Ki-etude Building – Folded Wood

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1. STUDY CASE _ Design and construction of a wooden housing building in an urban context

Wood construction is expected to play a growing role in the construction sector. By presenting our ki-etude housing project built in Namur, Belgium, we want to demonstrate that wood construction can be an effective, economical and ecological response for private housing in urban centers.

The design process was very challenging as the constraints were numerous. We will show how wood construction was relevant to deal with all the aspects of the project, architectural and technical ones. The building is located on a rather complex plot and strict requirements in terms of energy performance, fire resistance and acoustics needed to be met.

It was the pretext to innovate both architecturally and technically.
The ki-etude building was the highest CLT building in Belgium at this time.

Figure 1: Ki-Etude housing completed picture by Valentin Bianchi

1.1. ARCHITECTURAL DESIGN

The project is located in the historic center of the Belgian city of Namur. In a narrow alley right next to the train station. The land was occupied, originally by a building of three levels without architectural interest. The client, who is a real estate developer, wanted to build, on top of the existing building in order to get ten apartments.

The construction of 10 housing units required a minimum area of 700 m². It was therefore necessary to provide an extension of the existing building. The existing building was only 288 m². The only way to increase the surface was by adding levels on top of the existing house.
The soil tests carried out, quickly, showed that the ground had a very poor bearing capacity and it was impossible to simply add several floors. The project was therefore oriented towards designing a new building.

The plot is extremely small, only 96 m², plus, it is wider than deep. According to Urban planning regulations the new building couldn't be higher than 17,5 m. Implementing ten units on such a small land was complicated. That's why it was necessary to enhance the available surface seeking space overhanging the street. This sounded appropriate as many houses in the street featured bow-windows.

Another characteristic of the plot is that it is mainly mono-oriented. The wider façade facing south could be opened but not the other ones as they were adjoining other properties. Only one part of the north façade could be opened as it was overhanging the same property. The challenge was, therefore, to design great apartments despite their small size and the fact that only one of the exterior walls could have windows.

In addition, the proximity of the facade on the other side of the street created a form of tension. The buildings facing each other are only five meters apart. This very strong confrontation has oriented the design into spaces overhanging the street with obliques walls so as to deflect the views towards the axis of the street.

The architectural answer to these three main constraints has been to create a folded facade. This allowed to gain space in the housing but also to orient views to the public space. A wall, in plan, is a straight line. If someone fold this line, he gives it a depth. Transposed into architecture, this depth becomes a space.

The façade is folded like a ribbon on each level creating overhanging spaces onto the street. By translating the facade every two floors following a geometric grid, bonus spaces are created. In this case, terraces facing south.

The result is a geometric composition referring to the bow-windows of the art-deco houses in the street. The building seems less massive. The geometrical design is strengthened by the visual effect of light and shadows. The sculptural façade creates a distanciation between the street and the building. The privacy in the apartments is, therefore, increased. Still they are bright as the large opening let the daylight penetrates the rooms.

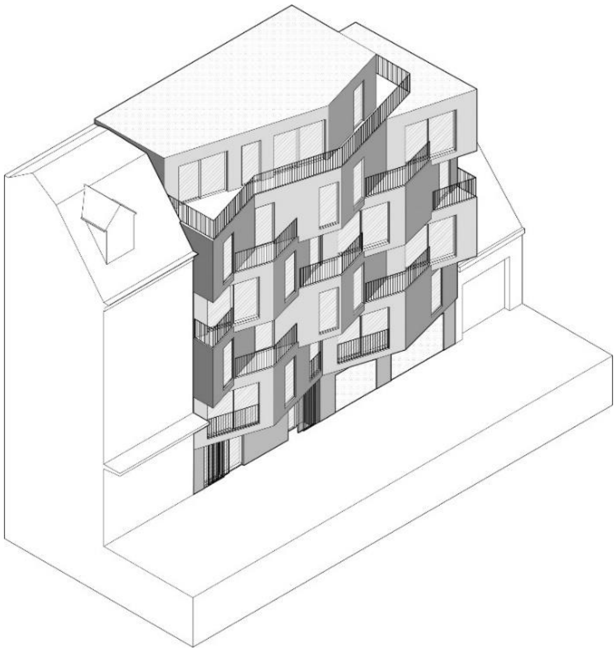

Figure 2: Ki-Etude housing axonometric view by specimen architects

1.2. WHY WOOD?

The constructive design of a building is always a matter of ratio between the advantages and disadvantages that each type of construction offers. In this case, wood construction solved more problems than it generated.

The goal was to build an energy efficient building with a reduced impact on the environment. Working with the wood therefore made sense as the 190m^3 of wood that was needed for the construction equals 190 T of Co^2 stored and 120 trees planted.

