Interreg Sudoe

EUROPEAN UNION

IMIP_
Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based Panels

European Regional Development Fund

# D.1.5.1
# Good practice guide on technical and quality evaluation of raw material

IMIP-SOE3/P3/E0963

Project funded by the Interreg Sudoe programme through the European Regional Development Funds (ERDF)

# PROJECT CONTEXT

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|---|---|
| *Project acronym* | IMIP |
| *Project title* | Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based Panels |
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| *Coordinator* | Universitat Politècnica de València (UPV), Instituto ITACA |
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| *Working Package (WP)* | WP.1 Integral design of the sustainable construction system value chain |
| *Deliverable* | D1.5.1 Good practice guide on technical and quality evaluation of raw material |
| *Summary* | The deliverable includes the technical and environmental quality requirements that the raw material must have to produce the interconnected panels that will be designed and manufactured in WP2 |
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| *Activity coordinator* | ISA |
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# CONTENT

# INTRODUCTION

This report is included within the tasks, Activity A.1.5, defined in the Work Package 1 (WP1), "Integral design of the sustainable construction system value chain" of the Interreg SUDOE project IMIP-SOE3/P3/E0963 "Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based Panels".

It includes the description of the technical and environmental quality requirements for the raw materials that will be used to produce the project interconnected panels that will be designed and manufactured in the Work Package 2 activities, WP2.

The project objectives, see Table 1, are oriented towards the improvement of energy efficiency policies in public buildings and homes as a support in the change towards a low carbon economy using bioproducts such as wood and cork for smart, sustainable and inclusive growth, by designing an ecological construction system.

The specific objective oriented to design an ecological construction system based on innovative wood an cork products for a low carbon economy require to include technical but also environmental features to the interconnected panels raw materials, including their impact in its manufacturing, transport, building use and of the final disposal of the elements once they have accomplished its function.

Table 1: Programme and Project objectives and results.

| | |
|---|---|
| ***Programme specific objective*** | To improve energy efficiency policies in public buildings and homes through the implementation of networks and joint experimentation. |
| ***Project main objective*** | To support the change towards a low carbon economy using bioproducts (wood and cork) for smart, sustainable, and inclusive growth with a special focus on the public construction sector. |
| ***Project specific objectives*** | To design, validate and implement a new ecological construction system to improve energy efficiency in public buildings. Related activities are:<br>- To design an ecological construction system based on innovative wood and cork products supporting a low carbon economy,<br>- To test prototypes,<br>- To develop an Information and Communication Technology for design, modelling, and evaluation of potential construction solutions,<br>- To compare the modular and interconnected insulating panels designed with currently used insulating panels,<br>- To disseminate results and to train prescribers. |
| ***Programme result indicator*** | Percentage of actors in the energy efficiency sector participating in transnational cooperation projects. |
| ***Project results*** | An interconnected modular system of insulating panels made of wood and cork to improve energy efficiency of buildings, including their entire life cycle.<br>A BIM plug-in to analyse the environmental benefits of bioproducts used in construction (carbon storage and substitute effect). |

# OBJECTIVES

The objectives of this report are:

- to assess the results obtained in other activities of WP1 regarding wood and cork products to be used in the interconnected panels in what regards to quality technical and environmental requirements.
- to summarize which requirements must be laid down for these raw materials.

The information obtained includes in first place the possible wood and cork products that could be used as components of the interconnected panels, assessing its advantages and disadvantages, availability, innovation, technical features and environmental characteristics.

Once the possible products and their use were established, their minimum technical requirements were assessed and its environmental features were defined providing guidelines for these features in the selection and use of the possible raw materials for the project panels', in accordance with the project objectives and good technical practices.

# THE SUDOE SUSTAINABLE WOOD AND CORK CONTEXT

The South-West Region of the EU is comprised by Spain, Portugal, regions of the South-West of France, Gibraltar and Andorra enclosing an intercommunicated context with common features but also climatic and cultural differences.

Among the wood species available for manufacturing construction wood products are generally softwoods, of these, especially pine trees of several Mediterranean and Atlantic climate species stand out. Over all these species, the only one that is present throughout the region is Maritime Pine (*Pinus pinaster* Ait.), which is the main wood species in Portugal and a very common and used species in France and Spain.

Other interesting species are hardwoods such as Sweet Chestnut or Oak commonly used in construction within the region. However, they are more difficult to use in building as they have higher prices and longer and more complex drying processes than softwoods.

Finally, one of the improvements expected as a result of this project is to increase the use of South-West European produced sustainable insulation cork or cork-based products. Cork is a natural and renewable product, bark of the cork oak, that Is present in Portugal and some regions of Spain and France and is commonly used for stoppers manufacturing but also for the fabrication of building products, with different processing degrees, such as thermal or acoustic boards or granulated products.

