WOOD, THE MATERIAL OF TOMORROW'S RETROFITS

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Abstract
The construction sector has focused for many years on performance improvement of new constructions. Today's largest problem is the energetic retrofitting of existing buildings. The building retrofit is an important strategy for energy savings. Building retrofit is addressed towards the real estate in Europe and allows for substantial gains, especially for heating houses and urban densification.
However retrofit requires the use of special construction techniques. The problem is quite different from that of the new buildings: adaptation to existing building, heritage conservation, elimination of thermal bridges, etc.
In this context, wood is experiencing strong growth in its use in new constructions, due to its qualities. And we think that some of those allow more appropriate responses to retrofit than other traditional materials.
In this study, we will first present succinctly the problems related to the renovation, then we will dedicate ourselves to define the characteristics of the wood. The focus will be on some problems that commonly arise in wood constructions. We will then discuss a case, highlighting different characteristics of wood that are particularly important in this particular renovation. This allows us to observe on the ground the coherence of the choice of wood in the renovation. A discussion will close the study by summarizing the advantages and limitations of the use of wood in the renovation
This is not to show that wood is one of the most environmentally friendly building materials, or demonstrate the sustainable character of retrofit. This is to see that the timber construction systems can provide an adequate response to many retrofit issues.

1 Introduction

1.1 Global issues

1972, « The Limits to Growth »; 1987, « Our Common Future »; 1992, « Agenda 21 »; 1997, « Kyoto protocol » are some of the steps that marked the awareness about the degradation of the global environment and to the emergence of the concept of sustainable development.
Beyond awareness, it is necessary to set specific goals to change society and meet "the needs of the present without compromising the ability of future generations to meet their own needs" according to the Brundtland Commission [1]. Thus to limit global warming to below 2°C long-term (danger threshold adopted by international community, compared to pre-industrial level), it seems essential to reduce global GHG emissions by 50-85% by 2050 from the 2000 level, according to the IPCC [2]. This requires a considerable effort of industrial countries. The European Union has already committed itself to reduce by 20% its greenhouse gas emissions and its energy consumption and to produce 20% of energy from renewable resources. This results in a similar reduction for Belgium [3].

1.2 Sustainable retrofit

In order that the construction industry exercise sustainable development, significant progress must be made to reduce the environmental impact of a sector that remains one of the main consumers of energy (128 million barrel of oil equivalent on the building use, 35% of the world

consumption) [4] and raw materials (50% of extracted natural resources are transformed into construction materials and products) [5]. This fact is even more challenging in Belgium which has an average energy consumption for heating residential building that is 72% higher than its European neighbors [4].
With a renewal rate of existing buildings of 0.12% and an increasing rate of housing stock of 0.71% over the last decade [6], it is clear that effort can't be made only for new constructions. While it is essential to aim for a high performance standard for new buildings, unilateral action in this sense would reduce the sector's emissions by only 2% [5].
However, the real challenge is in the renovation of the existing stock, which could enable major savings (31 million boe savings) at limited cost (cost for a barrel to $ 40)[4]. The challenges of sustainable renovation are multiple, because it saves gray energy induced by the construction of a new building and waste sector (waste from construction sector are evaluated in 2006 to 4 million tons, excluding land spoil, 72% of inert waste)[7], accelerate the energy transition by focusing on the work of lesser scope, monitor the artificial land (between 1985 and 2014, the area occupied by housing increased by 45% in Belgium, at the expense of agricultural land) [8] while safeguarding the built heritage and the existing urban fabric, improve the comfort of housing and reduce the cost of the energy bill.
In fact, almost all the objectives set out above have already been exceeded. In transport in particular, progress has been slow. And some analysts say already that these objectives have been undervalued by the IPCC to consensus. So we should expect to reassess the efforts to realize on building, and so on retrofit.

