



UNIVERSITAT POLITÈCNICA  
DE CATALUNYA  
BARCELONATECH

# Final dissemination event

Innovative Eco-Construction System Based on Interlocking  
Modular Insulation Wood & Cork-Based Panels  
(IMIP)



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Polytechnic University of Catalonia

Sevilla, 18/04/2023



## IMIP Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based



South European Forest





## Materials



## Pinus Maritimus Maritime Pine





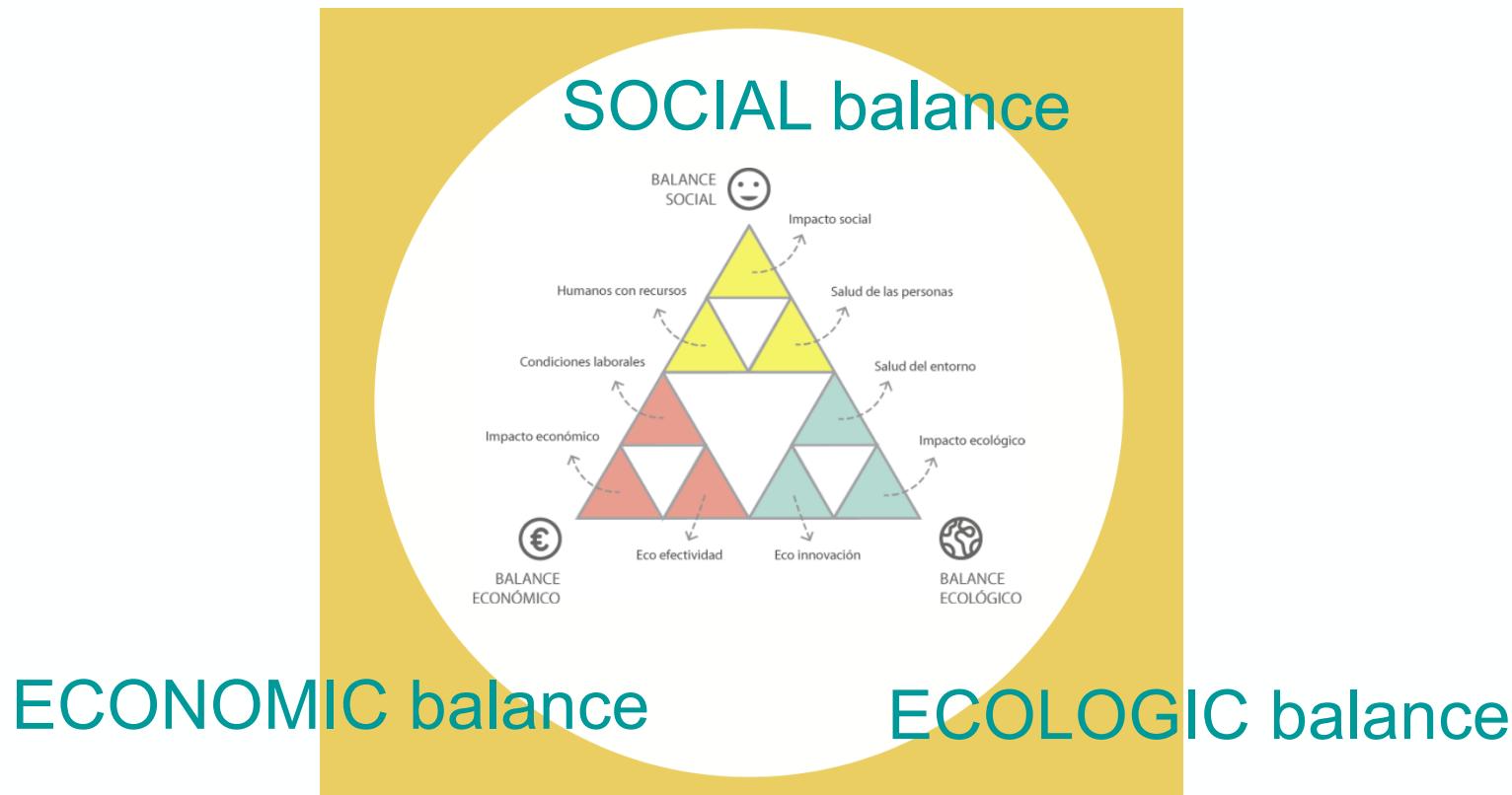
## Objectives



- Revaluation of low performance wood
- Design, use and sectorial integration of construction systems with low environmental impact
- Sustainable construction systems compatible with high energy efficiency
- Reusable and recyclable construction systems



## Triple Balance





## Circular Economy



### CICLO DE VIDA ALCACHOFA



# IMIP Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based



## IMIP Principle

ACV\_ CRADLE TO CRADLE



**IMIP Innovative Eco-Construction System Based on  
Interlocking Modular Insulation Wood & Cork-Based**

# Developed Products & Systems

**IMIP Innovative Eco-Construction System Based on  
Interlocking Modular Insulation Wood & Cork-Based**



**IMIP Systems**

## **SYSTEMS AND CONSTRUCTIVE DETAILS**



# IMIP Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based



## IMIP products

Product	type	IVE code	Composition mm				Width mm	Length mm	Pilot Action
Slab	C	EEFM.4\$	CLT 60	Cork + ribs 200	CLT 60	tot 320	1200	6000	Valencia, Portugal
Cover Salb	A	EEFM.5\$	CLT 60	Cork 100 + ribs 200	OSB 18	278	1200	6000	Valencia
Enclosure Wall	D	EEMM.8\$	CLT 100	Cork 100		200	2400	5500	Valencia, Portugal Espadilla
Structural Insulated Panels SIP	B	EFPM.4a	CLT-OSB 46	Cork 100	CLT-OSB 46	192	1000	2000	Portugal

	mm	Number of layers	Layer Thickness Mm
CLT	45	3	18+9+18
	60	3	20
	100	5	20
	120	6	20
	140	7	20
Cork	60		
	80		
	100		
	120		
	140		



## Panel types

Type A (roof): CLT60+ribs+black cork boards

Type A (Slab):

- CLT 60 mm
- 200mm ribs & granulated cork



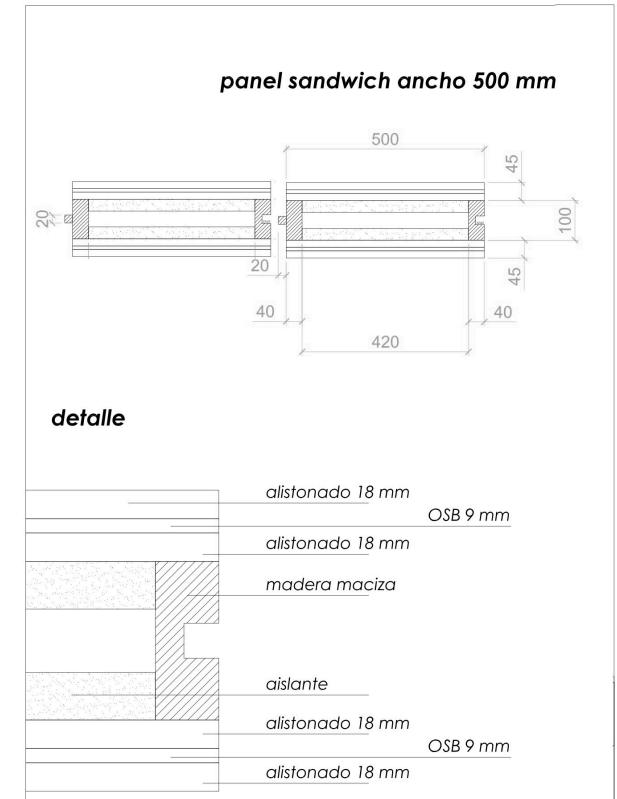


### Panel types

Type B (roof): SIP SWP-OSB45mm+black cork boards

Type B (Roof):

- Composite CLT 45 mm
- 100mm Black cork board
- Composite CLT 45 mm





## Panel types Type C (Slabs): CLT60+ribs+granulated cork

Type C (Slab):

- CLT 60 mm
- 200mm ribs & granulated cork
- CLT 60 mm

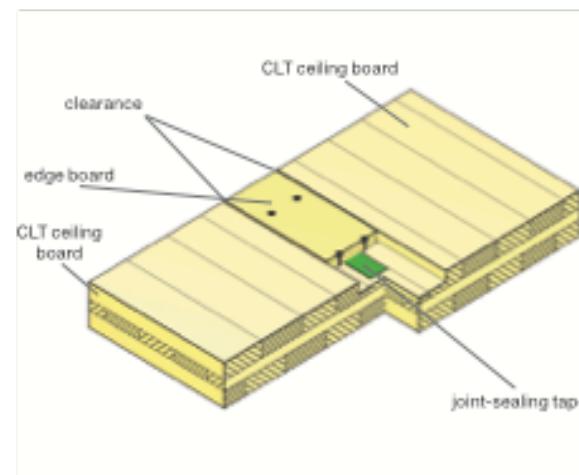




## Panel types Type D (façade): CLT100+black cork boards

Type D (Wall):

- CLT 100 mm
- 100 mm Black cork board

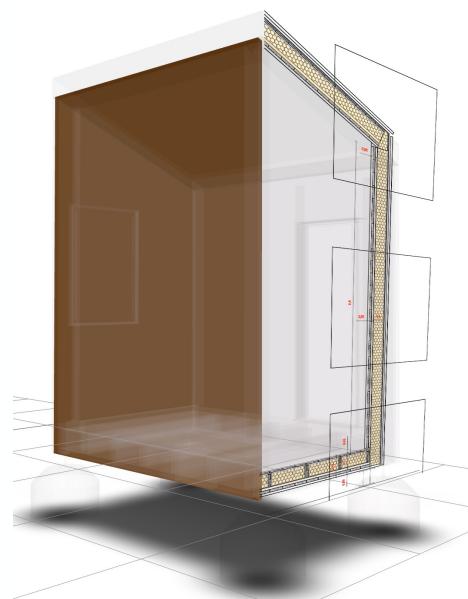
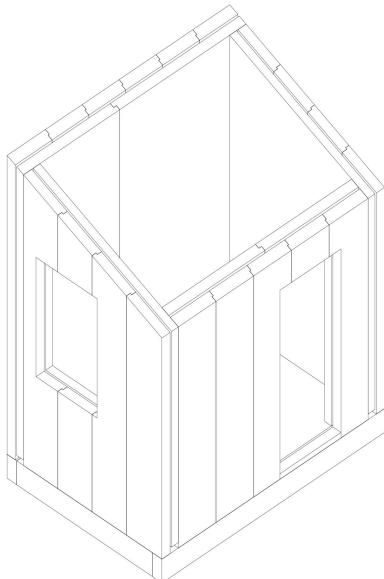