## RAW MATERIALS CONSIDERED FOR THE PROJECT

Within this frame two main autochthonous softwood wood species were selected as possible base for the manufacturing of the components of the Interconnected panels: Maritime pine (*Pinus pinaster* Ait.) and Aleppo pine (*Pinus halepensis* Mill.). The first was selected for being a species readily available and important in most of the SUDOE region and the second due to Its high presence in terms of surface in the Mediterranean area of the SUDOE region, although showing low industrial use.

Maritime pine is commonly used for low added value products but also is a species with possible applications as structural or loadbearing products since it is included in the grading standards for structural timber. Therefore, it was defined as the most suitable and advantageous species for the project, as its use in higher value applications will be interesting for most of the SUDOE countries.

Aleppo pine was considered very interesting during the preliminary research but, despite of its large distribution area, the availability of sawn wood was found to be very limited compared to other species such as maritime pine as is not commonly used for Industrial purposes, except for pallet manufacturing. The difficulty in finding graded or dried wood supply, the fact that is not currently included in any structural timber grading European standard except in the French standard, together with being a species not available in some important areas of the SUDOE region such as Portugal lead to disregarding this species as a component of the panels.

Other pines more often used for construction such as Scots Pine (*Pinus sylvestris*), Black Pine (*Pinus nigra* Arnold) or Radiata Pine (*Pinus radiata* D. Don) were

considered as interesting options in the preliminary research but since they are commonly used in structural products and none of them were present in Portugal, finally its use was also disregarded.

Having the use of Maritime Pine in mind a structurally graded derived product with intermedium-low Strength Class or the use of a reconstituted material was targeted as this species is known to be of high variability in its quality. Due to this feature its use in a high Strength Class requirement could lead to difficulties in its supply and generate a high percentage of rejected material, which would be against the objective of the project of looking for a sustainable and smart use of the raw materials.

Also, as the project aims to panel designs in which the amount of wood use is reduced when compared to other solutions, the use of graded finger-jointed lamellas and hollow or ribbed designs is deemed as important. To be able to produce these efficient load-bearing elements, the also the use of structural glued joints was considered necessary, although looking for a reasonable use of this raw material for example using adhesives which will require lower spread ratios, such as one-component structural polyurethane glues.

As for the cork, several products ranging from simply mechanically processed (grounded particles of cork) to naturally (through thermal treatment) or artificially bonded cork particle boards are available. All of them were considered of interest. However, those produced exclusively using cork such as granulated cork or expanded black cork boards (ICB) in different densities were considered the best option given the objectives of the project.

In order to reduce costs and $CO_2$ emissions due to transport operations, materials produced in the SUDOE region must be selected, except for those very specialised as PUR certified structural adhesives not available in the region.

Tables 2 and 3, show the main raw materials considered for the project, its main advantages and disadvantages and their possible uses.

Table 2: Wood-based raw materials and adhesives considered for the manufacturing of the interconnected panels of this project.

| | Species/Type | Potential use | Dimensions[a] (mm) | Performance/ Moisture content | Advantages | Disadvantages |
|---|---|---|---|---|---|---|
| ***Sawn timber for structural purposes*** | Maritime pine boards and planks | -Lamellas for glued laminated products<br>- Finger-jointed stringers or ribs, transversal pieces in panels | W: 100-160<br>L: 2000-2500<br>T: 10-50<br>W: 30-100<br>L: 2000-2500<br>H: 140-260 | C18 / 12%<br>C18 /12% | Availability<br>Species of interest<br>Natural and smart use of RM<br>Increase of added value | Quality variability |
| ***Wood-based panels*** | Maritime pine alone or mixed with other species (Plywood, OSB, SWP) | Sheathing or intermediate layers in glued products such as panels or panel faces | W: 500-1220<br>L: 2000-3600<br>T: 10-50 | Structural panels. According to its technical class. | Price<br>Species of interest<br>Natural and smart use of RM | Depending on the panel type: lack of thickness or dimensional changes to consider with moisture variations, etc. |
| ***Structural adhesives*** | MUF, PUR 1C, EPI | Glued laminated products bonding: stressed skin panels, and finger-jointed wood elements manufacturing | - | Type I structural adhesives certified using European standards, to be used according EN 16351/EN 14080 | Durability<br>Stiffness in joints<br>Standardization fulfilment | Synthetic element |

[a] W: width; L: Length; H: Heigth; T: Thickness

Table 3: Cork-based raw materials considered for the manufacturing of the interconnected panels of this project.

