

TOPIC: IMPLEMENTATION – PARIS / RESTRUCTURATIONS / HYBRID STRUCTURES / THE HALLE PAJOL PROJECT / FRANCOISE HELENE JOURDA AND RAPHAELLE LAURE PERRAUDIN ARCHITECTS

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ABSTRACT: Up to the Second World War, the materials selected and building methods used for traditional constructions were de facto, based on descriptive specifications representing standard solutions. Since the Second World War, the wide range of products and techniques available has led to the description of a standard solution being replaced by a liability to perform applicable to the building. In other words, do the technologies used for a project open up new possibilities in terms of the general organisational structures used for production purposes, generating hybrid systems by default?

That is the initial statement of the Halle Pajol project designed in Paris by the Architects Françoise Hélène Jourda and her associate Raphaëlle Laure Perraudin. This project is a remarkable example in which designing architectural technical solutions are:

- a process, leading to a new model (knowledge, innovation)
- the combination of two systems or two forces (distribution of new technics and adaptation to local context), led by the customer, legislation, the design team and constructors.

KEYWORDS: Hybrid / Assembly / wood-concrete structure

1 HYBRID / INTRODUCTION

1.1 FOREWORDS

The project of the rehabilitation of the Halle Pajol in Paris / France / is a very ambitious project: in the complexity of the co-education (mixing) of the program (youth hostel, activities, library and garden) ' adds that of the rehabilitation of hall, element of the Paris industrial heritage of beginning of the twenties century. At the same time an hybrid program in the North of the city and an hybrid technical answer for the structure using existing steel structure, concrete and wood together for the new building.



Figure 1: Sky view of the project

In view of today situation, of which we are well aware, I therefore suggest that we understand the term hybrid as highlighting the local roots of an architectural project. Is this something new? Priorities have reversed, and this



Figure 2: Front view of the project / Source: JAP Architects

could be considered as different, and perhaps new. At a time of hyper-standardisation and regulation, special and local solutions are standing out. Hybrids are considered as innovative if they are based on successive adaptations between the initial model and the final model. This will lead to the co-construction of a final hybrid model.

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Figure 3: Location plan / Source: JAP Architects



Figure 2: Ground floor including the garden / JAP Architects

The ecological footprint of the building aims to be a pilot project for the City of Paris, minimizing the ecological impact of the building. From this analysis, the paper is broken down as follows:

- A- Project General description
- B- Global design hypothesis.
- C- Hybrid wood and concrete design.
- D- Construction process

1.2 DESIGN PROCESS

The main design guidelines including the structure are the following:

- This existing hall is the protective envelope of the building. She so asserts her revival. The skeleton of the existing hall, freed of its overloads and freed from any new constraint becomes a canopy supporting a solar power plant.
- New buildings, in contrast with the existing hall, are volumes very compact, so limiting the energy decreases. Within this hypothesis the structure is mostly in wood but include at the same time concrete slabs for thermal inertia reason.
- The garden between the hall and railroad tracks is designed from north to south, in the biggest dimension of the site. A long railroad garden draws a continuous route: covered under hall Pajol, opened further north. This linear space organizes in successive, behind the scenes vegetable strips. The principle is to designed an evolutive garden in Paris.



Figure 3: View of the project on Pajol street / Source JAP

2 ARCHITECTURE AND CONTEXT

2.1 FROM AN EXISTING BUILDING

The rehabilitation of the Halle Pajol is a flagship operation across the city of Paris. Hall now host a library, hostel, offices and shops, an auditorium and a solar photovoltaic roof consists of 3.500 m² of photovoltaic panels and solar panels, the roof covers a large part of domestic hot water needs of the youth hostel. Halle represents today the largest urban solar power plant in France.

Under the renewed metal structure of the market develops a seemingly building timber frame but whose structure is finally hybrid wood & concrete. This combination of materials with the aim of forming a new construction system, a new coherence, is the object of the analysis of the chapter.