IMIP

# Panel types

## Portugal Pilot Action



**IMIP**

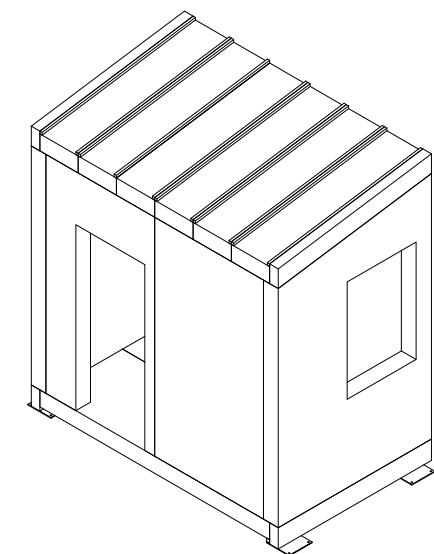
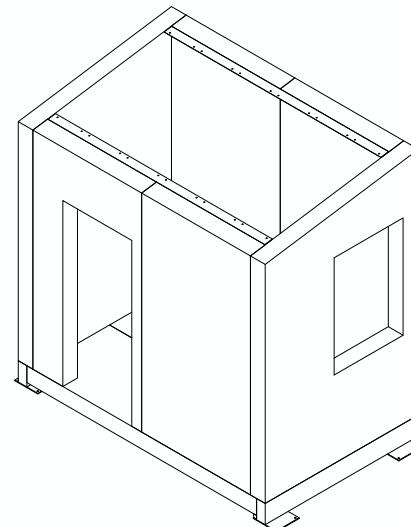
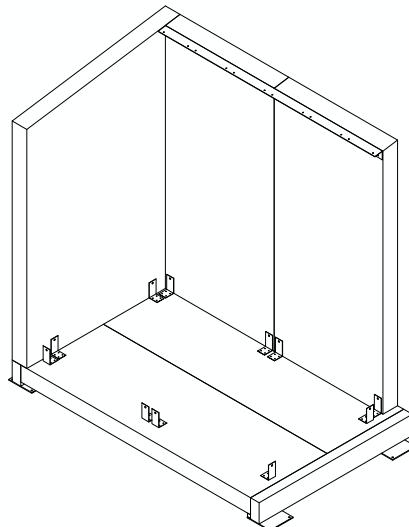
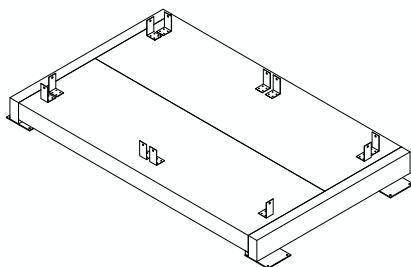
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Interlocking Modular Insulation Wood & Cork-Based**



## Panel types

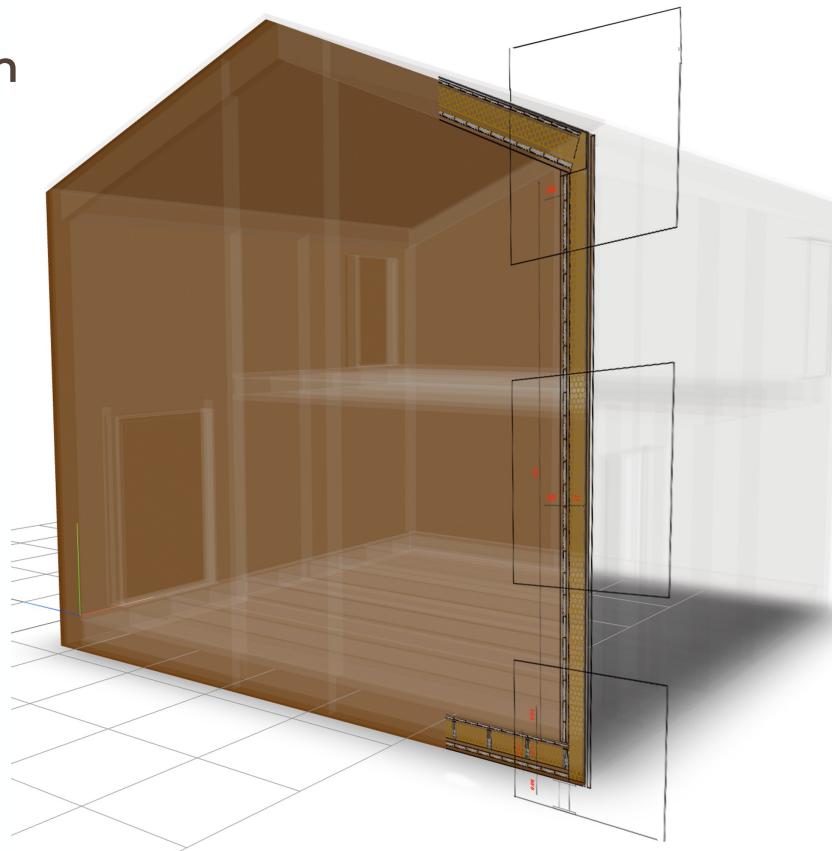
Portugal Pilot Action

**INTERLOCKING PANEL ASSAMBLED SYSTEM**





### Panel types Valencia Pilot Action





## Specific Result

- Innovation in low performance wood composite boards to achieve high performance boards
- Constructive systems based on wood and natural cork compatible with traditional systems
- Optimization of parametric configuration systems - Real-time data analysis ar option systems

# Mechanical Resistance

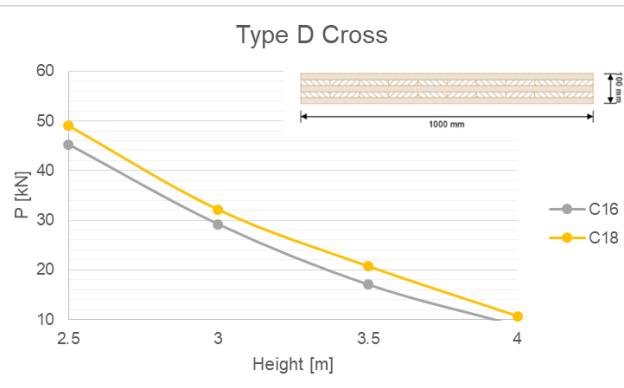


## Panel types Type D (façade): CLT100+black cork boards

Cross (perpendicular)

Type D		
Height [m]	P [kN]	
Material	C16	C18
2.5	45.3	49.0
3.0	29.2	32.1
3.5	17.1	20.8
4.0	8.8	10.7

-Material: C16/C18  
-Panel orientation in the perpendicular direction of the load  
-Loads considered: Wind 1kN/m<sup>2</sup> and eccentricity of 2cm  
-In graphs live load per meter of width [kN/m]  
-Vibrations not considered



### Type D (Wall):

- CLT 100 mm
- 100 mm Black cork board





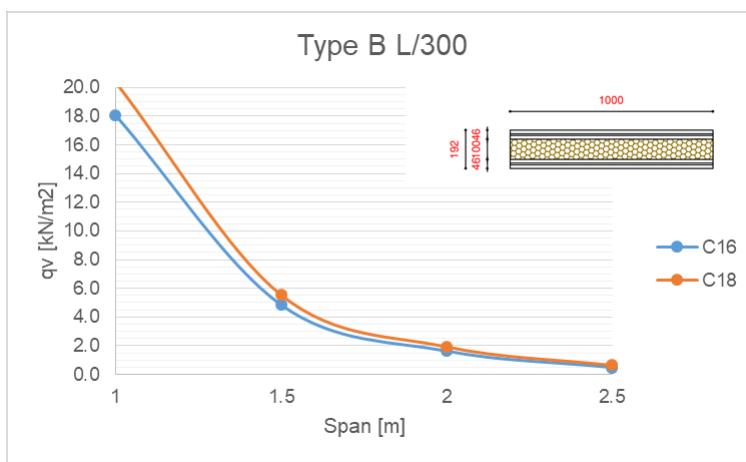
## Panel types

Type B (roof): SIP SWP-OSB45mm+black cork boards

L/300

Type B		
Span [m]	qv [kN/m <sup>2</sup> ]	
Material	C16	C18
1	18.1	20.4
1.5	4.9	5.5
2	1.6	1.9
2.5	0.5	0.6

-Material: C16/C18  
-Deformation L/300  
-Loads considered: PP  
-In graphs live load per meter of width [kN/m]  
-Vibrations not considered



Type B (Roof):

- Composite CLT 45 mm
- 100mm Black cork board
- Composite CLT 45 mm





## Panel types

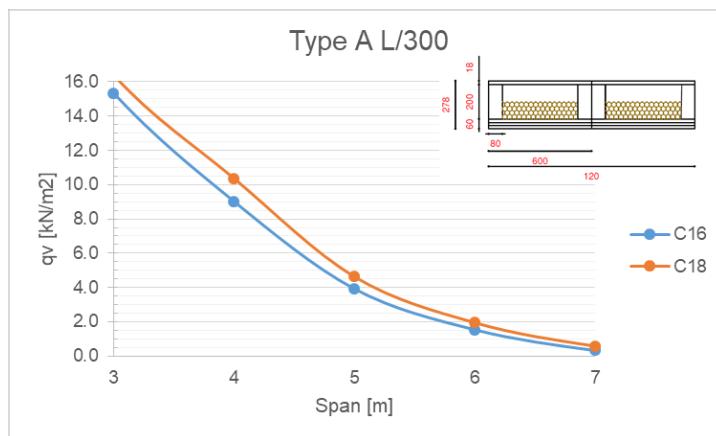
Type A (roof): CLT60+ribs+black cork boards