1.3 Methodology

In this study, we will first present succinctly the problems related to the renovation, then we will dedicate ourselves to define the characteristics of the wood. The focus will be on some problems that commonly arise in wood constructions. We will then discuss a case, highlighting different characteristics of wood that are particularly important in this particular renovation. This allows us to observe on the ground the coherence of the choice of wood in the renovation. A discussion will close the study by summarizing the advantages and limitations of the use of wood in the renovation

2 Problematic

2.1 Problematic of retrofit

The renovation is not just a question of will. Many problems are posed by the amendment of an existing building, let alone when we want to re-qualify in the use of different uses.
The first principle of a renovation is to restore a use value to the building. Excluding some special cases, this means spatial reorganization to respond to new functions. Unlike a new building in which the functions, the envelope and structure are conceived almost simultaneously, renovation imposes structure, and usually an envelope, which functions must adapt.
Hiding any heritage issues, retrofit main interest is to be able to retain, at least partly, the support structure. Indeed, while it's possible to replace almost anything in the second work, the destruction of the structural work involves the total reconstruction of the building. Follows the need to adapt to a structural system sometimes old / in bad condition it might be necessary to strengthen. At the very least, each overload is subject to a comprehensive study to verify the capacity of the building and its foundation to support it.
In view of the introduction, it seems obvious that the issue of performance arises. How indeed achieve high performance when it relies on existing elements which have generally not been designed for that?
Much more when it comes to the renovation listed heritage. Without going into detail, we can distinguish a double influence in the ranking of a building. On one hand, the introduction of

premium and the desire to preserve this heritage have contributed to the development of appropriate techniques and a skilled labor in the renovation. On the other hand, classification of a building involves respect for its heritage features and accentuates the difficulty of achieving a sustainable renovation respecting contemporary standards.
All these issues require a significant cost because of the importance of labor relative to the amount of implementation materials. The economic argument, especially on the initial investment remains paramount.

2.2 Characteristics of timber

2.2.1 Environmental characteristics

The wood has the advantage of a locally exploitable resource in most European regions, Wallonia included. Transport distances are shortened accordingly and avoid an increase in the gray energy of the material. From a social perspective, we also note the benefits of a local operation inducing preservation of jobs and capital locally. The Walloon timber accounts for 18,824 jobs, even though a large majority of them are not directly involved in the production of timber (timber production is mainly for the paper industry and wood energy) [9].
The expected benefits of the use of wood in construction are however highly dependent on its proper exploitation. From this point of view, Belgium has a growth potential still fairly important. The Walloon forest covers 554.000ha for growth estimated at 4.155.000m³ wood per year, to compare to an operating 2.800.000m³ softwood and 800.000m³ hardwood, whether an annual growth of 555.000m³ wood per year [9], a situation similar to that found in all European countries. These numbers should be compared with a volume of timber used in construction in Belgium estimated at 8.14% of the total volume of sawn timber in Belgium (the volume of wood used in Belgium takes into account the currently imported wood from other countries, overwhelmingly of the EU) [10], which suggests that the construction industry can afford to increase its demand of timber without risking inconvenience upstream
However, the situation is contrasted. The growth of the Walloon forest is largely focused on hardwood at the expense of overexploited softwoods. It is therefore important to ensure proper management of the forest both as the macro-territorial level than the forest level. PEFC and FSC classifications allow ensuring the sustainable management agreeing the renewal of the forest. The classification of 44% of Belgians forests is a pledge of effort which needs to be intensified, especially in private forests, which are still not certified for the vast majority [9].
The growth of forest use carbon dioxide take in the atmosphere to fuel growth and release, through photosynthesis, the oxygen and water vapor. Logging allows storage of the main greenhouse gas in a structure throughout the life of the structure. Besides many benefits to the biosphere linked to the presence of a forest.
The storage of CO^2 is effective throughout the life cycle. When it can no longer be used in its original form, the wood can still be valorized as energy and will get rejected only in the atmosphere as carbon equivalent of what had been used during its growth. Alternatives exist for recycling, in the form of particle board or wood fiber insulation. However, recycling opportunities are highly dependent on the absence of pollution of the wood. Each treatment must therefore be the result of a reflection because it could compromise its future uses.
Also, through its life cycle analysis, the wood has a much smaller environmental footprint than other materials its extraction and transformation are highly energy-intensive.

2.2.2 Physical characteristics

It’s impossible to develop all the characteristics of wood in a short article; the subject would require a book. After a quick review of the main physical characteristics of the timber, so let us focus on a few aspects that deserve special attention as part of the renovation. Moreover, given the variety of wood construction systems, we will base our considerations on a framing system, which is very large majority in Belgium, with 8 out of 10 achievements [10].