| | Species/Type | Potential use | Dimensions[a] (mm) | Performance/ Moisture content | Advantages | Disadvantages |
|---|---|---|---|---|---|---|
| ***Granulated cork*** | Mechanically ground cork | Insulation and filling element | Different granulometries | According to the properties declared by the manufacturer | Availability<br>Low price<br>Species of interest<br>Natural and smart use of RM | Lack of mechanical coherence<br>Lack of standardization and technical information on performance |
| ***Expanded cork boards*** | Insulated Cork Boards (ICB) | Insulation element, and load-bearing core in sandwich panels | W: 500<br>L: 1000<br>T: 30-100 | According to its density and properties declared by the manufacturer | Availability<br>Species of interest<br>Natural and smart use of RM | Price<br>Low mechanical properties (depending on density)<br>Limited sizes |
| ***Adhesive bonded cork boards*** | Agglomerated Cork Boards | Insulation element, impact acoustic insulation element | Different dimensions depending on the manufacturer | According to its density and properties declared by the manufacturer | Availability<br>Species of interest<br>Natural and smart use of RM | Price, lower thermal insulation properties<br>Lack of standardization and technical information on performance |

[a] W: width; L: Length; H: Height; T: Thickness

# TECHNICAL REQUIREMENTS FOR THE RAW MATERIALS

This chapter summarizes the minimum technical requirements considered within the frame of this project for the selected raw materials included in Tables 2 and 3.

## SOFTWOOD SOLID WOOD AND LAMELLAS QUALITY REQUIREMENTS

There are two general different solid wood grading methodologies: grading for visual or decorative purposes and grading for structural purposes. Also, specific grading for some industrial products such as pallets exists. In addition to wood quality, moisture content, dimensions and surface planning must be considered as very important features.

Since most of the interconnected panel system's elements are expected to be used as load-bearing members with different degree of responsibility, the use of structural solid wood (strength graded solid wood) must be necessary as raw material. In addition, for some wood used as a sheathing or siding visual or decorative grading should be stablished prior to the production of the elements.

### Lamella or finger-jointed structural solid wood. Requirements.

The manufacturing of lamellas or finger-jointed solid wood products for the production of glued laminated products as components of the interconnected panels require grading the wood for structural purposes in accordance with a standard depending on its country of origin. Within the main countries of the SUDOE region, these standards are:

- Portugal: NP 4095:1995. *Madeira serrada de pinheiro bravo para estruturas. Classificação visual.* Grades included in this standard: E grade.
- France: NF B52-001-1 Avril 2018. *Règles d'utilisation du bois dans la construction - Classement visuel pour l'emploi en structures des bois sciés résineux et feuillus - Partie 1 : bois massif.* Softwood grades included in this standard are ST-I; ST-II; ST-III and ST-IV.

- Spain: UNE 56544: 2011. *Clasificación visual de la madera aserrada para uso estructural. Madera de coníferas.* Softwood grades Included in this standard: ME-1; ME-2 and ME-G.

For glued laminated products manufacturing, these standards are used in the lamella production process for removing, by cutting, sections of board that do not fulfil the requirements of the grade prior to the finger-jointing process.

For a C18 target strength class according to EN 1912:2012 standard and its amendment EN 1912:2012+AC2013, the visual strength grades required for maritime pine are: E grade for pine grown in Portugal, ST-III grade for pine grown in France and ME-2 grade for pine grown In Spain, see Table 4, grading requirements.

The cross-section of the wood is important in the French and Spanish standards. Because the maximum solid wood cross-section to be used in the boards or planks is expected to be 60 x 260 mm, the grading table to use in the NF standard is the one for sections of a maximum of 16.000 $mm^2$, and in the UNE standard a ME-2 grade, that apply to wood of a maximum of 70 mm thick.

Manufacturers that produce solid structural timber for sale in Europe must have CE Marking according to EN 14081-1 requirements (designated grader, factory production control, initial type testing or use of a wood species included in EN 1912, etc.). All the timber has to be graded visually or in some cases using grading machines that have to be also certified according to EN 14081-2 standard.

A very important requirement in the production of finger-jointed wood lamellas or stringers is the need to fulfil minimum distances between the knots to the joint as required in the manufacturing standards for glued laminated products such as EN 14080 (3*knot size), and other requirements, see Table 5.

For lamellas to be used in a panel's face that will be left uncovered additional visual grading requirements can be requested, named as "Visible" quality. See table 5.

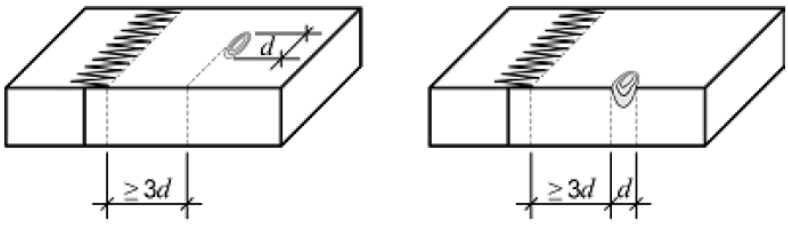


Figure 2: Minimum distance between knots and finger joints y lamellas. Source: EN 16351, Annex I.