The original building was built in the early 20th century belonged to the SNCF who used to unload the parcel . Equipped docks and various platforms, the free space under the roof as it appears today did not exist. The metal, original structure has undergone various interventions before finding the clarity of a large shelter that welcomes new buildings and covered garden. Thus, having been partially cleared successive fillings (concrete, bricks, tiles), the structure has undergone a refurbishment, decontamination lead paint, sanding, repainting and one-off and reinforcements additions that have adapted its structure to the new requirements of stability





Figure 4: View of the existing building

Totally independent buildings that fit under it, the metal framework meets its own constraints on fire safety, fire stability of the new buildings is ensured by its own wood facade. Similarly, the sealing of the new construction is assured regardless of the steelwork. The architectural has been first to come simply slide the new buildings in this market, under the framework, in order to preserve both the integrity, independence and historical and heritage value.

The building lies in structural terms, on a strict dichotomy between the existing metal frame of the hall - itself coated glass panels and photovoltaic panels - and equipment that fit underneath.

Between the hall and the railway tracks, along a railway garden draws a continuous path: covered garden in the Halle Pajol, open garden to the north. This linear space is organized into successive strips, vegetable scenes. The ponds collect rain water from the photovoltaic roof. This water is stored in order to meet in garden watering needs. In the north, the garden follows the topography, causing pedestrians by successive slopes and plateaus down to the Riquet Street.

The original length of the Halle was 200m but about a third of its length was demolished. It develops today on 140 meters long by 41 meters wide. It consists of 11 bays arranged in an axis between 14 meters and cross the primary structure is made of 11 multi-frame to release two longitudinal aisles. The frame of the cover is constituted by a set of sheds. The ridge of the sheds of the hall rises to a height of 20m over the traffic area of the lower ground floor. The level of the channels is disbursed over the esplanade. Today Halle is simultaneously a level with the esplanade through a floor and with the railway lines localized low. The framework of the market (post and beam "I" and "H" reconstituted and trusses) is mainly carried out by the flat assembly and angles riveted and bolted sometimes. Existing longitudinal stability is done firstly by stairwells and partly formed by cross channel sections. The transverse stability is achieved by the multi-frame.

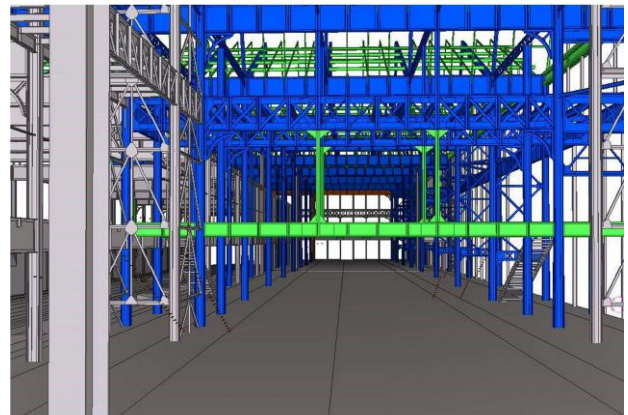
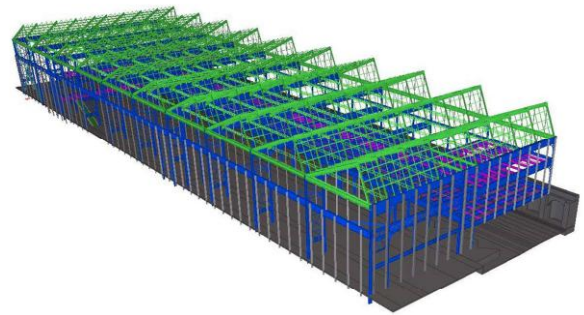


Figure 5: Bim model of the steel existing frame before modifications.