Type A		
Span [m]	qv [kN/m <sup>2</sup> ]	
Material	C16	C18
2	24.2	25.8
3	15.3	16.4
4	9.0	10.4
5	3.9	4.6
6	1.5	2.0
7	0.3	0.6

-Material: C16/C18  
 -Deformation L/300  
 -Loads considered:  
 PP+1kN/m<sup>2</sup>  
 -In graphs live load per  
 meter of width [kN/m]  
 -Vibrations not considered

Type A (Slab):

- CLT 60 mm
- 200mm ribs & granulated cork





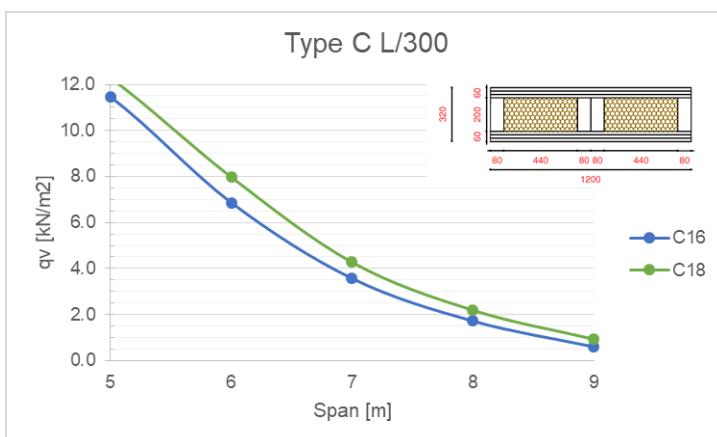
## Panel types Type C (Slabs): CLT60+ribs+granulated cork

Type C		
Span [m]	qv [kN/m <sup>2</sup> ]	
Material	C16	C18
5	11.5	12.3
6	6.9	8.0
7	3.6	4.3
8	1.7	2.2
9	0.6	0.9

-Material: C16/C18  
 -Deformation L/300  
 -Loads considered:  
 PP+1kN/m<sup>2</sup>  
 -In graphs live load per  
 meter of width [kN/m]  
 -Vibrations not considered

### Type C (Slab):

- CLT 60 mm
- 200mm ribs & granulated cork
- CLT 60 mm



# Co2 emissions



## **Quantification of the carbon sink and substitution effect**

Carbon stock's estimate of the prefabricated interconnected modules, according to the methodology described in the UNE-EN standard. 16449:2014.



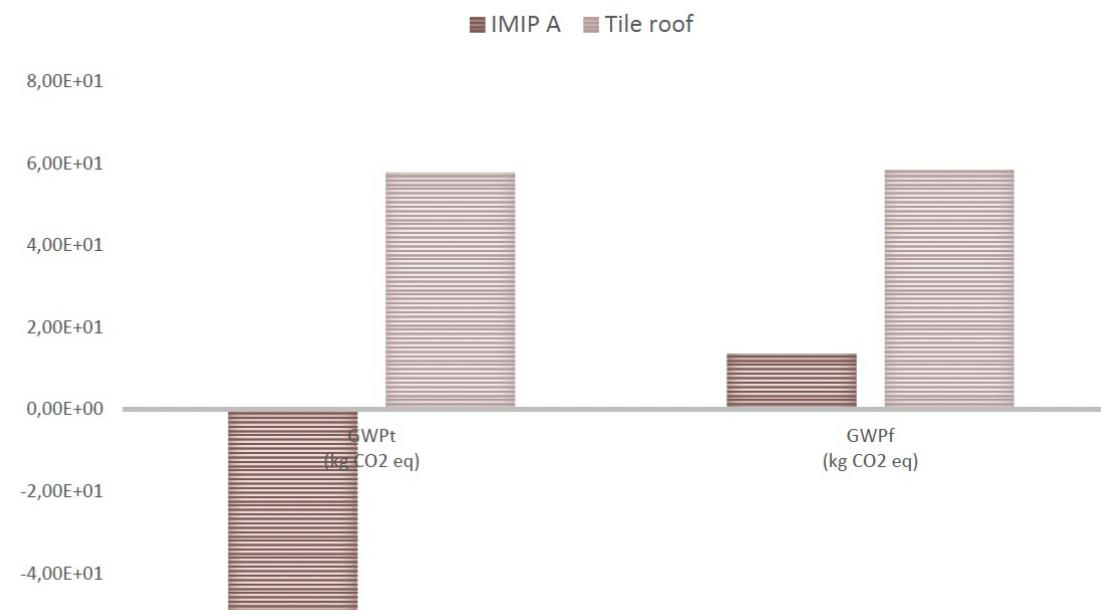
# IMIP panel types

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Interlocking Modular Insulation Wood & Cork-Based



## Co2 Emissions

Chart 5: Comparison between IMIP A (roof) and Tile roof. WLC indicators



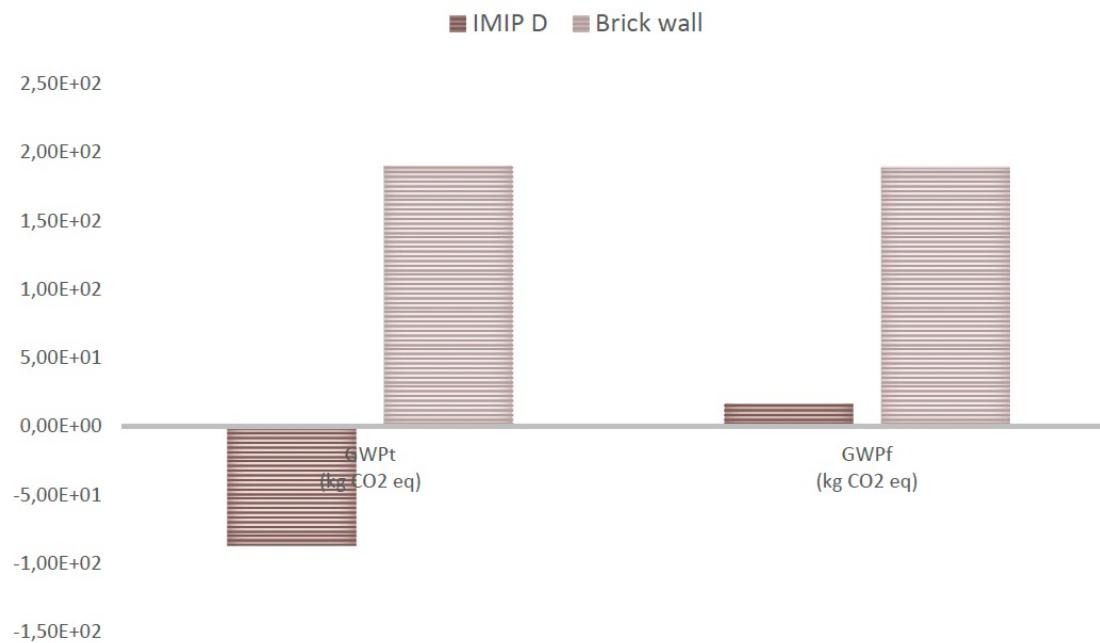
# IMIP panel types

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## Co2 Emissions

Chart 1: Comparison between IMIP D (façade) and Brick wall. WLC indicators



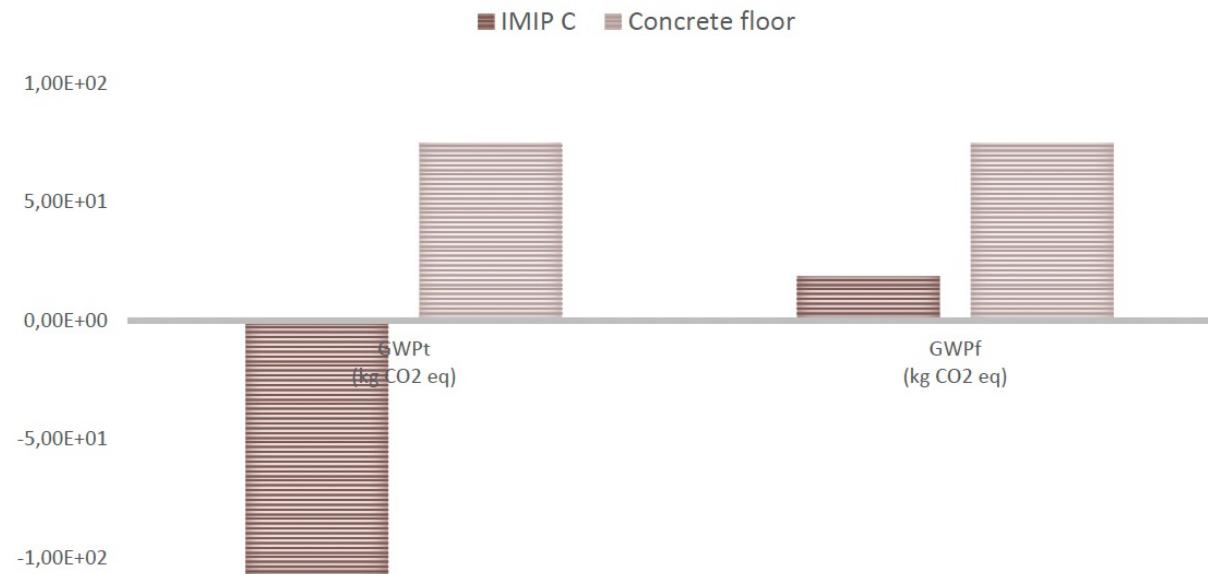
# IMIP panel types

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## Co2 Emissions

Chart 3: Comparison between IMIP C (floor) and Concrete floor. WLC indicators



# ANALYSIS OF ENERGY EFFICIENCY IMPROVEMENT IN PILOT ACTIONS

# IMIP panel types

IMIP Innovative Eco-Construction System Based on  
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## Energy efficiency

