TECHNICAL SHEETS

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FOR THE SUSTAINABLE MANAGEMENT OF TROPICAL FORESTS

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16

TIMBER UNDER RAILS AND RELATED USES

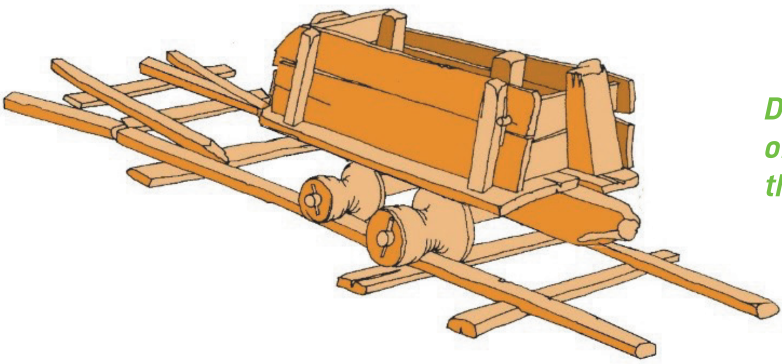
CONTENTS

Azobe sleepers (Photo by Emmanuel Groutel, WALE, Gabon)

PREAMBLE

The development of railways from the 19th century onwards is directly linked to the development of timber and the improvement of its implementation techniques.
However, as early as the 15th century, timber was already used to make rails for Central Europe's first mining "railways".

In its early days, the "iron" railway could have been called a "timber railway"; in the 19th century, whereas iron rails became more widespread, wooden rails still had their supporters.



Drawing (anonymous) of a mining wagon from the Renaissance era[1]

1. *The earliest historical mention of a guided transport system using rails is that of Sebastien Münster in his book "Cosmographie Universelle" published in Basel in 1550. The author describes the rail cart system operating in the mines of Leberthal (Alsace region), with carts pushed by miners in the galleries. The cart and its wheels are made of timber, and both tend to feature iron rolling parts to compensate for the wear and tear that inevitably digs into the wheel treads or reduces the height of the rails.* (**The timber of which railways are made**, Clive Lamming).
https://trainconsultant.com/2021/07/14/le-bois-dont-on-fait-les-chemins-de-fer/

Timber is now the world's most widely used material for the manufacture of railway sleepers and railway switches and crossings in general.

In Europe, four main species are used:

- Oak (pedunculate and sessile), France's most widely used species, both for sleepers and bearers in switch and crossing layouts.
- Beech, mainly used for sleepers, in German-speaking countries as well as in Central and Eastern Europe.
- Pine, used almost entirely in Scandinavia and Poland, as well as in the UK.
- Azobe, used in Western Europe for railway switches and crossings

In recent years in France, Okan has become the leading species used for sleepers.
The share of timber on the railway network has decreased during the last few decades, in favour of concrete.
Almost all sleepers laid on the main track are made of concrete.

However, timber still retains a significant market share for specific applications, such as:

- railway switches and railway junctions,
- engineering structures,
- the occasional replacement of sleepers on tracks that already use timber sleepers (no mix of timber and concrete on a same track),
- service tracks (access to workshops and terminals) which have derailment risks.

Sleepers made of Angelim (photo: Stéphane Glannaz, Mil Madeiras Preciosas Ltd. - Precious Woods Amazonas, Itacuatiara, State of Amazonas, Brazil)

1. TYPES OF TIMBER UNDER RAILS

The term *timber under rails* covers different types of products, mainly sleepers, but also technical components with very specific uses for various railway switches, and for which it is necessary to provide precise definitions.

- **Sleepers[2] for plain lines**: a wooden beam that supports running rails, guard rails and conductor rails, perpendicular to its axis. Typically, the beam supports two running rails to form a track.

- **Bearers in switch and crossing layouts:** a timber beam similar to a sleeper but usually longer, which is used to support the running rails, guard rails, conductor rails, crossings and the systems used to manoeuvre the railway switches and crossings.