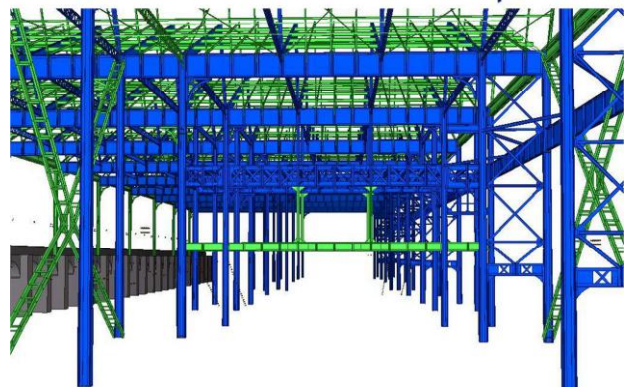


Figure 6: Bim model of the steel existing frame after structural modifications

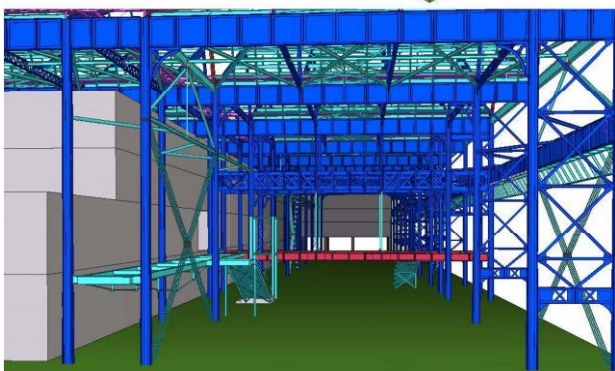
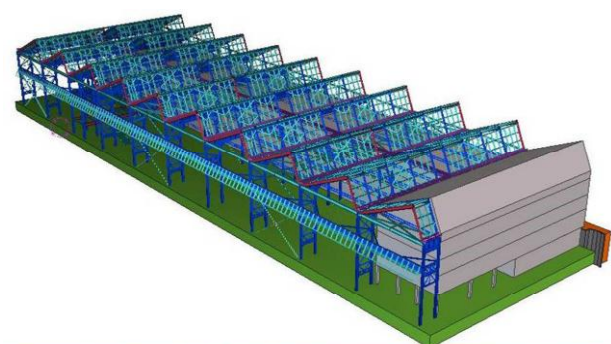
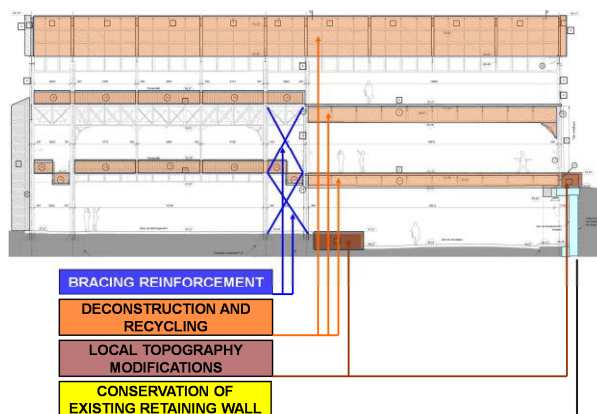


Figure 7: Bim model of the steel existing frame with the new independent concrete&wood project.

- The longitudinal retaining wall is nailed over its entire length to ensure its stability without lean on the infrastructure of the proposed new building.
- Surfaces reported in the superstructure of the hall made of mixed wood / concrete frame are entirely self-made stable and favoring the functional efficiency, structural and thermal. They are implemented on new foundations.



2.2 STRUCTURAL DESIGN HYPOTHESIS



Figure 8: Construction stage wood and steel / JAP Architects

In its planned configuration, the hall consists of three statically independent sets: the "Halle-canopy"; mixed wood buildings and the garden and the existing retaining wall. The key assumptions that are used are as follows:

- The roof of the hall, like a canopy, receiving coverage in photovoltaic panels south and north canopy. Its main structure, which ensures its integrity and static volumetric size is generally retained for 10 of the 11 multi frames, with local adaptations and enhancements that are developed further in this note.
- To take into account the issue of thermal expansion of the hall, two joints are created at connections between existing sheds and cross gantries.