The choice of wood construction was, in the first place, related to structural requirements. It divided by three the weight of the structure. It was important as the soil tests had shown that the plot has a poor bearing capacity.

In addition, the particular design of the facade gives it a very low number of loads transfer points. Reducing the weight was therefore crucial.

Another reason that made the wood interesting is the small size of the plot and the will to optimise the useable area. Building in wood instead of concrete allowed to reduce the thickness of insulation required. Each apartment gains almost one square meter cut back on the wall composition.

In addition, working with CLT floors effectively solved the problem of balconies by working with a single interior-exterior horizontal structure element.
The wood is particularly suitable for the offbeat folding game that the architects wanted to put in place.

"*Solid laminated wood panels allow*," to paraphrase the Swiss architect Andrea Deplazes, *"to work on architecture as a life-size cardboard model".*[1]

Finally, crossed laminated timber offered advantages as it reduced the construction period. This was important as the project was located in a downtown lane where the construction site facility represents a significant part of the budget. The building rose in six weeks at the rate of one floor per week. The building was dry very quickly since all the windows had been ordered before the mounting of the CLT structure.


Figure 3 and 4: Ki-Etude housing construction site pictures by Pascal Themans

1.3. CONSTRUCTIVE APPROACH AND TECHNICAL CONSTRAINTS

LOWERING LOADS

The design of the six-storey building entirely made of wood, required the proficiency of one the best Belgian engineering office specialized in this type of structure. The WOW branch of the NEY & PARTNERS office located in Namur was commissioned for the stability study. Among the two challenged engineering offices, they were the only ones to propose a structural principle that does not distort the architectural concept.

Engineers imagined the south facade as a stack of Vierendeel beams. These beams are pile up while shifted laterally from level to level. They are therefore sometimes supported, sometimes suspended.

The complexity is that the intersections between the different levels are made in three specific points only. The loads are then transferred to the ground via the bearing walls then through the concrete raft in combination of micro-piles as foundation.
The position of the openings in the main facade has been studied very precisely to meet the double objective:

- To agree with the rigid geometrical composition desired by the architects
- To brace the Vierendeel beams

The Vierendeel beams are composed of two steel beams forming the lower and upper bases and CLT panels for bracing.