- **Longitudinal timber for bridges and pit roads:** This refers to timber placed underneath the railway rails and in line with the rails, to support them and to shift the loads to the infrastructure in the axis of the track.

- **Listed cuts that are specific to certain structures.**

The following specifications are largely based on the elements of the two referenced documents, "AFNOR 2011" (the European standard) and "SNCF 2018" (SNCF specifications IG4019 and IG4020). They concern "raw" timber pieces (that haven't been shaped or machined) intended for the manufacture of standard or narrow gauge track sleepers and standard gauge switch and crossing layouts.

Crossings made of Kempas (photo: Benoit Gommet, France Timber, Nagoya, Japan)

2. Or "ties" (USA)

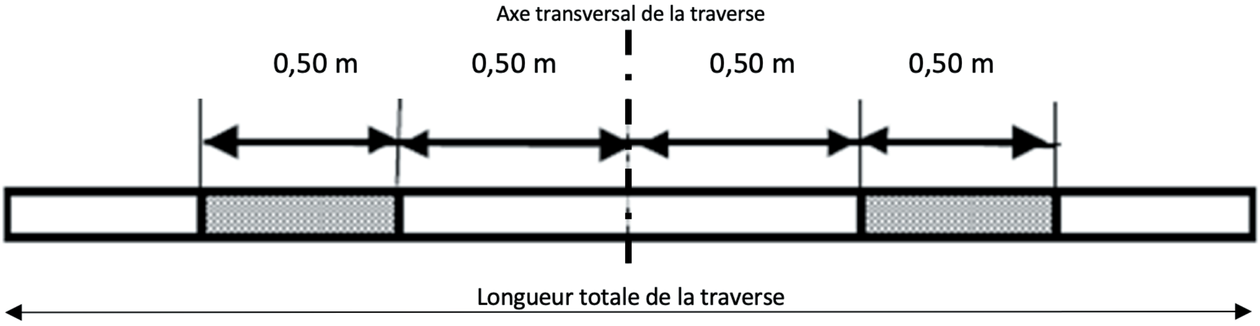
2. FORMAT AND DIMENSIONS

The following descriptions are based in part or in summary on those in the "SNCF 2018" document, which is the reference source.

2.1. IN FRANCE (SNCF RAILWAY OPERATOR)

2.1.1. Description of the supporting surface

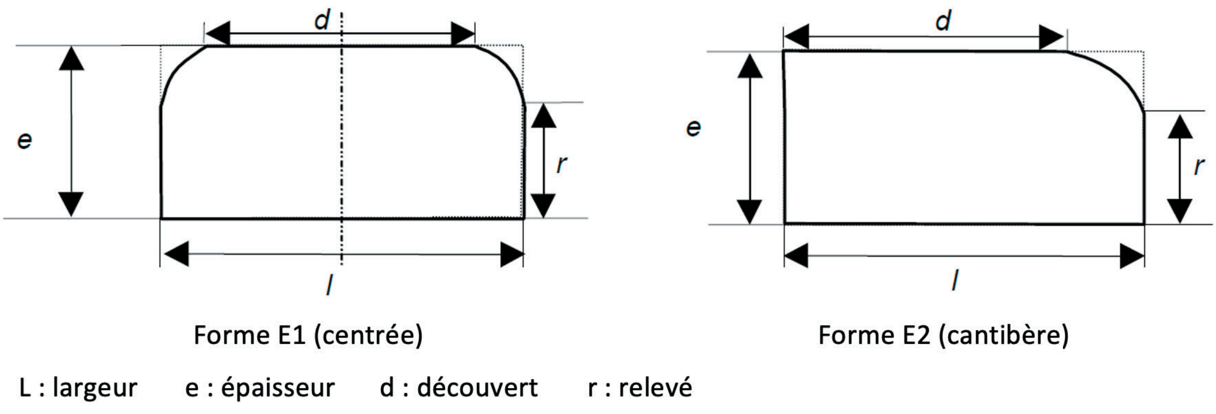
*** Timber support surface for standard track sleepers**
The bearing surface of timber for standard track sleepers covers a length of 50 cm from a distance of 50 cm on either side of the middle of the sleeper (see below diagram).