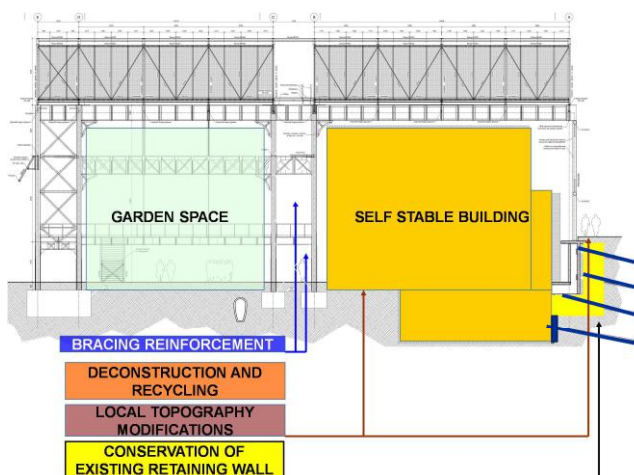


Figure 9: The new anchorages on the retaining wall and the design hypothesis

3 HYBRID STRUCTURAL DESIGN

3.1 WOOD&CONCRETE STRUCTURE REVERSE

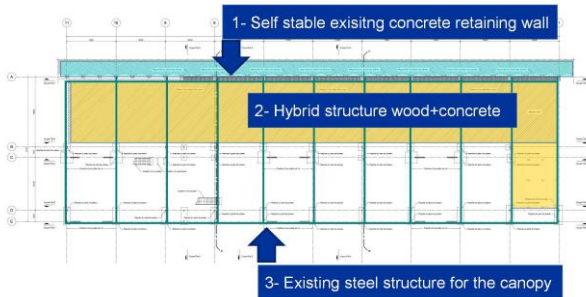


Figure 10 : The three statically structural systems

The massive use of wood based on the requirement to reduce to the minimum the environmental impact of new construction, including a rehabilitation context. The wood also gives the building a strong potential for flexibility, redevelopment, convertibility. One could thus imagine that the building in a few decades either for all or part disassembled for the shelter of the structure welcomes a new function. The use of wood has been a determining factor for the prefabrication of building elements especially on facades, interiors with wood sides and poles.

But the main innovation is the implementation of a concrete hybrid wood structure. Originally planned entirely in wood, the development of the necessary thermal inertia was solved project by the implementation of a material having a mineral consistency in our case reinforced concrete.

On this basis, was born an amazing combination of making wearing slabs implemented at each level by a vertical wooden frame. It is the use of wood as vertical structure which resulted in technological innovation, wood bearing columns and wall are supporting the concrete slabs expect for the roof which is remaining in wood.

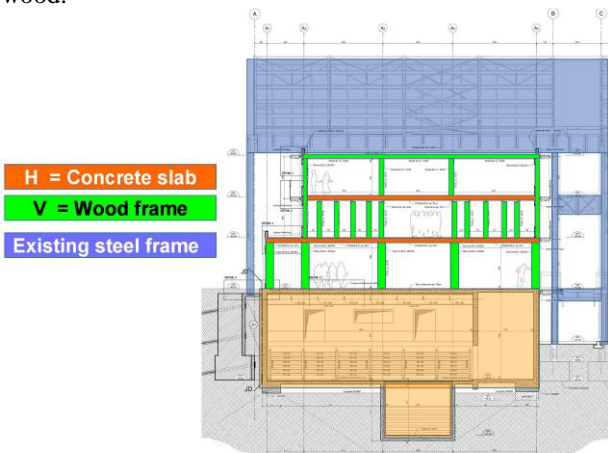


Figure 11 : Typical cross section showing the concrete and wood structure.

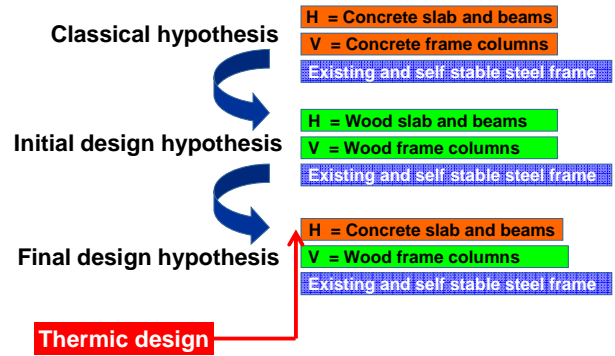


Figure 12: Schematic diagram showing how thermic design is influencing structural design.

3.2 INNOVATIVE CONSTRUCTION SYSTEM

4.2.1 Concrete timber system

Constructive concrete timber system is implemented in the equipment located in the covered market in steel structure. The reinforced concrete slabs (and associated beams) are implemented through the levels ... and are supported by poles or wood sides while the overall bracing is achieved by reinforced concrete cores made of prefabricated panels.



Figure 13: The new wood structure is totally independent from the existing steel structure / Source : Arbonis

4.2.1 Assembly beam concrete / wooden post

The reinforced concrete slabs -are carried by post Wooden Glued Laminated and GL 28 h of 400 x 400 sections on the ground garden at 260 x 260 at R + 1 where loads raids are lower. The posts include Length fittings which ensure the junction with foundations and slabs of different levels.