In addition to the structural grade, it is very important to prescribe the correct moisture content depending on the final use. A moisture content of less than 20 % is commonly considered “Dry graded” in solid timber, but for glued laminated products or composite products the moisture content of the boards or planks used to manufacture shall be inferior, 12±2 %. This has to be prescribed when ordering the raw material and will require the use of kiln dried wood.

Drying will reduce the dimension of the solid wood boards, and therefore the final dimension of the material (planks, boards) should be related to the final supply moisture content when ordering the wood.

Also, it is important to know if the final product to be considered will be planned or not, and the final dimensions of the boards or solid wood provided by the supplier must be consulted with the manufacturer prior to ordering the pieces. Some pre-planning is recommended for not fully planned boards to be used in any load-bearing glued product.

For manufacturing glued laminated products, the supply of boards will be finger-jointed and the lamellas produced shall be planned again, so lack of thickness should be prevented in advance by consulting to the manufacturer the dimension that will be required to reduce in the planning, when ordering the raw material.

Dimensional tolerances for solid wood are described in EN 336 standard, depending on the accuracy required and on the piece dimension. Glued Laminated Timber (GLT) and Cross Laminated Timber enclose dimensional requirements for the lamellas once planed, and extreme care has to be taken with their thickness uniformity, since a very low dimensional tolerance is allowed (0,1-0,2 mm for GLT is

stated in EN 14080, depending on the lamella thickness, type of glue and dimension).

If the boards or planks used for manufacturing structural finger-jointed elements (lamellas or stringers) are not previously graded for structural purposes and this will be done in the process, also in this case at least the wood must be previously graded with a visual non-structural minimum quality, in four faces, close to the target structural grade, see “Non-structural graded wood” section of this document. This will avoid high amounts of material rejection and must be arranged with the wood supplier before ordering.

Table 4: Summary of main requirements for a C18 Strength Class for maritime pine according to three grading standards

| | Portuguese wood - NP 4095:1995 / E grade | | | French wood - NF B52-001-1 Avril 2018 / ST-III pine grade | | Spanish wood - UNE 56544:2011 / ME-2 grade | |
|---|---|---|---|---|---|---|---|
| | **Method for measuring** | **Requirement** | | **Method for measuring** | **Requirement** | **Method for measuring** | **Requirement** |
| ***Knots-isolated or grouped*** | Knot Area Ratio (KAR)<br>Projected area occupied by the knots in a cross-section referred to the total cross-section | $KAR_{TOTAL} \leq 1/2$<br>$KAR_{MARGIN} \leq 1/2$ | $KAR_{TOTAL} \geq 1/2$<br>$KAR_{MARGIN} \leq 1/3$ | Knot diameter perpendicular to the edge related to the face or edge dimension | 2/3 of face and ≤30 mm<br>1/2 of edge and ≤30 mm | Knot diameter perpendicular to the edge related to the face or edge dimension | 2/3 of edge<br>1/2 of face |
| ***Grain deviation*** | Transversal deviation referred to the longitudinal direction | 1/6 | | Transversal deviation referred to the longitudinal direction | 1/4 local deviation<br>1/6 general | Transversal deviation referred to the longitudinal direction | 1/6 |
| ***Bark inclusions/ resin pockets*** | Length measurement | Only in one face: ≤ Face width; appear in two opposite faces ≤ 1/2 Face width | | Length measurement and visual inspection | Bark inclusion not admitted. Admitted resin pockets < 80 mm | Length measurement and visual inspection | ≤ 1,5 x Face width (for both features) |
| ***Pith and growth rate*** | Visual inspection of pith presence. Radial growth divided by no. of rings | Pith admitted<br>Growth rate < 10 mm | | Visual inspection of pith presence. Radial growth divided by no. of rings | Pith not mentioned. Growth rate < 10 mm | Visual inspection of pith presence. Radial growth divided by no. of rings | Pith admitted. Rate of growth not limited |
| ***Other features*** | fissures, wane, deformations etc. | Consult standard requirements | | fissures, wane, deformations etc. | Consult standard requirements | fissures, wane, deformations etc. | Consult standard requirements |