*** Timber support surface for bearers in switch and crossing layouts**
The timber support surface for bearers in switch and crossing layouts extends over the entire length of the timber piece.

2.1.2. Cross-section of sleepers

The sleepers must have a cross-section (transversal cut) in accordance with one of the two shapes below (taken from standard EN 13145+A1).

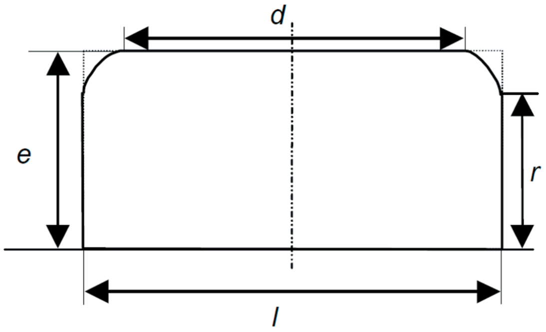


Outside of the supporting surface, shapes without relief or overhangs are accepted with nothing less in terms of width at the base and nothing less in terms of thickness [SNCF 2018].

2.1.3. Cross-section of railway switch bearers

*** Tropical species**
The parts for bearers in switch and crossing layouts made of tropical timber are 4-sided square-edged timber pieces (rectangular cross-section with sharp edges).

*** Temperate species**
The cross-section of the supports must comply with the shape shown on the right:



L : largeur e : épaisseur d : découvert r : relevé

2.1.4. Names and dimensions of timbers for normal track sleepers (type G)

The names and dimensions (in mm) of the timbers for standard railway sleepers are given in the below table. The clearances and elevations are measured at the bearing surfaces.

Group	Width (l)	Thickness (e)	Length (L)	Minimum exposure (d)		Minimum elevation (r)
				Form E1	Form E2	Forms E1 and E2
G2	260	150	2600	170	200	80
G6	240	140	2600	160	180	70
G8	220	130	2600	150	160	50

Detail of the assembly of an Azobe part (rail/tyre) for metro line no. 6 in Paris (photo: Rail Europe)

2.1.5. Names and dimensions of timbers for bearers in switch and crossing layouts

The name of a timber bearer for switch and crossing layouts has 2 characteristics:

- a number from 1 to 3 designating the dimensions of its cross-section,
- a letter from A to U (excluding letters F, I, O, Q, L, T) designating its length.

The details of these designations in relation to the corresponding dimensions are available in the "SNCF 2018" document.

The below table summarises the dimensions **(cross-section dimensions in mm, lengths in m)** of timber for bearers of switch and crossing layouts. For tropical timber bearers, the parts are edged on 4 sides and therefore have no exposed or raised edges.

<table>
<tr><th rowspan="2">Width (l)</th><th rowspan="2">Thickness (e)</th><th rowspan="2">Length (L)</th><th colspan="2">Minimum exposure (d)</th><th rowspan="2">Minimum elevation (r)</th></tr>
<tr><th>Form E1</th><th>Form E2</th></tr>
<tr><td>260</td><td>150</td><td rowspan="2">2,60 - 2,80 - 3,00 - 3,20 - 3,40
3,60 - 3,80 - 4,10 - 4,40 - 4,70
5,00 - 5,35 - 5,70 - 6,00 - 6,80</td><td>210</td><td>230</td><td>120</td></tr>
<tr><td>300</td><td>150</td><td>240</td><td>270</td><td>120</td></tr>
<tr><td>350</td><td>150</td><td>2,60 - 3,60 - 4,40 - 4,70 - 5,35</td><td>290</td><td>310</td><td>120</td></tr>
</table>

2.1.6. Dimensional tolerances

The tolerances defined by standard NF EN 13145 are applicable unless otherwise stipulated in the below table.

These specific tolerances apply to freshly sawn timber. An extra allowance is to be made for dimensional shrinkage during sawing, which may occur during storage at the supplier's stockyard and during shipping. If the inspection is carried out on dried tropical timber (more than 2 months after sawing), the tolerances to be applied to the vertical and horizontal curvatures are those defined in the NF EN 13145 standard increased by 50% (less strict tolerances).