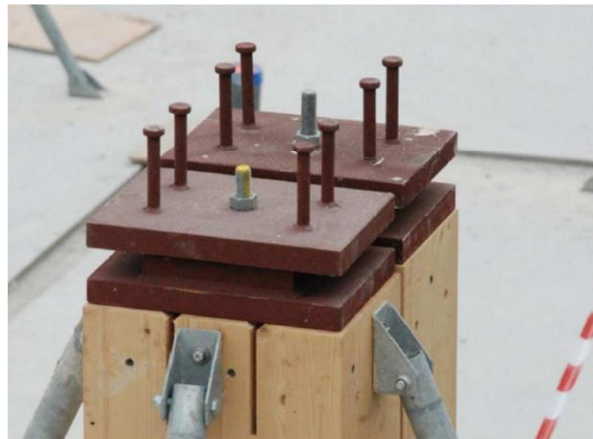


Figure 14: wood post connexion / Source Arbonis

The special assembly slab concrete / wood post is in the design of connections in order to obtain a possible rotation of the slab on the pole and then protect the wood. The rotation is made possible by the implementation of a steel plate in Fe510 steel assembled wooden post by pins 16 mm in diameter. Screws ensure the shrinking of the device to the right of platinum steel / wood touch.

On top of the steel connectors provide the interface with prefabricated reinforced concrete beams. The bearing capacity of the steel plate is 230 t. The fittings are exposed to fire, - they are coated with an intumescent paint

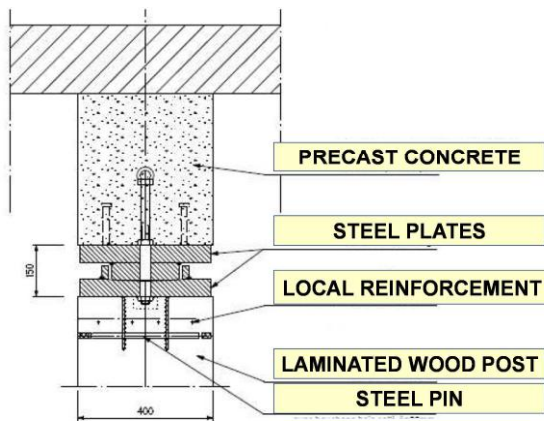


Figure 15: detail of the connexion



Figure 16: column 400x400 mm / Source Arbonis

4.2.2 Assembly slab concrete / wooden walls

Timber bearing walls carrier also concrete slabs. They are made of laminated posts 140x140mm interconnected by metal fittings at the head and foot.

These fittings have connectors provide the interface with the reinforced concrete slabs along the entire length of the timber frame. The chosen mounting method is that of the platform, the typical installation of timber-bearing walls.

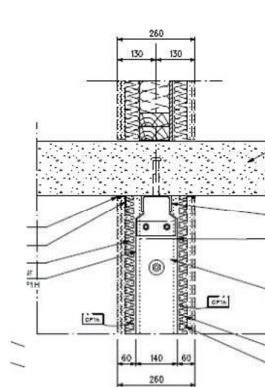


Figure 17: typical details and photos of the timber wall / Source Arbonis

4.2.3 Construction process

The schedule corresponding to the implementation is as follows:

- Wood posts
- Exterior nonbearing timber walls
- Precast concrete beams
- Prefabricated concrete sails
- Shuttering Table of reinforced concrete slabs.
- Reinforcement of slabs and edge beams
- Pouring the concrete slabs and beams.



Figure 17: Construction process / Source Arbonis



Figure 18: Typical case of the column within the nonbearing façade timber wall / Source Arbonis

To reduce the risk of uncontrolled release of the head of the wooden post in a specific provisional stage stability tool was developed for the project. The goal is not to break the wooden post by implementing a steel framework to encircle the wooden post to the butonner on its outskirts during the casting phase or it is not maintained.