**edifici antic**  
113 kg de CO<sub>2</sub>/m<sup>2</sup>/any  
6,5 t CO<sub>2</sub> per habitant/any

OLD OBSOLETE CONSTRUCTION SYSTEMS

250 kWh/m<sup>2</sup>

**edifici segons codi tècnic**  
80 kg de CO<sub>2</sub>/m<sup>2</sup>/any  
5,1 t CO<sub>2</sub> per habitant/any

CONSTRUCTION IN CTE

200 kWh/m<sup>2</sup>

**edifici segons decret d'ecoeficiència de Catalunya**  
50,4 kg de CO<sub>2</sub>/m<sup>2</sup>/any  
3,3 t CO<sub>2</sub> per habitant/any

ECOEFICIENT CATALONIA CONSTRUCTION

130 kWh/m<sup>2</sup>

**edifici de baix consum**  
35,3 kg de CO<sub>2</sub>/m<sup>2</sup>/any  
2,9 t CO<sub>2</sub> per habitant/any

ENERGY EFFICIENT CONSTRUCTION

menor de 85 kWh/m<sup>2</sup>

**edifici passiu**  
16,6 kg de CO<sub>2</sub>/m<sup>2</sup>/any  
2,2 t CO<sub>2</sub> per habitant/any

PASSIVE BUILDING

menor de 42 kWh/m<sup>2</sup>

1 habitatge = 119 m<sup>2</sup> útils  
1kg CO<sub>2</sub> = 1,95 kWh - mix espanyol

**3 ha**



**0,04 ha**



## Certification software

### **Energy calculation engines:**

- DOE2
- EnergyPlus
- ladyBug (grassHopper)
- Celeste (EEE)

### **Software officially recognized in Spain for energy certification:**

- HULC (Ministry of Industry)
- CERMA (IVE)

Others: (Out of the study of IMIP project)

- SG SAVE (uses sketchUp as graphical environment)
- TypeTherm
- CE3 (developed by HULC team with the same engine but simplified (only for existing buildings) promoted by the Ministry of Industry.)
- CE3X (initially only for existing buildings, now with extension for new ones) promoted by the Ministry of Industry.

### **Possible extension to PT and FR certifier programs**

# Webinar

## Pilot Actions

### RESULTS

- Decision making based on the results and final detail definition



IMIP systems

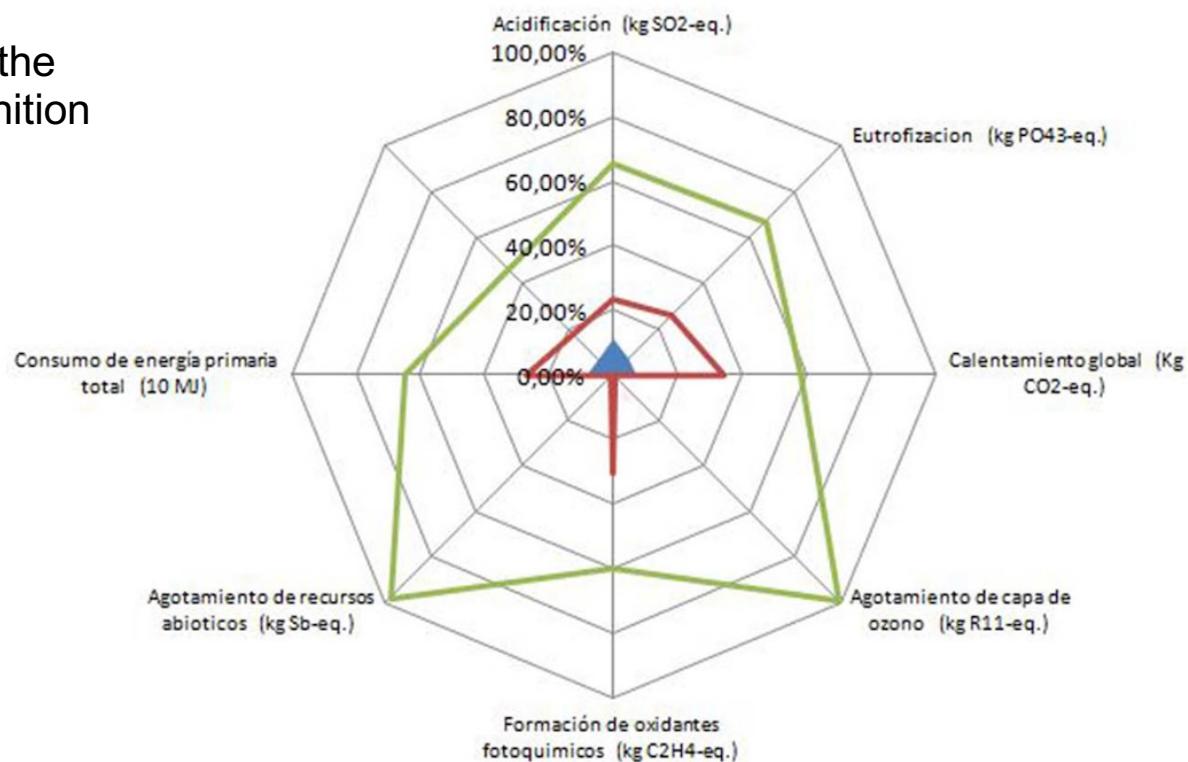


Standard systems

**IMIP Innovative Eco-Construction System Based on  
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### RELATIVE IMPACT /M2



**IMIP Innovative Eco-Construction System Based on  
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# COMPATIBLE SYSTEMS



## COMPATABLE SYSTEMS WITH IMIP

### A. WALL FORMING SYSTEMS

A.1 FRAME WALL

A.2 SOLID TIMBER WALL

A.3 PANELS OR PLATED SYSTEMS

A.4 CLT for Walls

A.5 TIMBER BLOCK WALLS



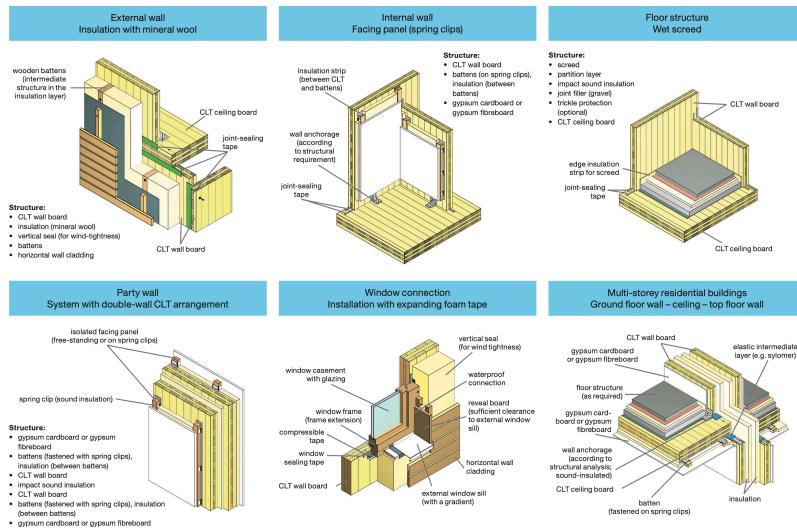


## COMPATABLE SYSTEMS WITH IMIP

### B HORIZONTAL STRUCTURE

#### B.1 PLATFORM FRAME (Rib systems)

#### B.2 CLT, Flooring & Slabs

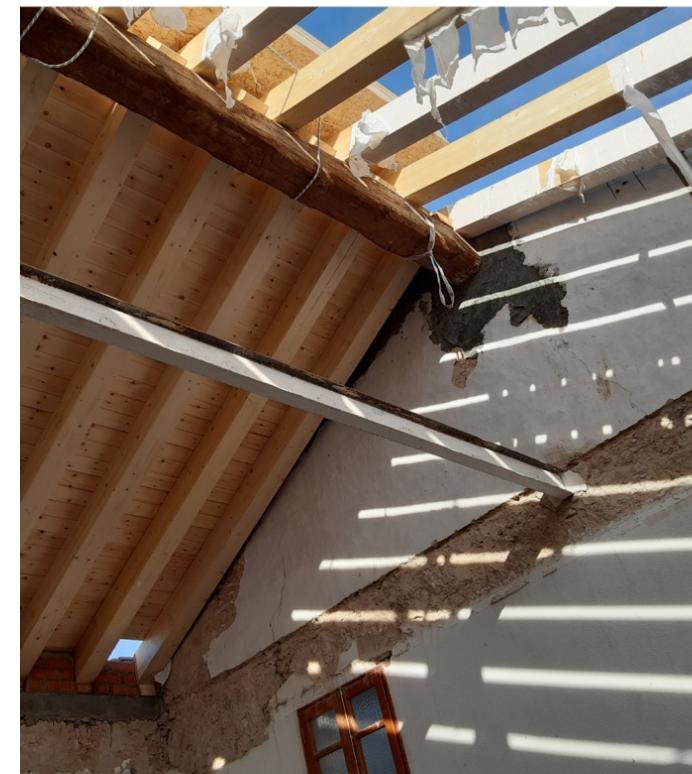




## COMPATABLE SYSTEMS WITH IMIP

### *C ROOF FORMING SYSTEMS*

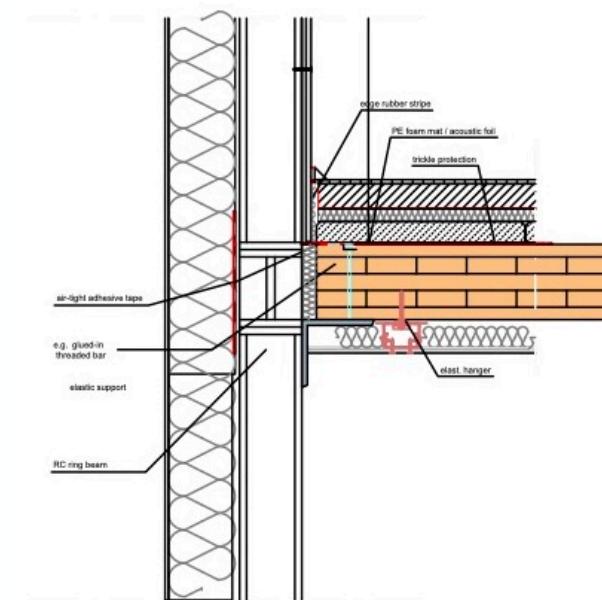
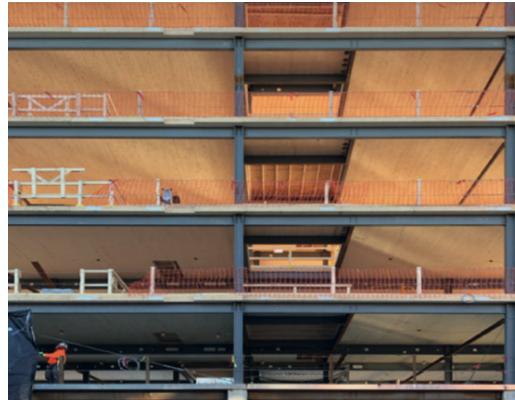
- C.1 CLT CROSS LAMINATED TIMBER FOR ROOF*
- C.2 SIP PANELS FOR ROOF*
- C.3 SANDWICH PANELS*