All values are in mm:

<table>
<tr><th>Types of pieces (dimensions)</th><th>Length</th><th>Width and thickness</th><th>Maximum vertical curvature*</th><th>Maximum horizontal curvature**</th><th>Maximum split pass-through length</th></tr>
<tr><td>G2 (2600 x 260 x 150)
G6 (2600 x 240 x 140)
G8 (2600 x 220 x 130)</td><td>± 30</td><td rowspan="6">+15
0</td><td>7</td><td>50 (temperate)
6 (tropical)</td><td>200 (temperate)
100 (tropical)</td></tr>
<tr><td>A8 (2000 x 220 x 130)</td><td rowspan="5">± 30</td><td>5</td><td>40</td><td>200</td></tr>
<tr><td>Switch and crossing timber
A (2.60 m) to C (3 m)</td><td>6</td><td>30 (temperate)
6 (tropical)</td><td rowspan="4">200 (temperate)
100 (tropical)</td></tr>
<tr><td>Switch and crossing timber
D (3.20 m) to G (3.6 m)</td><td>7</td><td>35 (temperate)
7 (tropical)</td></tr>
<tr><td>Switch and crossing timber
G (3.80 m) to K (4.4 m)</td><td>8</td><td>40 (temperate)
9 (tropical)</td></tr>
<tr><td>Switch and crossing timber
M (4.70 m) to U (6.8 m)</td><td>10</td><td>50 (temperate)
11 (tropical)</td></tr>
</table>

* = bow ** = spring

End through-splits with an opening greater than 5 mm are excluded. All splits or beginnings of splits at the ends must be consolidated by means of s-shaped hooks or connector plates. For the ends of the pieces, a maximum bias of 10 mm is tolerated.

Sleepers made of Kempas (photo: Benoit Gommet, France Timber, Nagoya, Japan)

Sleepers made of Angelim and Angelim vermelho (in the back) (photo: Stéphane Glannaz, Mil Madeiras Preciosas Ltd. - Precious Woods Amazonas, Itacuatiara, Amazonas State, Brazil)

Sleepers made of Okan (photo: Frédéric Viroux, Pallisco, Cameroon)

2.2. SPECIFICATIONS OF EUROPEAN STANDARD EN 13145+A1

The following descriptions are based on those of **standard NF EN 13145+A1** (December 2011) *Railway applications - Track - Timber sleepers and bearers*, which is the reference source.

2.2.1. Cross-sections of sleepers and bearers in switch and crossing layouts

Identical to those presented in section 2.1.

2.2.2. Most commonly used names and dimensions of sleepers

Group	l (mm)	e (mm)	d* (mm)		r* (mm)
			Shape E1	Shape E2	Shapes E1 et E2
1	260	160	160	200	80
2	260	150	160	200	80
3	260	130	130	170	60
4	240	150	160	180	70
5	240	160	160	180	80
6	240	140	160	180	70
7	240	130	130	170	60
8	220	130	130	160	50
9	250	125	205	230	100
10	305	125	255	280	100
11	305	150	255	280	125
12	250	130	200	225	105
13	300	130	250	275	105
14	200	120	110	140	40