Table 5: Complementary requirements for lamellas manufactured with C18 Strength Class wood

| | Feature description | Requirements | |
|---|---|---|---|
| | | Unplanned lamellas supply | Planned lamellas supply |
| ***Knots distance to finger-join*** | Distance between the knot perimeter and the finger-joint edge | Distance ≥ 3 x knot diameter | Distance ≥ 3 x knot diameter |
| ***Decorative features*** | Presence of blue stain, black knots, hollow knots or resin pockets | Depending on project decision could not be allowed for the lamellas defined to be used as "visible" quality | Depending on project decision could not be allowed for the lamellas defined to be used as "visible" quality |
| ***Wane*** | Presence | Not allowed if exceed the dimension that can be removed in the planning process to be carried out afterwards. | Not allowed |
| ***Finger-joint geometry*** | Finger joint geometrical features (length etc.) | According to EN 14080, Annex I, chapter I.4 | According to EN 14080, Annex I, chapter I.4 |
| ***Planning tolerances*** | Planning and deformation tolerances in the piece | No deformation (bowing, cup, twist) allowed over the dimension that can be removed by the planning process to be carried out afterwards. Dimension tolerance by accordance with the supplier. | No deformation (bowing, cup, twist) allowed in lamellas. Planned thickness tolerance according to EN 14080 |
| ***Moisture content*** | All components of the lamella measured. | 12±2% Moisture content | 12±2% Moisture content |
| ***Adhesive and manufacturing*** | Adhesive for finger-joint and manufacturing process | Structural certified adhesives according to EN 301, EN 15425 or EN 16254. The gluing must fulfil the adhesive technical sheet and EN 14080 requirements. | Structural certified adhesives according to EN 301, EN 15425 or EN 16254. The gluing must fulfil the adhesive technical sheet and EN 14080 requirements. |
| ***Finger-joint strength*** | Lamella strength in bending or tension with a finger-joint | According to EN 14080 or EN 16351 requirements for the declared Strength Class of the wood (C18). | According to EN 14080 or EN 16351 requirements for the declared Strength Class of the wood (C18). |

## Non-structural graded wood:

Appearance grading shall be applied to all non-structural visible elements whatever its end use. This non-structural grading could be used also to some extent to pre-grade when ordering boards or planks for finger-jointed structural element manufacturing in order to avoid excess of rejected material.

Structural grading is focused on strength reducing features such as certain knots, but disregards other features that are not considered important for this purpose such as blue stain, surface or hollow knots presence, that in visual applications could be considered important.

European standards such as EN 1611-1 allow to grade softwood non-structural wood in two or four faces according to different qualities (G2-0 to G2-4 and G4-0 to G4-4), see Table 6. However, the use of this standard is complex and, at least in Spain, uncommon. Also, other industrial specifications for non-structural grading rules are available such as the Nordic Timber Grading Rules of 1994 (also known as the “Blue book”) with classes A, B, C and D; and the Nordic Timber Grading Rules of 1960 (“Green book”) with grades U/S, V, VI and VII, which are still in use sometimes for wood produced in the Nordic Countries or Central Europe. Figure 2 includes an example table with possible correspondence between both gradings.

**Table 2. Quality classes of timber. Approximate relations between the different quality classes**

SS-EN 1611-1 (2000)
*Sawn timber. Appearance grading of softwoods. European spruces, firs, pines, Douglas fir and larches.*

| | | | | | |
|---|---|---|---|---|---|
| Two faces and two edges | G4-0 | G4-1 | G4-2 | G4-3 | G4-4 |
| One face and one edge* | G2-0 | G2-1 | G2-2 | G2-3 | G4-4 |

Nordic Timber Grading rules (1994)
("The Blue book")

| A | | | | B | C | D |
|---|---|---|---|---|---|---|
| A1 | A2 | A3 | A4 | | | |

Guiding principles for grading of Swedish sawn timber (1960)
("The Green book")

| U/S | | | | Fifth quality | Sixth quality | Seventh |
|---|---|---|---|---|---|---|
| I | II | III | IV | V | VI | VII |

*One face and one edge is seldom used in Sweden.

Figure 2: Example of approximate relations between aesthetic quality grade according to Scandinavian guidelines and European standard. Source, based on: **https://www.swedishwood.com/wood-facts/about-wood/wood-grades/**

On the other hand, it is common to find that each sawmill or supplier has its own non-structural quality specifications that must be consulted (e.g., size or number of knots), considering also that the requirements could be higher for one of the faces (visible face) than for the others. Mainly in Spain, the manufacturers tend to use 3 different general quality classes:

- First quality: normally for joinery and furniture purposes. Little knots are allowed (number and size). It depends on the manufacturer.
- Second quality (segunda o corriente): for general purposes, similar quality to average structural timber. Knots are allowed but must be sound and up to certain size.

- Others (construction quality) for scaffolding and other uses. Knots or defects are not limited provided they do not affect the timber piece integrity.

Finally, some special products such as Pallets have their own wood quality (EN 12246), dimensions and tolerances (EN 12249). For instance, the standard EN 13698-1 summarizes the quality requirements for a type of pallets (EUR 800*1200 mm), including dimensions and dimensional tolerances of the components considered at a 22% reference moisture content and wood quality.