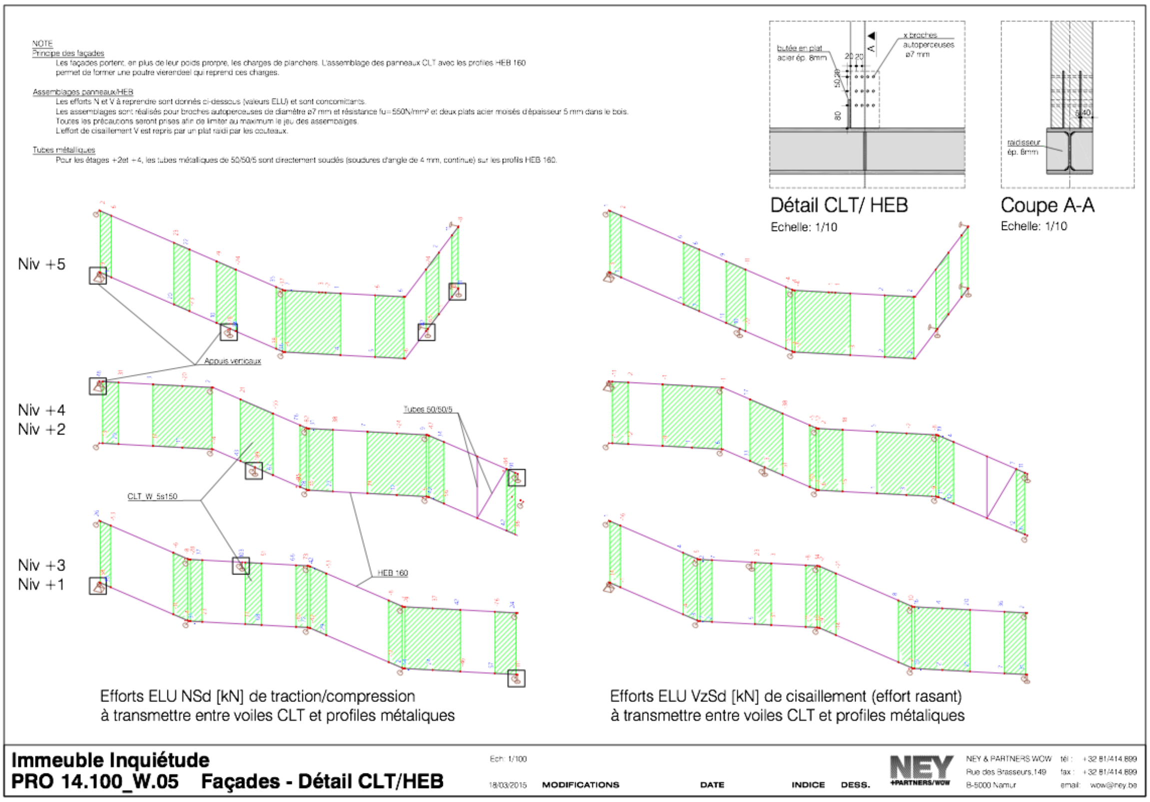

Figure 5: Ki-Etude housing stability diagrams by Ney/WOW

WIND PRESSURE

The general shape of the building (wider than deep) and its total height (17.3 m) makes it very subject to wind pressure. The CLT walls perpendicular to the main facade could be under significant wind pressures. To solve this problem, some horizontal CLT floor panels are cut to accommodate vertical pieces of Wood in order to obtain a better resistance in compression at critical locations.

ACOUSTIC

One of the weak points of wood construction is the low density of the material which generates acoustic weaknesses from one floor to another but also from one apartment to another via the common wall. This problem was solved, on the vertical axis, by creating a complex consisting of a suspended ceiling with acoustic properties, below the CLT floor and, above, placing an acoustic filling layer under a reinforced concrete screed separating each floor.

On the horizontal axis, the building was split in two parts. Each level featuring two apartments they are completely independent to avoid acoustic weakness. That's why the common wall is duplicated.

FIRE RESISTANCE

The requirements in terms of fire resistance were reached by doubling the CLT bearing wall with fireproof plasterboard.

1.4. WOOD IS MORE

Building the wooden building could not be reduced to a skeleton that is hidden. There was the will to show the materiality of the building inside the flats to enjoy the additional quality that wood can bring to the atmosphere. This is the reason why some walls have not been covered with plasterboard. The wood reveals the true nature of the structure. The dwellings gain in heat and acoustic comfort. It has a positive influence on the spatial quality. Its color is reflected on the concrete floor and in the glazing of the windows. It's just a wood wall but it changes everything.

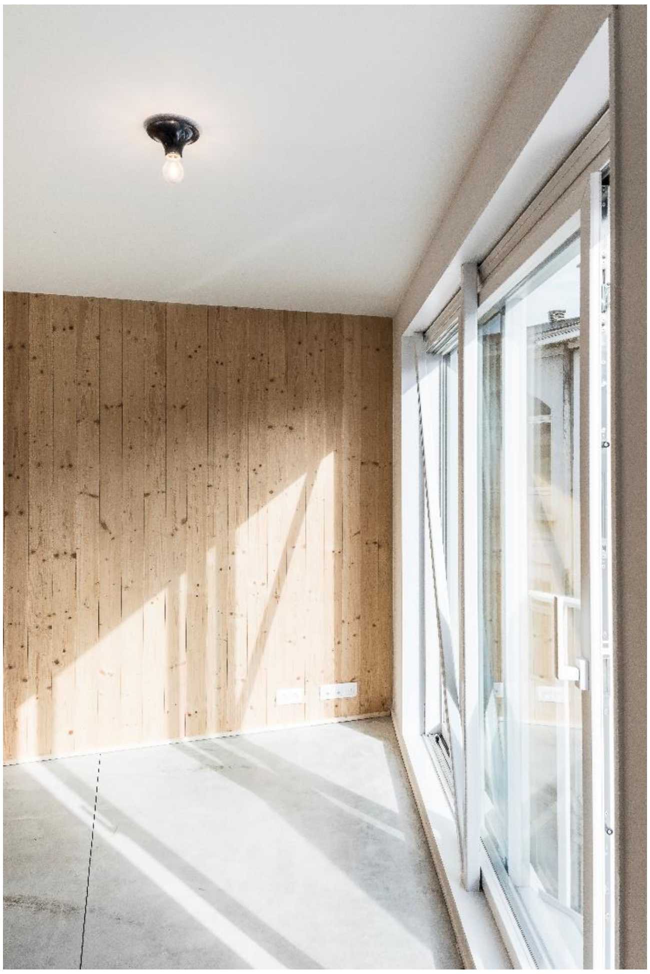

Figure 6: Ki-Etude housing completed picture by Valentin Bianchi

1 - DEPLAZES, Andrea. Construire l'architecture, du matériau brut à l'édifice. Bâle : Birkhäuser, 2008, p.79.