*: minimum dimensions

2.2.3. Most commonly used names and dimensions for bearers in switch and crossing layouts

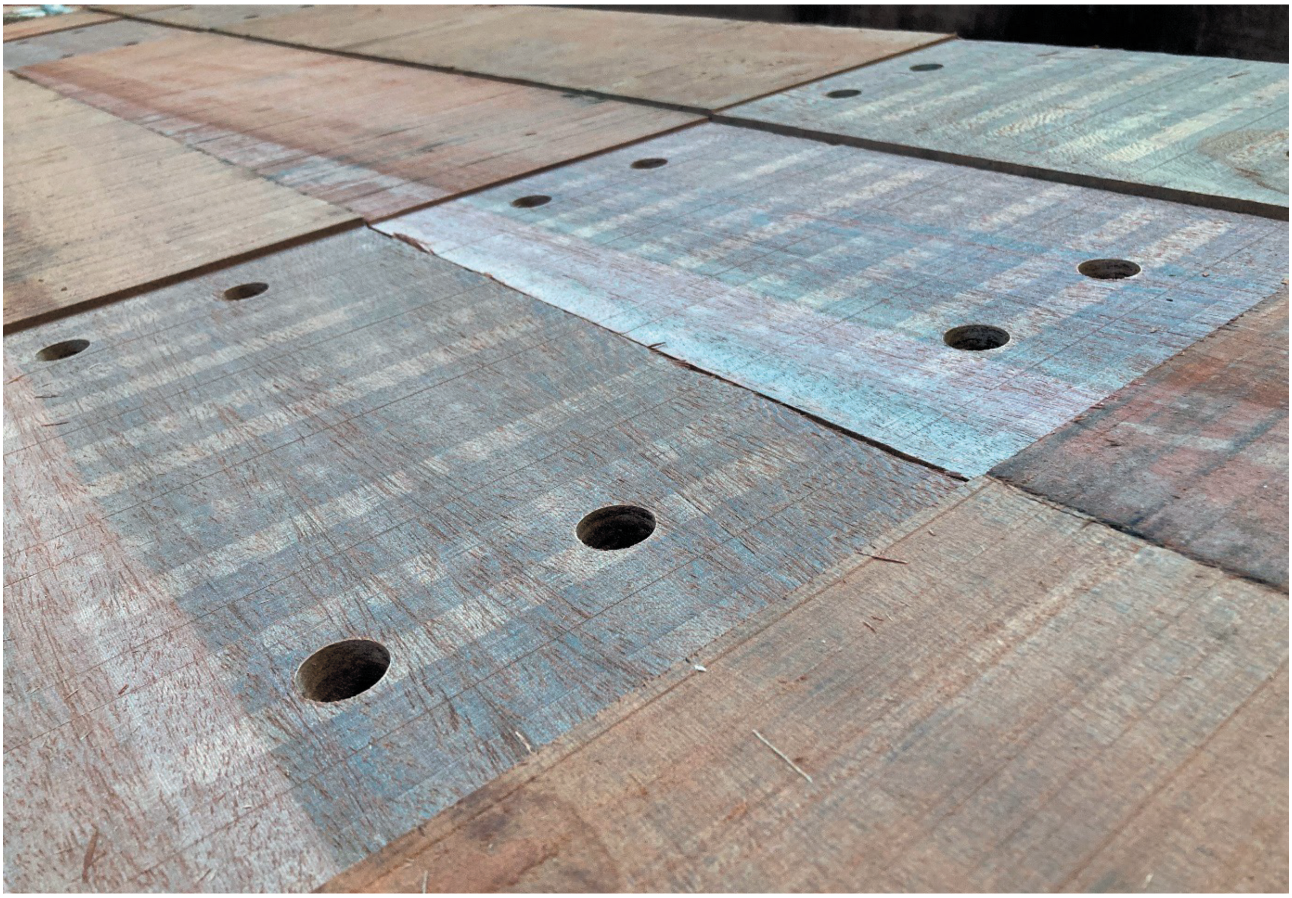
Group	l	e	d*	r*
1	300	150	240	120
2	280	140	220	120
3	260	160	200	100
4	260	150	210	120
5	240	150	200	90
6	240	160	160	80
7	240	140	200	80
8	300	130	200	80

*: minimum dimensions

Sleepers made of Azobe in the Cairo metro in Egypt (photo Rail Europe)

2.2.4. Dimensional tolerances

These tolerances apply to all sleepers and bearers ready for use and/or treatment:
Length: ± 30 mm
Width: + 10 mm / - 3 mm
Thickness: + 10 mm / - 3 mm
Cross-section cut (90°): maximum deviation of 3°
For the length tolerance to be permissible, the ends of the sleeper or bearer must be sawn at a right angle.