Remind first than the physical characteristics of wood can't be discussed without mentioning its anisotropic composition. Whether we consider the behavior of wood parallel or perpendicular to the fibers, the results differ. Subsequently, we will consider the direction of fiber commonly used.
For all those interested in sustainable construction, the wooden structure is characterized primarily by its low thermal conductivity, around 0.15W / mK, compared to other common structural materials such as steel or concrete. The thermal bridges are severely limited, and so are the risks of internal condensation and mold. And basic wood fiber materials exist for thermal performance identical to other bio-based insulation.
The wood is also a lightweight structural material, with a density four times lower than that of the concrete and 15 times lower than that of steel. In renovation, where loads often have to be limited on the existing structure, especially on the foundations it is complex to strengthen, it is a significant advantage. In return, the wood has a lower resistance to the forces, especially than steel. The lower resistance requires the use of larger sections. However, wood also works as well in compression as in tension and bending which allows a simpler implementation than concrete requiring reinforcement. Particular attention should also be paid to the deformation of the construction.
The wood is very sensitive to changes in humidity conditions; it tends to put in equilibrium with its environment, with several consequences. On the one hand, the wood has a significant scalability depending on its moisture. Furthermore, wood is an organic material which, when extended humidification, presents risks of rotting and attack by wood-eating insects. So the moisture management is crucial, especially in old buildings where it was previously not addressed. Any connection between an existing wall and the new wooden structure must be treated using capillary barriers to prevent the passage of moisture. The weather protection is also crucial. The most problematic point concerns the transfer of water vapor inside the wall. The use of vapor barrier membranes can limit internal condensation problems with the new wall, but can lead to disorders in the case of dubbing an existing wall that cannot evacuate its internal moisture. It is therefore crucial to study the moisture by capillary transfer, convection and diffusion in the existing structure before considering wood renovation. Timely interventions can be planned to drain the existing.
The acoustic of a wooden construction can cause problems if it is badly studied. The low density plays against it and forces to think about a more delicate to implement mass-spring-mass system. Nevertheless, the latest systems developed by CSTC in Belgium help ensure performance equivalent to masonry walls. In a shared wall, acoustic performance of 69dB can be achieved with a double stud wall perfectly detached. This is the equivalent of a 32cm concrete wall. Such results requires rethinking the internal combination of materials for a large central cavity for spring, while ensuring fire protection of building elements to prevent the spread of a possible fire. [11]
The problem is even more present for floors, due to the importance of impact noise. This is a recurring element of discomfort for residents. One of the solutions developed by CSTC also meets the technical requirements of insulation materials, waterproofing, structural and fire safety. It implements chipboard simply placed on acoustic pads upper face which will be poured on the screed and a loose stone materials in lower part resting on a sheet of fiber cement ensuring a diaphragm effect. The entire complex provides 75dB of acoustic insulation, coupled with a shock sound insulation of 46dB, almost the equivalent of a floating screed on concrete slab 16cm. From an acoustic perspective, wood construction now allows for performance nearly equivalent to other traditional systems. [11]
With regard to fire performance, wood has recognized characteristics. If it is indeed a combustible material (unless adequate treatment), it turns out that burning wood causes the formation of a heat-protective carbon layer. The thermal characteristics of the coal isolate the heart of the piece of wood and allow retention of its bearing capacity, enabling the removal of the occupants. But the good performance of wood strongly depends on sections implemented. The framing structures have low sections and may require protection, plasterboard type when

significant resistance is required to delay carbonization amounts. It is then necessary to ensure the in situ strength of the elements implemented, to pay particular attention to the assemblies of the different elements and the crossings fire resistant walls. Their treatment must ensure the continuity of strength criteria, sealing and insulation to fire. Finally, as it develops composite solutions to ensure the different criteria of comfort and quality of the building, it becomes important to study the risk of spread of fire and smoke in the cavities of the wall. He should regularly clog its cavities using fire-resistant materials. [12]

2.2.3 Other characteristics

The use of wood in construction is perfectly suited to a partial prefabrication of elements, which optimizes the planning of the building site and its progress on the shortest period of time possible. However this advantage is less important in the renovation due to the presence of pre-existing envelope that requires going through a longer assembly phase on site, especially to ensure that the elements adapt to the existing.
In the case of roof renovation it is possible to complete the work without interrupting the occupation of the spaces below. In all cases, the absence of drying time speeds up the site and make them more readily available premises.
The variety of construction systems can be adapted better to the constraints encountered. Also the variety of aspects of the wood makes it possible to consider its use as well in heritage construction as for contemporary renovation.