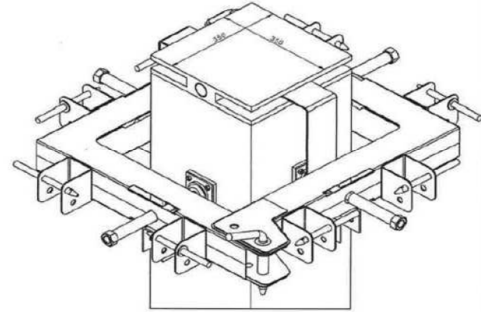


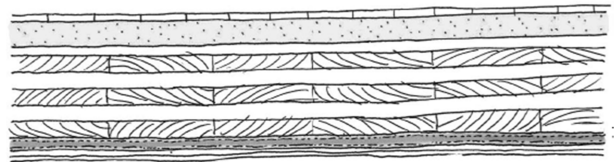
Figure 19: Construction process / post temporary stability / Source Arbonis

4 FLOOR AND EVELOPE

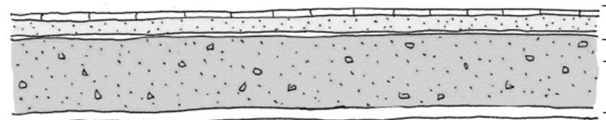
4.1 TYPE OF FLOOR

Given the stakes in terms of precast floors of the design was the subject of specific consideration. 3 types of floor were analyzed:

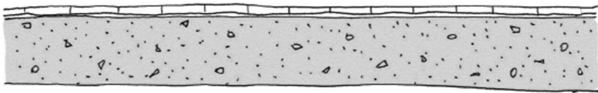
- **TYPE 1:** floor within CLT wood panel and concrete screed / thickness. = 35,8 cm



- **TYPE 2:** Full floor concrete slab with concrete screed / thickness. = 26,5 cm



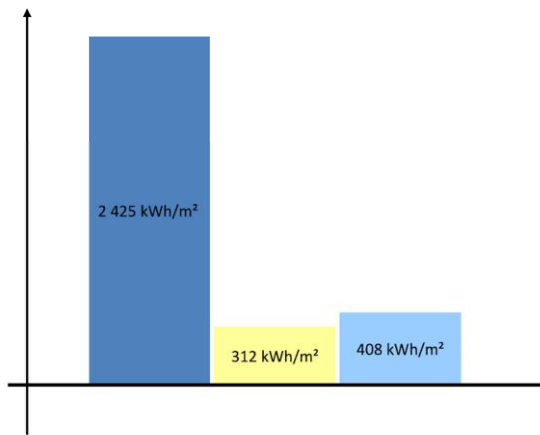
- **TYPE 3:** Full floor concrete slab / thickness.= 20 cm.



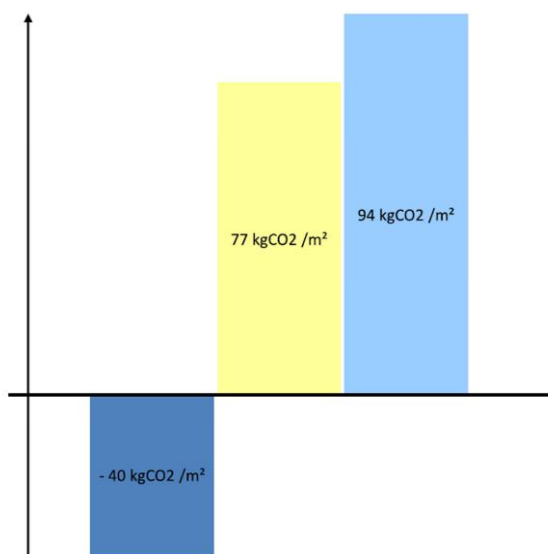
The comparative analysis of different floor types is as follows:

HYPOTHESIS	FLOOR TYPOLOGY		
	TYPE 1	TYPE 2	TYPE 3
	Wood panel CLT	Full concrete slab with concrete screed	Full concrete slab
Prefabrication	+	?	+partial
Demountability	=	=	=
Gray energy	+	-	-
Fire resistance	-	+	+
Inertia	=	=	+
Economy	-	+	++
Thickness	--	-	+

An embodied gray energy consumed to:



Is a CO2 emission :



The technical solution chosen for the floors finally is the following:

- Roof + façade : **TYPE 1 / WOOD PANEL**
- Intermediate floors : **TYPE3 / FULL CONCRETE**

4.2 ROOF

The roof is supported by a wood Arbodal complex which comprises panels in laminated wood -GL 28 h 440 mm wide and 135 mm thick and carries on average from about 5.50 m . The complex functions as the assembly of laminated wood. A gasket compressed Altofeu - in rebates ensures a firebreak of 1 hour 1h.