## COMPATABLE MIXED SYSTEMS WITH IMIP

### D STEEL STRUCTURE + IMIP

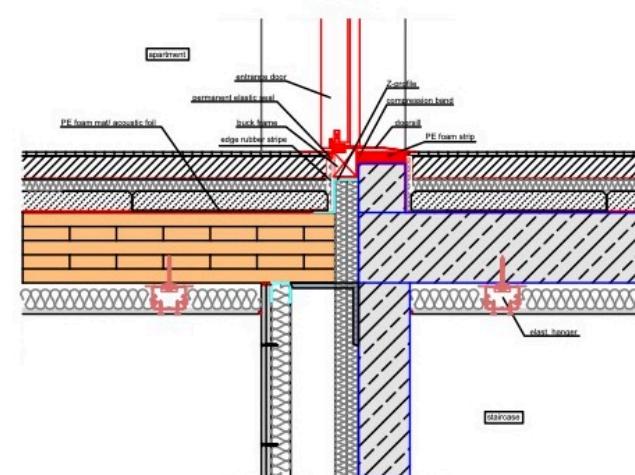


For structural systems that are made up of different resistant materials, it is important to take into account that the expansions and contractions, as well as the movements of the structures derived from the stresses of tensions and moments, are very different depending on the material.



## COMPATABLE MIXED SYSTEMS WITH IMIP

### E REINFORCE CONCRETE + IMIP

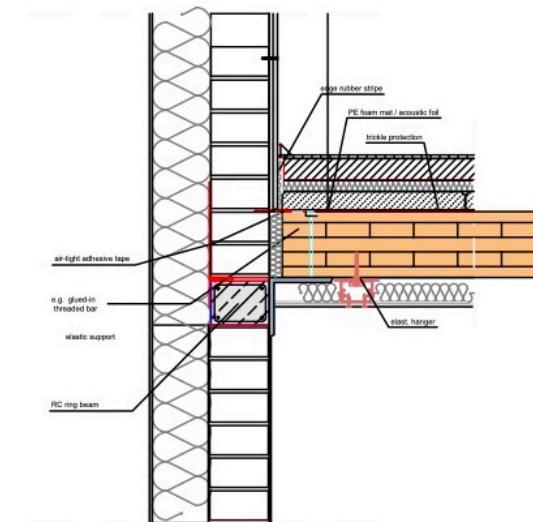


In a different way than in the steel case, the reinforce concrete is working in a very rigid way and the join is able to be rigid. But even in this case, it is necessary a union between the systems that allow possible differential movements between wood and concrete. The union between both systems is usually made by means of an intermediate piece such as a metallic L-shaped profile, separating the clt enough so that the semi-joint does not produce interference between the systems.



## COMPATABLE MIXED SYSTEMS WITH IMIP

### *F LOAD-BEARING WALLS + IMIP*



The structural systems of load-bearing walls are not rigid joint systems either, they tend to be semi-articulated joints due to the differences in behavior between the joint mortars and the resistant pieces.

The floors that are supported by these load-bearing walls generally need a more rigid base on which to make the support or semi-articulated joint.