3 Case study - Sleepwell in the Sky

Year: 2014
Use: Youth hostel
Adress: rue du Damier 239, 1000, Bruxelles, Belgium

Figure 1 - Atelier d'Architecture Galand sprl

3.1.1 Context and project

The Sleepwell is a hostel located in downtown Brussels, between the Canon street and the Damier street. Its construction in phases spaced 15 meet the growing needs for capacity. Differential settlement was found during construction of adjacent plots.
In 2012, a fire, fortunately without human consequences, partially destroyed the roof of the hostel. The hostel management decided to take advantage of the renovation necessary to rethink the organization and improve premises to better respond to customers' new expectations.
Since its creation, the youth hostel answered social objectives. These are quickly doubled with a growing interest in environmental preservation. It was the first Brussels hostel receiving an eco-label in 2008 with the company label Ecodynamique renewed in 2012 and then by the

international label Green Key in 2013. So it's not a surprise to see the interest of the project owner for a sustainable renovation, and more specifically to control energy. This is the project of the Atelier d'Architecture Galand who convinced them. It has made a specialty of wood low energy construction and transformation and was able to offer an innovative project, both in its exterior as its interior organization and the techniques he employs. The building integrated many insights on energy which allowed him to be named exemplary building 2013 in Brussels.
By organizing around the patio, the new premises have a

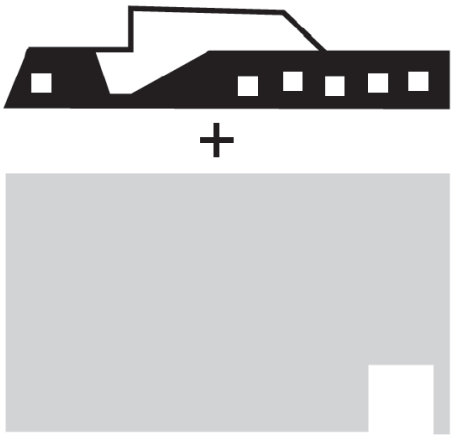

Figure 2 - Atelier d'Architecture Galand sprl

double exposure synonymous with lighting and natural ventilation Duplex develop on two floors, preserving the 6th floor for terraces while access to the rooms is at existing 5th floor. On the 7th floor, a gym tops all and gives the renovation its distinctive look.

Figure 3 - Atelier d'Architecture Galand sprl

3.1.2 Wood use

The first challenge was to greatly limit the overload on the roof. As architect he has logically oriented towards a timber frame construction
Locally, particular structural constraints have pushed the project management to choose the use of glulam and steel elements. The sawn timber has undeniable qualities but cannot meet the same constraints that these two systems.
Wooden panels ensure the bracing of the assembly, as it's usually made in the Belgian timber frame constructions.
The construction in the city center did not allow the transport of solid element too. The presence of a backyard allowed the installation of a crane and the prefabrication of structural elements on the floor before their installation on the roof.
The lack of wet phase, the continued protection of the roof and the building speed allowed the hostel to stay open on the lower floors, without business interruption.
Special attention was paid to the treatment of fire wood elements to meet the stringent standards of the city of Brussels for accommodation establishments. Obviously, after the initial incident, he was not about to compromise on this crucial aspect of construction. This achievement proves once again that in the right conditions of implementation, the wood can perfectly meet the requirements of fire departments.