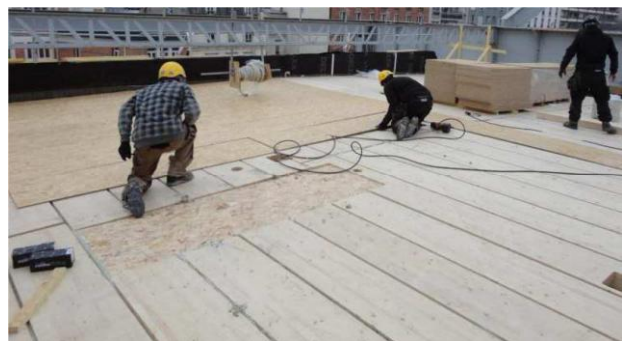
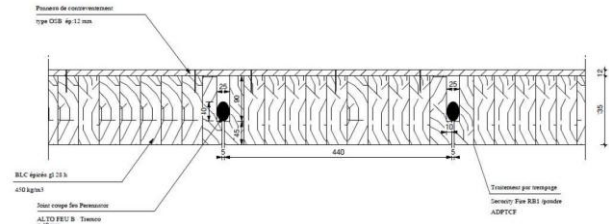


Figure 20: Arbodal wood panels used for the roof / Source Arbonis

4.3 FACADES

The thermal requirements not being the same in terms of premises, two types - of timber frame walls have been implemented.

The hostel uses a frame BM G 24 45 x 220 and contains an insulating - mineral wool 220 mm. outside, one- OSB

3 of 15 mm receives cleats 70 x 70 frame a who-mineral- wool coat insulation of 70 mm. The library benefits, as To- it, a double frame BM G24 2 x 45 x 120-300 mm for blowing of cellulose.- wadding By adding 70 mm mineral wool you finally have 440 mm of insulation.



Figure 21: The façade

5 CONCLUSIONS

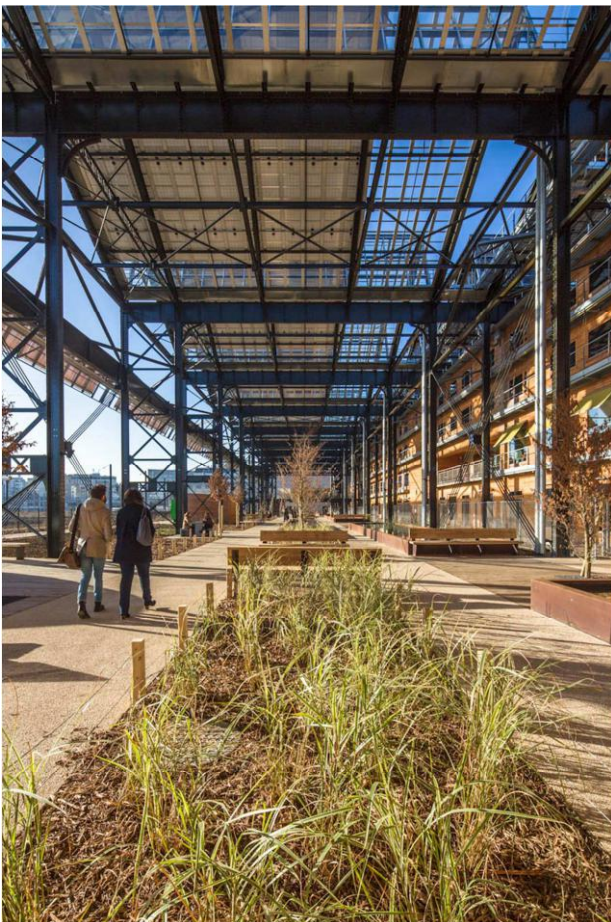


Figure 22: The garden under the roof / Source JAP Architects

This document covers the analysis of the wood-concrete structure of the hall Pajol restructuring Project in Paris and particularly the presentation of the assumptions adopted for the structural design process.

As a general view the uniqueness of this so-called innovative hybrid structure is to be the result of a cross analysis including the relation with the existing steel structure of the hall and the thermal requirements of a contemporary buildings. This situation has led to a very unusual level of analysis regarding the engineering design of a so called common building also maximize by the use of a non-isotropic material such as wood associated with concrete.

6 ACKNOWLEDGEMENTS

From more than anything else this very ambitious project was a success because of the exceptional attitude from members of the design team and from the contractor's ambition to innovate and develop such a structural scheme. I would like then to express my gratitude to:

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