Moisture content and planning must be prescribed accordingly to the product or application in which the wood will be used, bearing in mind that this content must be close to the one in which the wood is going to be installed or used, in order to avoid swelling or shrinkage of the wood (dimensional changes with moisture content changes), twisting and fissures occurrence. Also, dimensional tolerances and planning must be agreed with the producer before ordering the wood.

Table 6: Example of some features in appearance grades according to EN 1611-1

| | Feature description | Requirements for 4 faces appearance grading according to EN 1611-1 | | | | |
|---|---|---|---|---|---|---|
| | | **Grade G4-0** | **Grade G4-1** | **Grade G4-2** | **Grade G4-3** | **Grade G4-4** |
| **Face knots** | Sound knots | 10% face +10 mm. | 10% face +20 mm. Max. 4/m | 10% face +35 mm. Max. 6/m | 10% face +35 mm. Max. 2 | Non limited if the piece keeps Its integrity |
| | Black knots | 10% face | 10% face+10 mm | 10% face+20 mm | 10% face+20 mm | |
| | Bark knots | Not allowed | 10% face | 10% face+15 mm | 10% face+15 mm | |
| | Unsound knots | Not allowed | Not allowed | 10% face+15 mm | 10% face+15 mm | |
| | No. knots per m | 2 | 4 | 6 | Not limited | |
| **Edge knots** | Sound knots | 50% edge and < max. face knot | 90% edge and < max. face knot | 100% edge and < max. face knot | 100% edge and < max. f. k. | Non limited if the piece keeps Its integrity |
| | Black knots | 33 % edge and < max. face knot | 67 % edge and < max. face knot | 75 % edge and < max. face knot | 100 % edge and < max. f. k. | |
| | Bark knots | Not allowed | 33 % edge and < max. face knot | 50 % edge and < max. face knot | 90 % edge and < max. f. knot | |
| | Unsound knots | Not allowed | Not allowed | 50 % edge and < max. face knot | 90 % edge and < max. f. knot | |
| | No. knots per m | 1 | 2 | 4 | Non limited | |
| **Bark pocket** | No / Total length (mm) | 0/0 | 2/100 | 2/200 | 4/300 | Non limited |
| **Resin pocket** | No / Total length (mm) | 2/75 | 4/100 | 4/200 | 4/300 | Non limited |
| **Others** | Wane, pith, fissures, cup, twist, Insect attacks, etc. | See the standard | See the standard | See the standard | See the standard | See the standard |

## WOOD-BASED PANELS

Wood-based panels with a structural purpose must be classified in one of the structural technical class included in its specific product standard accordance to its test performance results. As they will be incorporated permanently in a building, they have to bear CE-Marking fulfilling EN 13986 harmonized standard.

A declaration of performance will be required including its technical class. Also, a technical sheet will be needed. Only panels for structural purposes should be included in the composition of the interconnected panels or in bearing additional functions. For roofs or for structural elements the higher performance bonding in terms of moisture resistance must be used. Other types of panels could be used for decorative or non-load bearing uses. Fire reaction and resistance requirements shall be assessed and the panels shall be protected or sheathed accordingly.

Types of panels:

- Solid wood panels for structural purposes of the following classes: SWP/1, SWP/2 or SWP/3
- Plywood panels for structural purposes with bonding according to the service class.
- Particleboards of the technical classes P4, P5, P6 or P7, according to the service class
- Oriented Strand Boards (OSB): OSB/2, OSB/3 or OSB/4, according to the service class

Table 7: Example of some wood-based panels requirement and mechanical properties standards

| | Requirements for production | Mechanical properties for structural purposes |
|---|---|---|
| **Particleboards (P4, P5, P6, P7)** | EN 312 | EN 12369-1 |
| **OSB** | EN 300 | |
| **Solid wood** | EN 13353 | EN 12369-3 |
| **Plywood** | EN 636 | Test according EN 789 and EN 1058 or values based in small bending test EN 310 + EN 636 + EN 12369-2 |
| **Any type (testing for obtaining mechanical properties)** | | EN 789, EN 1058 and EN 14358 |

## CROSS-LAMINATED TIMBER (CLT)

Cross laminated timber panels are structural glued laminated elements used as floor, roof or wall elements, that are composed by several layers of wood lamellas oriented at 90° and glued by its wide faces. When used as a component of the Interconnected panels of this project, they must be manufactured according to EN 16351 requirements.

## ADHESIVES

The most common types of adhesives for the manufacturing of structural glued laminated products and composite elements such as IMIP panels are:

- Phenol-Resorcinol-Formaldehyde (PRF).
- Melamine-Urea-Formaldehyde (MUF).
- Emulsion Polymer Isocyanates (EPI).
- One Component Polyurethane Reactive (1C PUR).