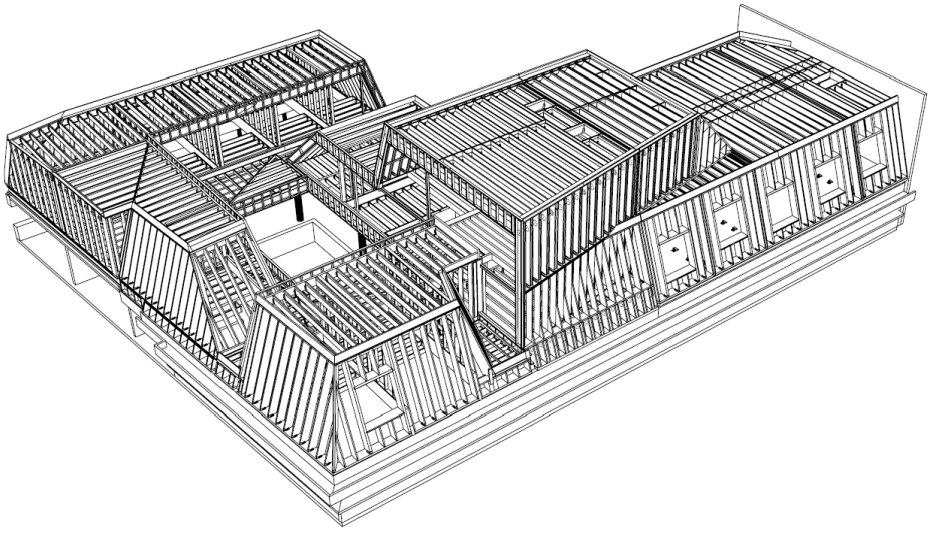

Figure 3 - Atelier d'Architecture Galand sprl

The airtightness and good building acoustics required upstream a good study of construction details of the structure to meet the complexity of the environment. There is nothing to show through the omnipresence of wood once the renovation completed. Whether inside or outside, the building material was put in the service of architecture without imposing the image that persists to expect from a wood-frame building, proof of versatility of this method of construction, despite the particularly stringent requirements which weighed on the project.

4 Discussion

Sustainable renovation imposes many important constraints, sometimes even contradictory. Yet it is essential to accelerate the transformation of our habitat. In Belgium, the sustainable renovation of old industrial cities such as Brussels, Liege and Charleroi, requires inventing techniques for intervention at lower cost, both economically and environmentally, while respecting the heritage. A quick analysis of the characteristics of the wood shows promising results. For its light weight and resistance, it answers many constraints commonly observed in renovation.

From an environmental point of view, wood renovation is widely positive compared to other materials. Renewable, recyclable, energy efficient, local, it combines the advantages if well done. If that was not mentioned in the previous cases, the wood also has the advantage of staying easily changed once set up.

From a social point of view, wood renovation allows the relocation of resources and manpower.

It’s the economic side that is often proves decisive in the choice of particular materials. This aspect leads to a reasoned choice of wood in projects where it meets a particular expectation, as the two cases discussed above. As for new construction, wood is not necessarily the best renovation material. But it has advantages that give it full place in a range of sustainable renovation solution.

Analysis of the Sleepwell hostel in Brussels and elsewhere highlight several of these aspects. In an urban context constraining in elevation of a weakened building by differential settlement, the architects were able, through intensive use of this material, giving new life to the roof. Not satisfied with technically and functionally meet the demands of project management, they managed to create an architecture that reflects the choices of the project without being constrained by its technical requirements. This project also shows that if the architect has some action levers to create sustainable architecture, this is the project owner who is responsible for starting such projects.

However, it is important to keep a critical look at the entire life cycle of wood. Much of the wood advantages are theoretical and based on an ideal implementation of it. Also special attention should be paid to the successful completion of the construction details, especially the air

tightness and the moisture of the structure, which is sensitive to thermos-hygro changes, the point that it could jeopardize the integrity of the work. The wood has a virtually unlimited life, as can be seen in some constructions dating back centuries. However this durability depends strongly on the correct build, even further in more complex building systems whose optimal functioning involves attention at all times, at the risk of losing some of the anticipated benefits of the renovation.
Furthermore, it should not be that the use of wood in renovation to become the tree that hides the forest. One and the other are not synonymous, quite the contrary. Obviously a wooden renovation can be also a waste of energy, materials and money. And some projects are more sustainable by using other materials, steel, concrete or other, despite a significantly impacting life cycle. The renovation is the realm of the particular case. Each project requires a comprehensive analysis of the building. And only in the light of the results of this analysis that informed critical choice may be made in favor or not of wood.
It is only at this price that we could speak wood as a sustainable renovation material.

5 Literature

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