# 4 Pilot Actions

2 New Buildings  
2 renovation project



## Pilot Actions

### **4 PILOT ACTIONS**

PA 1 - PREFABRICATION & PORTABLE

PA 2 - FULL BUILDING

PA 3 - BUILDING RENOVATION

PA 4 - COMPATIBLE CONSTRUCTIONS



## IMIP Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based

### Pilot Actions

PREFABRICATION + PORTABLE  
Lisbon, Portugal



**IMIP Innovative Eco-Construction System Based on  
Interlocking Modular Insulation Wood & Cork-Based**



## Pilot Actions

PREFABRICATION + PORTABLE

Lisbon, Portugal





## Pilot Actions

TEST SITE BUILDING  
**Valencia, Spain. UPV**



ALZADO SUR

TEST SITE BUILDING



ALZADO NORTE



## Pilot Actions

TEST SITE BUILDING

Valencia, Spain. UPV



ALZADO ESTE

TEST SITE BUILDING



ALZADO OESTE

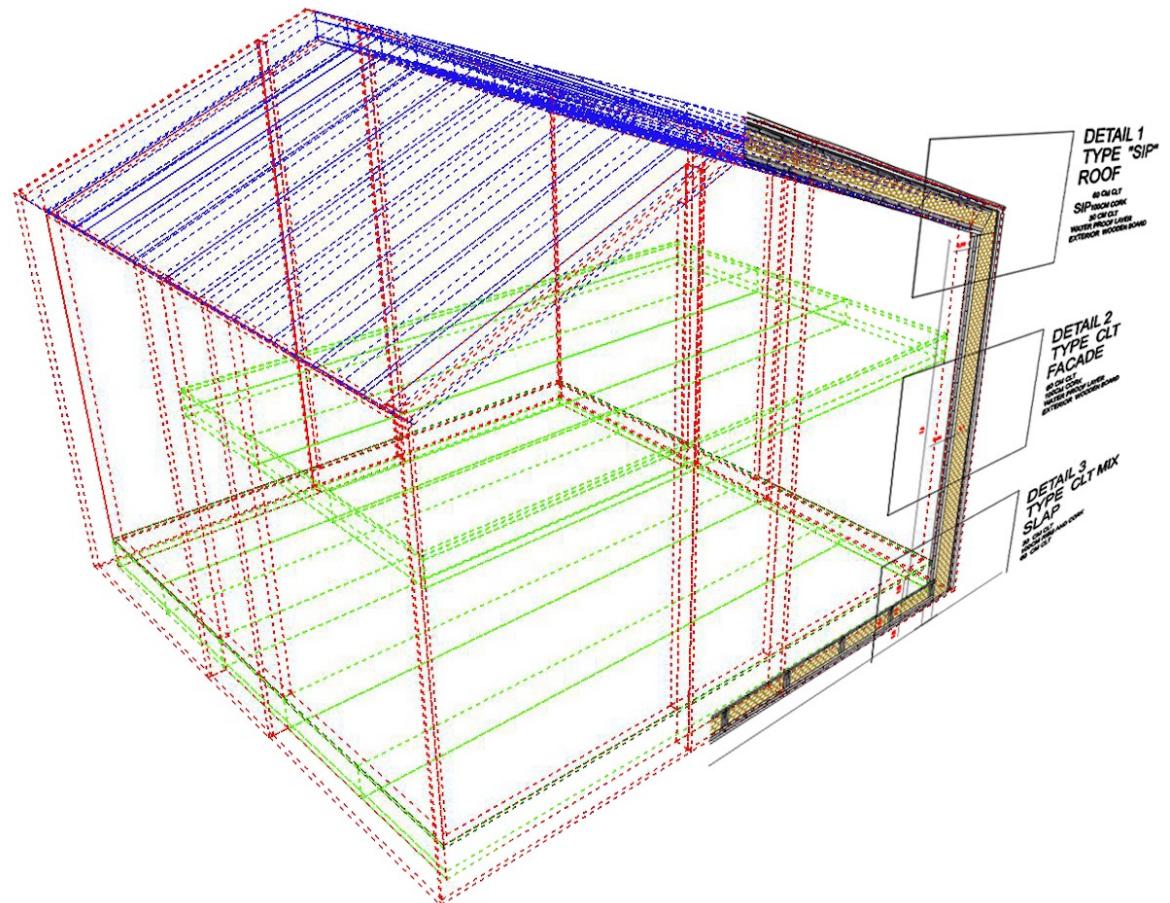


## IMIP Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based

### Pilot Actions

TEST SITE BUILDING

Valencia, Spain. UPV





## IMIP Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based

### Pilot action

ROOF RESTORATION

Espadilla, Spain. UPV



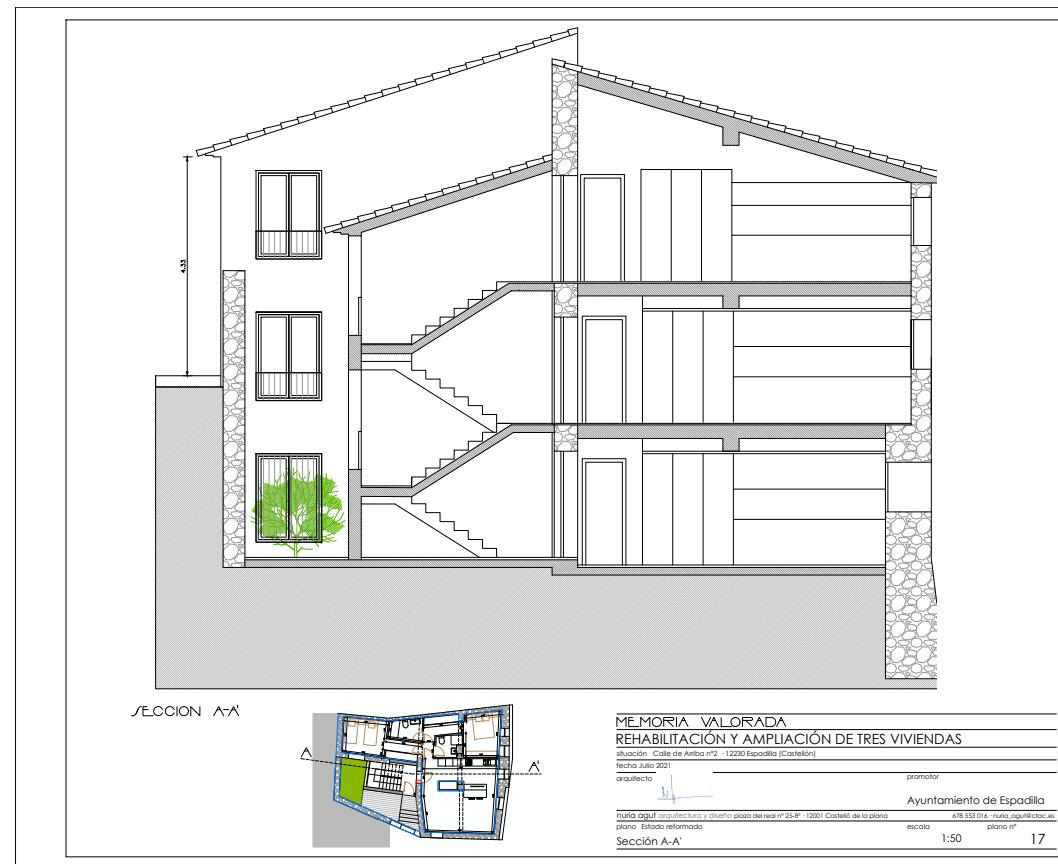


## IMIP Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based

### Pilot action

ROOF RESTORATION

Espadilla, Spain. UPV



**IMIP Innovative Eco-Construction System Based on  
Interlocking Modular Insulation Wood & Cork-Based**



**Renovation project**

5 Spain. UPV





## Renovation project

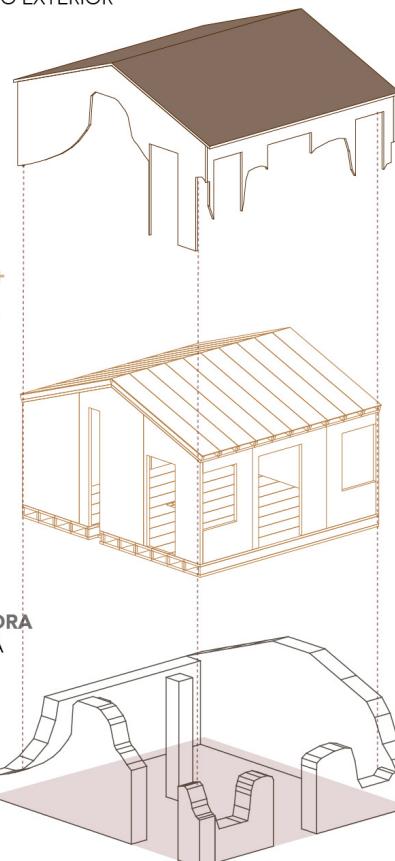
### PREFABRICATION

Spain. UPV

# IMIP Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based



MADERA QUEMADA  
RECUBRIMIENTO EXTERIOR



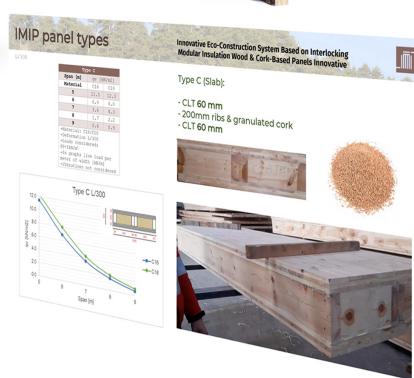
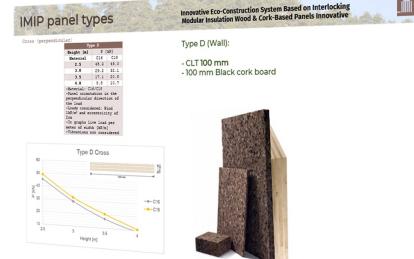
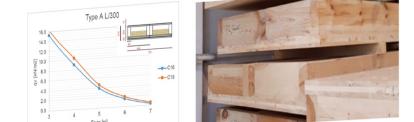
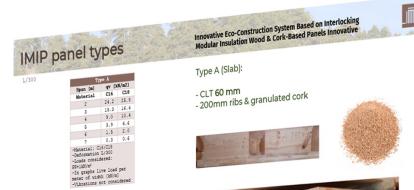
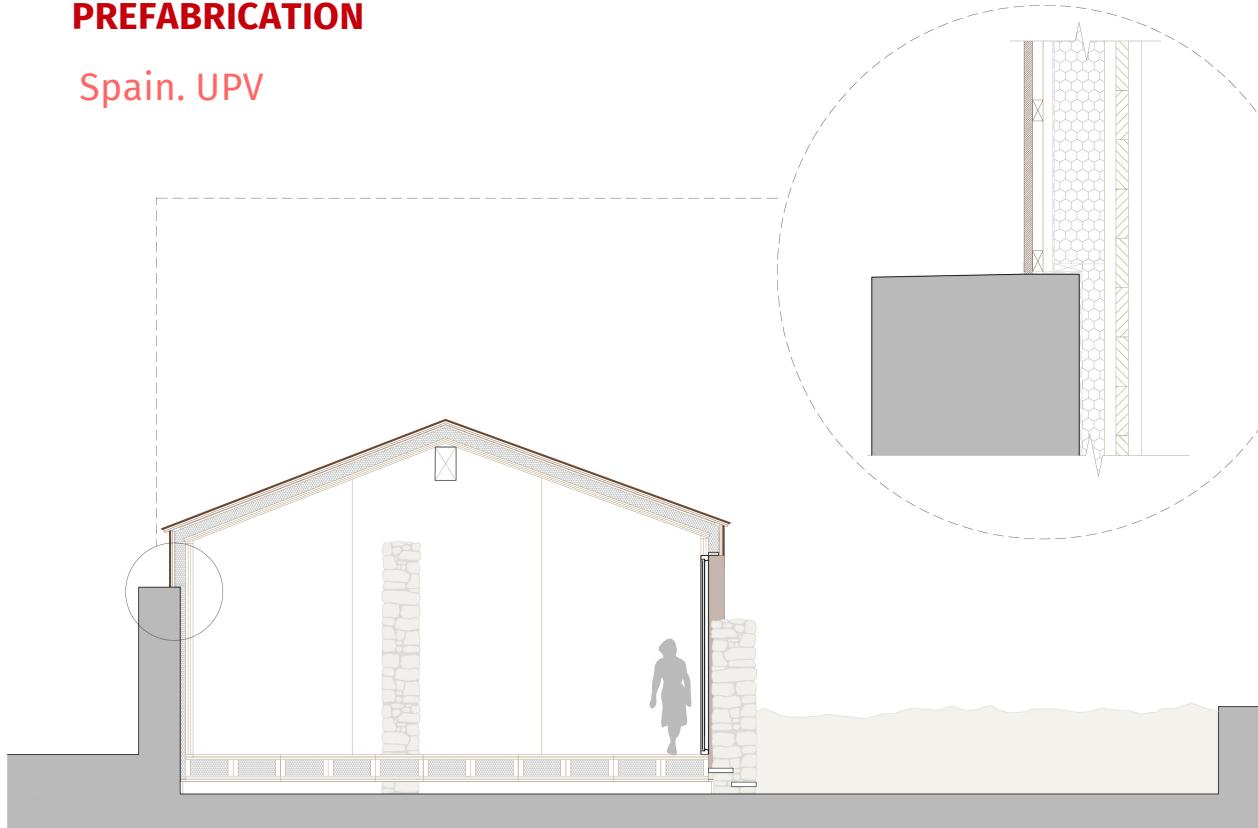
# **IMIP Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based**