Preparation of Azobe sleepers (photo: Emmanuel Groutel, WALE, Gabon)

3. MAIN QUALITY REQUIREMENTS, DEFECT TOLERANCES

For timber that does not require a preservative treatment, the application of a so-called "anti-splitting" product to the cross-sections of the pieces is recommended.
The recommendations in the below table are based on, and sometimes adapted from, those mentioned in the "AFNOR 2011" and "SNCF 2018" documents.

DEFECT	TOLERANCES
Healthy sapwood (altered sapwood excluded)	***Recommendations in France / SNCF (SNCF 2018)*** * Sapwood allowed without limits for sleepers. * For temperate timber bearers, the volume of sapwood should be less than 1/3 of the volume present in the piece. The sapwood must not appear on the underside. * For tropical timber bearers, a sapwood tolerance of 25% of the nominal width for the entire length of the top side (standard EN 13145). The sapwood must not appear on the underside.
	Recommendations of European standard EN 13145 * For tropical hardwoods, sapwood is tolerated outside of the bearing surface with a maximum of 50% of the nominal width for sleepers, or 25% of the nominal width over the entire length of the top side for bearers in switch and crossing layouts. * For temperate hardwoods, sapwood is tolerated.

Thread	***Recommendations of European standard EN 13145*** Maximum permissible deviation from the longitudinal axis: 1/10 (deviation measured over a length of 600 mm)
Bark gap	Not allowed on the bearing surface. Tolerated outside of the bearing surface on one side only and over a maximum length of 150 mm.
Healthy knots	***Recommendations in France / SNCF (SNCF 2018)*** Tolerated except for sharp knots (knots appearing on the front and on the edge of sawn timber)
	Recommendations of European standard EN 13145 * European softwoods and tropical hardwoods: tolerated if adherent, with a diameter not exceeding 25% of the dimension of the front side for sleepers and bearers. Not tole-rated in the support surface of sleepers * European hardwoods: tolerated if adherent
Chips and splits from surface drying	Tolerated
Splits that pass through	***Recommendations in France / SNCF (SNCF 2018)*** Length: see section 2.1.8. Dimensional tolerances Tolerated if the opening < 5 mm on freshly sawn timber Reminder: end splits that pass through with an opening greater than 5 mm are rejected; all end splits or the beginnings of splits must be adequately reinforced by means of s-shaped hooks or connector plates.
	Recommendations of European standard EN 13145 * European hardwoods: tolerated up to 250 mm from the ends * European softwoods: tolerated up to 75 mm from the ends * Tropical hardwoods: Tolerated up to 200 mm from the ends
Internal splits	Tolerated if they don't reach the top or lateral sides of the pieces
Curls	Tolerated if diameter ≤ 50 mm; not tolerated if visible on the top or on the lateral sides
Springs	***Recommendations in France / SNCF (SNCF 2018)*** See section 2.1.8. Dimensional tolerances
	Recommendations of European standard EN 13145 * Tropical hardwoods: max. 6 mm for sleepers, max. 2 mm/m for bearers * European hardwoods: max. 2% of the length for sleepers, max. 1% of the length for bearers * European softwoods: max. 0.5% of the length for sleepers and bearers
Bows	***Recommendations in France / SNCF (SNCF 2018)*** See section on Dimensional tolerances
	Recommendations of European standard EN 13145 Tolerated if the correct inclination of the saddle is ensured, but limited to: max. 0.6% of the total length for sleepers max. 0,2 % of the total length for bearers
Dead punctures	Tolerated if the sleeper or bearer's mechanical properties are not affected
Pith	Tolerated only in temperate timber
Felling cracks, sawing defects, double bends, warping, bowing, splitting, rotting, rotten knots, worm holes	Not tolerated

Timber pieces for sleepers and for bearers in switch and crossing layouts must be processed in the freshly sawn state; in fact, drying is not technically or economically feasible. Furthermore, and especially in the large sections that are most often necessary for these types of uses, these very hard and dense timbers cannot be processed in the dry state.

This aspect must be emphasised to the competent authorities of producing countries (Ministries of Water and Forests, Customs, etc.) so as not to break this specific supply chain.