These adhesives must be certified for structural purposes by an external recognized laboratory according to EN 301 for MUF/PRF, to EN 15425 for PUR glues, or UNE-EN 16254 for EPI adhesives, and if required by the product standard such as EN 14080 or EN 16351, they must fulfil complementary test requirements. A type I adhesive will be used for all load-bearing elements since they are the most commonly used and provide the highest moisture resistance.

This certification is required in the glued laminated product standard such as EN 14080 for Glued laminated timber or EN 16351 for Cross Laminated Timber.

PUR adhesives are the most commonly used adhesives in CLT and composite panel manufacturing because they do not require pressing at high temperatures, do not have formaldehyde emissions and the spreads used are lower than the ones used in other adhesive types. However other adhesives such as MUF or EPI are also used.

## CORK INSULATION PRODUCTS

Cork products can be used within this project for insulation purposes (thermal or acoustic Insulation) using agglomerated or not agglomerated cork elements or also for mechanical purposes for example as core of sandwich panels by using cork panels.

Granulated cork products can be found as simply mechanically grounded cork in several particle sizes or expanded (using heat and pressure) granulated cork.

On the other hand, also two different cork boards based on cork particles are available: granulated glued cork boards or white cork boards, and expanded cork boards (ICB) or black cork boards. The first ones require the addition of glue to the cork particles providing boards of higher density than the black cork boards and being produced with non-expanded particles of cork. The second type is manufactured by expanding and adhering the cork particles using heat (water vapour) and pressure providing usually a less dense with expanded particles dark cork board.

Both types of cork boards have higher densities than other common insulation foams such as EPS or XPS, environ 100-120 kg/m$^3$ for ICB.

For this project ICB or expanded cork board has been considered more interesting than glued cork boards since in the ICB boards the adhesion is obtained by natural methods and good insulation properties are achieved. However, other cork boards such as adhesive bonded agglomerated elements can be considered within the project for special purposes such as impact Insulation in floor elements or when a special mechanical or surface strength performance can be needed.

ICB expanded cork boards can be found in two different densities, normal (110-120 kg/m$^3$) and a higher density, usually denoted as MD around 130 kg/m$^3$. The first one is used in standard insulation applications and the last is used for applications in which higher mechanical requirements are needed (claddings, etc.).

One of the problems that arise is the lack of technical information and standardization of some of the products, such as the granulated cork or the adhesive bonded cork boards. However, other products as ICB of common density are standardized as an insulation product according to EN 13170, requiring CE-Marking and a declaration of performance according to AVCP level 3.

Since these products can absorb water and are not vapour resistant, its use will require the appropriate analysis or to provide the necessary protection against moisture.  In non-standard situations or specific applications, the Instructions and

recommendations of the manufacturer or the ETA in which the elements could be Included must be followed.

Test methods and specification are available in the Portuguese or Spanish standardization for granulated or other cork products characteristics. For example, for granulated cork, density and granulometry (UNE 56918), moisture content (UNE 56917) or other specifications (NP114 or UNE 56920) must be fulfilled.

Other products of cork not used for insulation would be included in harmonized standards for floor or wall coverings such as EN 14041 or EN 15102. However, these are not standards specific for cork products. Finally, floor specific products made with cork are standardized e.g. EN 655 or EN 688 or generic cork elements UNE 56915, or as base for flooring EN 12103 and EN 12455.

Table 8: Example of some cork-based products standards as insulation products

| | **Requirements for production** | **Mechanical/thermal/acoustic properties and use** |
|---|---|---|
| **Granulated cork** | No EN standard available | Manufacturer technical sheet or test reports provided [a] |
| **Insulation Cork Boards (ICB)** | EN 13170 | Manufacturer technical sheet or test reports provided [b] |
| **Adhesive Binded Cork Boards** | No EN standard available | Manufacturer technical sheet or test reports provided [c] |

[a] Portuguese and Spanish standards available for some features such as density or moisture content determination

[b] Test for insulation materials according to European standards for this purpose for example: EN 1603 for dimensional stability, EN 1609 for water absorption, EN 826 for compression strength, EN 12090 for shear Strength.

[c] No current European standard available for this product

Due to the lack of standardization in some products or specific uses, if a standard Is not available, the control of the product shall be relied on the information provided by the manufacturers based on third party laboratory tests for the different performance requirements (thermal, acoustic, physical, mechanical or durability behaviour) . Also testing on supply samples will be required for assessing or controlling its characteristics (density, moisture content, mechanical properties, etc.).