## **Renovation project**

# PREFABRICATION

Spain. UPV



**IMIP Innovative Eco-Construction System Based on  
Interlocking Modular Insulation Wood & Cork-Based**



**+1 Renovation project**

5 Spain. UPV



**IMIP Innovative Eco-Construction System Based on  
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# OUT IMIP



## IMIP Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based

**Vilamarxant  
Town hall building**

**Renovation**



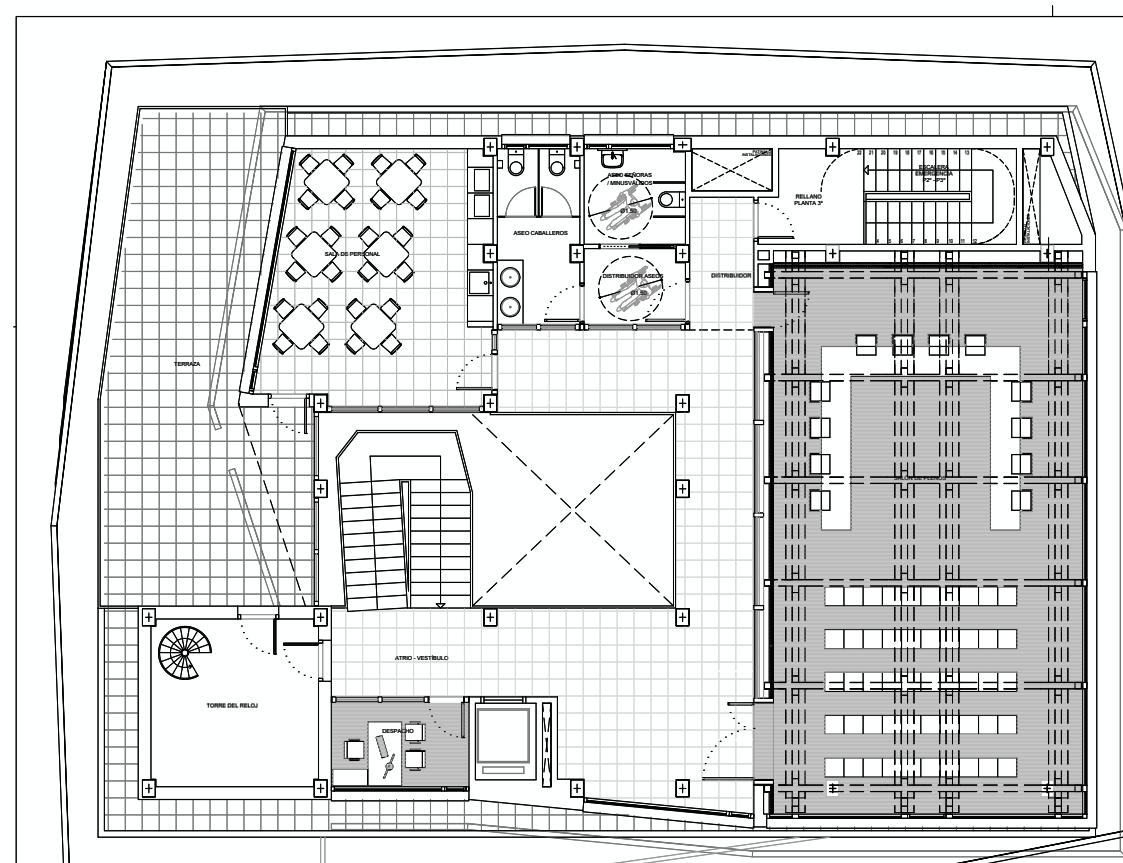


**IMIP Innovative Eco-Construction System Based on  
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**Vilamarxant  
Town hall building**

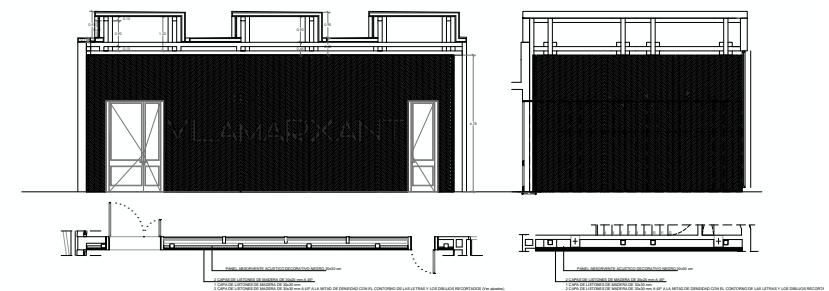
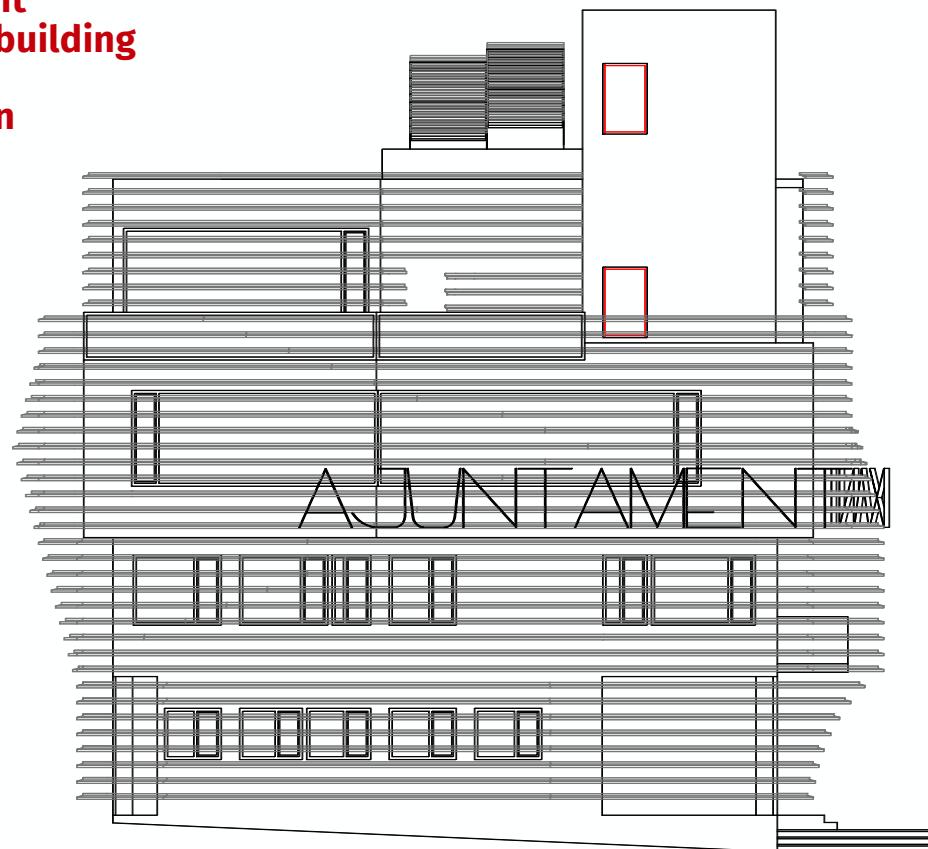
**Renovation**





**Vilamarxant  
Town hall building**

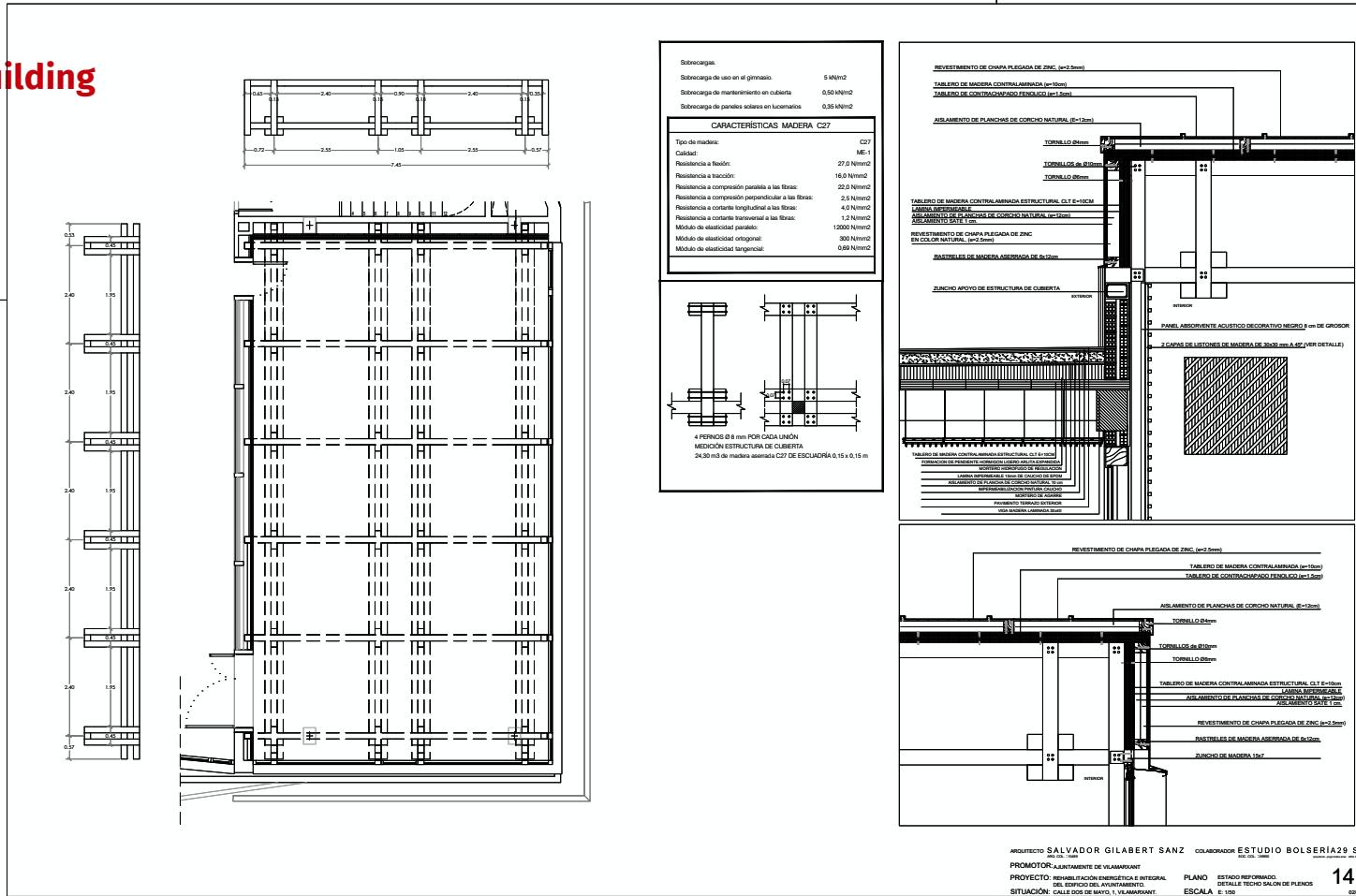
**Renovation**





## IMIP Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based

Vilamarxant  
Town hall building  
Renovation





**Salinas Alicante  
Public Pavillion**

**Nerw Building**



**IMIP Innovative Eco-Construction System Based on  
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**Salinas Alicante  
Public Pavillion**