Shaping of Azobe pieces for railway switch and crossing layouts, RATP, Paris (photo Rail Europe)

4. COMPARATIVE ADVANTAGES OF TIMBER COMPARED WITH COMPETING MATERIALS

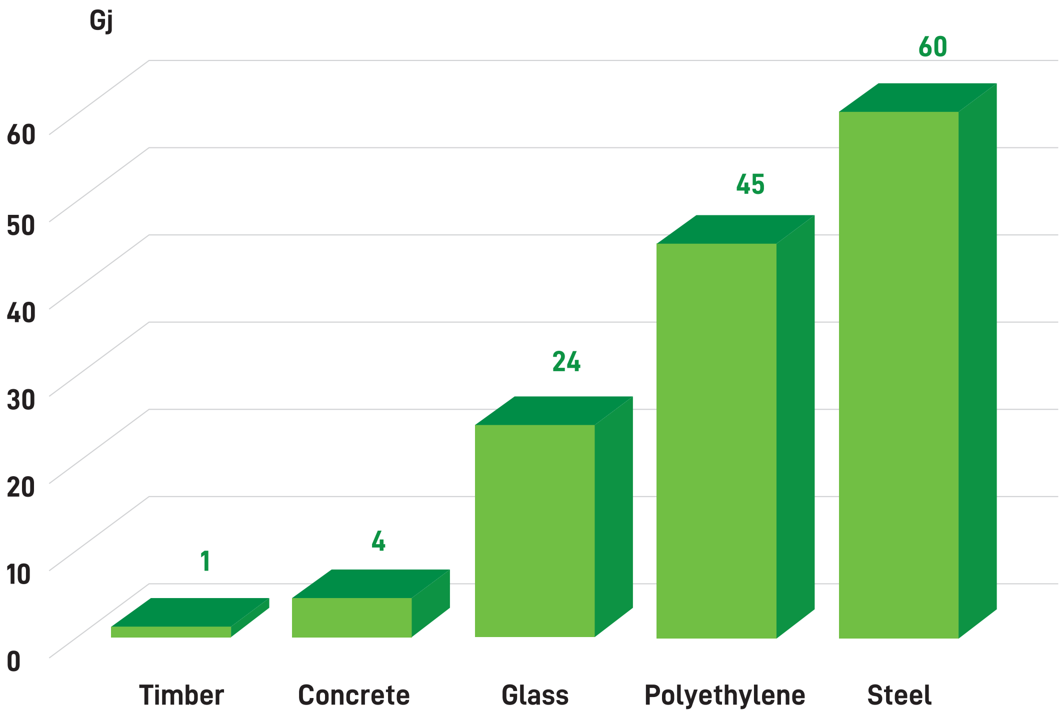
4.1. TIMBER AS A CARBON-SAVING AND ENERGY-EFFICIENT MATERIAL

Timber is an eco-material that on average consists of up to 50% carbon (by mass) from the CO_2 captured by trees from the atmosphere during photosynthesis.

Examples of the positive impact of trees and timber in terms of the capture of atmospheric CO_2

- **The production of one m³ of timber is associated with the capture of one ton of atmospheric CO_2.**
- **Timber is the only material whose manufacture and use are associated with a negative balance of CO_2 production in the atmosphere.**
- **When the forest produces 1 m³ of timber, it purifies the equivalent volume of air polluted by a plane carrying 600 people over a distance of 2,500 km.**
- **To produce one kilogram of timber, a tree must consume all of the CO_2 contained in 2,600 m³ of air (2,600 m³ represents the average volume occupied by a building housing 40 people).**
- **In France, one kilometre of track with timber sleepers stores on average about 60 tons of carbon, which is the amount of carbon contained in 220 tons of CO_2.**

Timber has a low energy cost as the following chart illustrates:



Energy required to manufacture 1 ton of material

4.2. THE TECHNICAL ADVANTAGES OF TIMBER FOR SLEEPERS AND BEARERS IN SWITCH AND CROSSING LAYOUTS

In addition to being environmentally friendly, the use of timber for railway sleepers and for other track bearers offers many technical advantages:

- The physical and mechanical characteristics of timber provide it with significant technical advantages:
  - It's a good natural electrical insulator, and its use doesn't require the addition of an extra insulating element.
  - The elasticity of timber allows sleepers to warp without breaking in the event of derailment.
  - Timber sleepers are best suited for situations of high stress and impacts due to their high bending capacity and shear strength.
  - Timber tends to absorb vibrations and sound waves, which is particularly useful in urban networks and at railway stations.