# ENVIRONMENTAL REQUIREMENTS FOR THE RAW MATERIALS

This chapter summarizes the minimum environmental requirements for the selected raw materials included in Tables 2 and 3. These requirements must be in accordance with the triple bottom analysis criteria defined in the IMIP project document D 1.4.1 "Criteria and indicators for the evaluation of the IMIP eco-construction system value chain":

a. Managing natural resources sustainability
b. Reducing dependence on non-renewable resources
c. Mitigating and adapting to climate change
d. Increasing competitiveness and creating jobs
e. Ensuring human health and safety

Criteria "b" and "d" are met in this case due to the project's decision of using wood and cork products grown and manufactured in the SUDOE region in order to increase the use and value of local renewable raw materials.

Considering the criteria "a", "c" and "e" previously indicated, the requirements to be considered for the raw material correspond to the following categories:

- Sustainable management origin certification
- Life Cycle Analysis (LCA) features
- Emission of health threatening substances
- Recyclability

By using the sustainable management origin certification for the wood products as requisite for the raw material, the project will be ensuring the use of renewable natural resources, thus increasing the bioeconomy and a sustainable raw material utilization.

Life Cycle Analysis data are also necessary to assess the impact of the final product in the environment, for that reason data for this analysis must be gathered for all the components and, as far as possible, used in the decision process when assessing different products and origins of supply.

As an important issue for the users and workers related to the products under development, it is important to take into consideration all possible chemical substances known effect on health, and to incorporate it in the decision process when selecting raw materials and suppliers.

Recyclability is also one of the most desired features for the parts, or even the product itself, when considering a new construction product such as the IMIP panels. For that reason, this aspect must be considered when selecting raw materials and products as far as possible, taking into account its possible reutilization for other uses once the life cycle of the panels finish, in accordance with the mentioned “a” criteria, managing natural resources sustainability.

Tables 9 and 10 show some of the expected requirements to be applied to the raw materials. However, the full application of some requirements will depend on their availability. When unavailable, other options will be considered in the decision process for acquiring the raw materials, for example by selecting a different supplier able to fulfil the requirements whenever is available.

Table 9: Environmental requirements for the raw materials

| | Sustainable management origin certification | LCA features | Emission of health threatening substances | Recyclability |
|---|---|---|---|---|
| ***Sawn timber for structural purposes*** | PEFC or FSC certification and Chain of Custody will be required | Data for LCA calculation will be required to the manufacturer. Transport distance to the interconnected panels factory will be used for manufacturers assessment If more than one option is available, the option with lower transport distance will be selected. | Information on treatment or other chemical products used will be requested to the manufacturer before ordering | A previous assessment possible issues and recycling possibilities will be performed before ordering |
| ***Wood-based panels*** | PEFC or FSC certification and Chain of Custody will be required | LCA document will be requested if available. Transport distances to the panel factory will be taken into account, reducing it as much as possible. | Information on treatment or other chemical products used will be requested (declaration of performance).Formaldehyde emissions rating will be requested, if possible a product with no emssions will be used or at least a product with the lowest emissions available will be selected | A previous assessment possible issues and recycling possibilities will be performed before ordering |
| ***Structural adhesives*** | - | LCA document will be requested if available. Transport distances to the panel factory will be considered. | Information will be requested to the adhesive manufacturer. If possible adhesives without formaldehyde or that provide global low formaldehide emissions in the product will be used. | A previous assessment possible issues and recycling possibilities will be performed before ordering |
| ***Granulated cork*** | PEFC or FSC certification and Chain of Custody for the product will be required | Data for LCA calculation will be required to the manufacturer. Transport distance will be used for comparison between manufacturers if more than one option is available | Information on treatment or other chemical products used will be requested to the manufacturer | A previous assessment possible issues and recycling possibilities will be performed before ordering |

Table 10: Environmental requirements for the raw materials

| | Sustainable management origin certification | LCA features | Emission of health threatening substances | Recyclability |
|---|---|---|---|---|
| ***Expanded granulated cork*** | PEFC or FSC certification and Chain of Custody for the product will be required | Data for LCA calculation will be required to the manufacturer. Transport distance will be used for comparison between manufacturers or suppliers if more than one option is available | Information on treatment or other chemical products used will be requested to the manufacturer | A previous assessment possible issues and recycling possibilities will be performed before ordering |
| ***Adhesive bonded corkboards*** | PEFC or FSC certification and Chain of Custody for the product will be required | Data for LCA calculation will be required to the manufacturer. Transport distance will be used for comparison between manufacturers or suppliers if more than one option is available | Information on treatment or other chemical products used will be requested to the manufacturer | A previous assessment possible issues and recycling possibilities will be performed before ordering |
| ***Expanded insulation cork boards*** | PEFC or FSC certification and Chain of Custody for the product will be required | Data for LCA calculation will be required to the manufacturer. Transport distance will be used for comparison between manufacturers or suppliers if more than one option is available | Information on treatment or other chemical products used will be requested to the manufacturer | A previous assessment possible issues and recycling possibilities will be performed before ordering |

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## PARTNERS

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