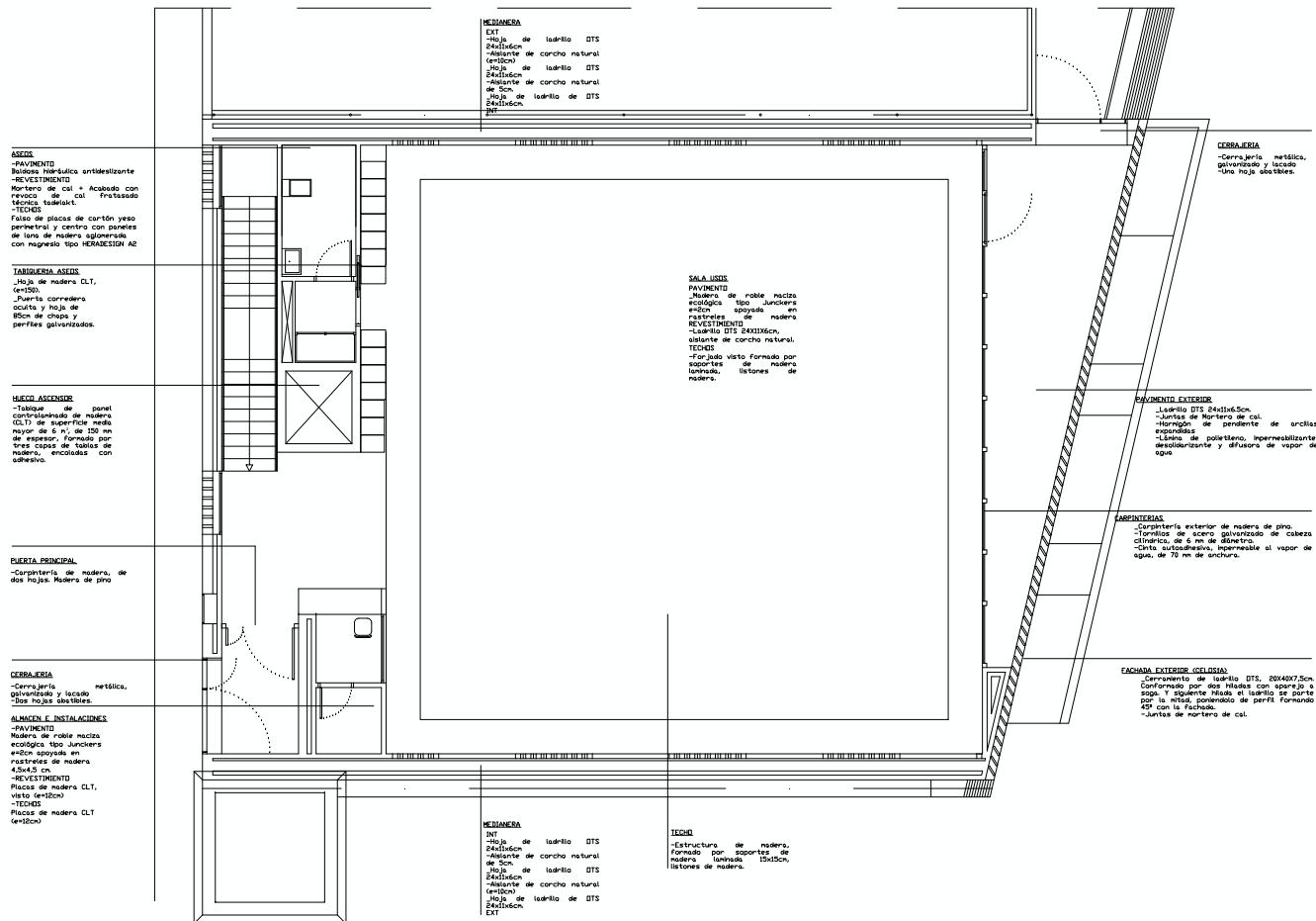
**New Building**





## Salinas Alicante Public Pavillion

### Nerw Building

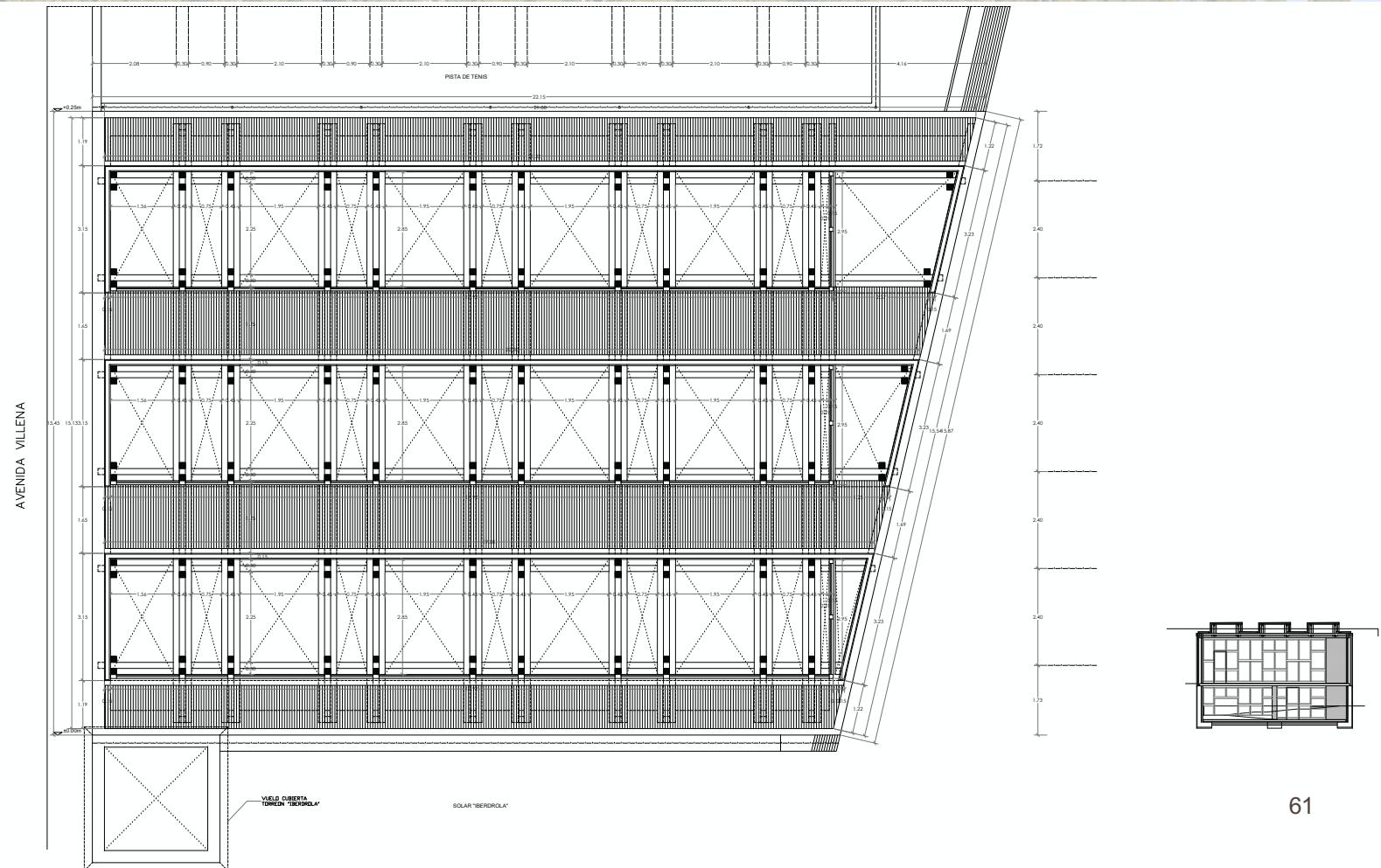




**Salinas Alicante  
Public Pavillion**

**New Building**

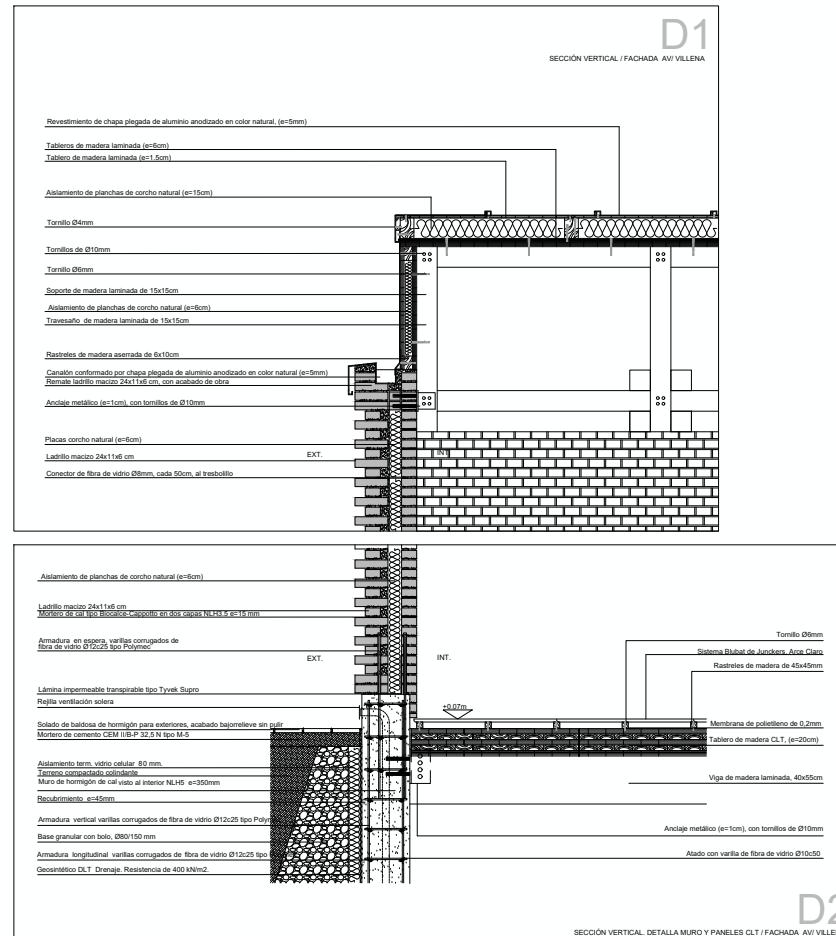
**IMIP Innovative Eco-Construction System Based on  
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## Salinas Alicante Public Pavillion

## Nerw Building





**IMIP Innovative Eco-Construction System Based on  
Interlocking Modular Insulation Wood & Cork-Based**

**Salinas Alicante  
Public Pavillion**

**New Building**



# IMIP

**Salvador.gilbert@upc.edu**

# Thank you for your attention