, the research highlighted the leading role of the envelope in defining new characteristics, performances, and appearance for the construction.

The envelope can be interpreted as a liminal space between the inside and outside, thus regulating the relationship between the building and the environment, but also between the building and the users. The envelope is able to determine climate control, energy performances, aesthetical values, and architectural characteristics, and is also able to influence the structural stability of the building in relation to the technologies applied [24].

The final consideration is that an approach directed to the envelope might be an effective strategy of integrated intervention, which can also support the life-cycle extension of estates.

In this study, the building envelope was not only defined as a surface wrapping the building, but also as a component for which three-dimensional transformation increases or decreases the entire volume. With this respect, additions and subtractions, such as attaching building volumes and selective demolition, are incorporated within the range of physical measures for renovation directed to the envelope.

The scale of the envelope-directed approach is technically limited to a single estate; however, since a number of measures involve the immediate surroundings, results could reverberate on the urban level as well.

Studies and personal experiences teach us how the image of a city changes continuously over time [25]. The introduction of a dimension of temporariness in the field of built environment is coherent with the vision of the building as a living organism, able to develop in relation to user needs, and progressive modification can be interpreted as the natural development of a design project.

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