- Timber is a light material, which therefore makes it cheaper to transport and install, making it well suited for both bridges and sloped areas.

- The high density of tropical timber, up to 1.1 or 1.2, gives them good resistance: they can be used in track segments with high stresses such as railway switches.

- Timber is characterised by its high flexibility of use, as it can be shaped on site with basic portable tools. This is particularly ideal for maintenance in areas with various types of installations. Timber sleepers are custom-shaped for special areas such as tunnels or bridges.

- In old tunnels, it is sometimes impossible to install concrete sleepers because of issues linked to thickness: in fact, installations on timber sleepers are generally 10 cm thinner than those on concrete sleepers. The natural flexibility of the timber material allows it to adapt to variations in the ground, and therefore allows for a thinner ballast layer.

- In train stations, the heights of platforms are determined according to the thickness of the timber sleepers, and the extra height due to concrete sleepers poses technical problems.

- The use of timber is necessary in certain areas which have specific technical constraints:

  - A need for direct fixing (a "rigid" installation) on specific bearers on metal bridges.
  - Areas with a low curvature radius where the rails have mechanical joints (instead of "continuous welded" rails); installations on timber sleepers is necessary:
    - to avoid severe shocks that can affect the track and equipment, and which are also unpleasant for passengers,
    - to ensure that the two rails are worn in a more or less uniform manner,
    - to allow the rails to be spread out in very tight radii.

4.3. TIMBER UNDER RAILS AND ECO-CERTIFICATION

The use of timber - especially tropical species - for sleepers and for switch and crossing layouts goes hand in hand with the implementation of forestry eco-certification systems as tools for economic, social and cultural development, and the preservation of biodiversity.
The main labels (FSC®, PEFC-PAFC) thus ensure compliance with a set of requirements aimed at protecting the environment and local populations. The practices of certified forest management in natural tropical forests involve a great deal of investments in several areas:

- Socio-economic development at the local level
- Support for proper forest governance and law enforcement
- The preservation and conservation of forest ecosystems and biodiversity
- Involving local communities in forest management

They help limit imported deforestation and provide sustainable employment in the producing countries.

5. SPECIFIC CONSTRAINTS THAT APPLY TO TIMBER UNDER RAILS

No matter which product is considered, whether it's a standard sleeper or a more technical product such as bearers of railway switches or crossings, timber under rails requires:

- Solid mechanical characteristics due to the high stresses to which it is subjected (rigidity, resistance to transverse compression, impacts and longitudinal bending).
- High resistance to attacks by lignivorous fungi.

5.1. MECHANICAL CHARACTERISTICS

Among the species recommended by the standard NF EN 13145 and the NetworkRail document, temperate timbers have average densities and therefore average mechanical characteristics.
The two hardwoods referred to, oak and beech, have average densities of around 0.70 but the softwoods mentioned in the standard have weaker characteristics, with average densities of around 0.55 for Pine and Douglas timber, and up to 0.60 for Larch timber. On the other hand, the tropical timbers recommended present higher performances with an average density[3] that's higher than 0.75[4], this average density often reaching 0.85 (chart 1).
These timbers, which usually range from heavy to very heavy[5], correlatively present superior mechanical characteristics.

3. Obtained at 12% humidity
4. Of these timbers, Bilinga has the lowest average density: 0.76
5. According to CIRAD classification:
   0.65 < density < 0.80: medium-heavy timber
   0.80 < D < 0.95: heavy timber
   0.95 < D: very heavy timber

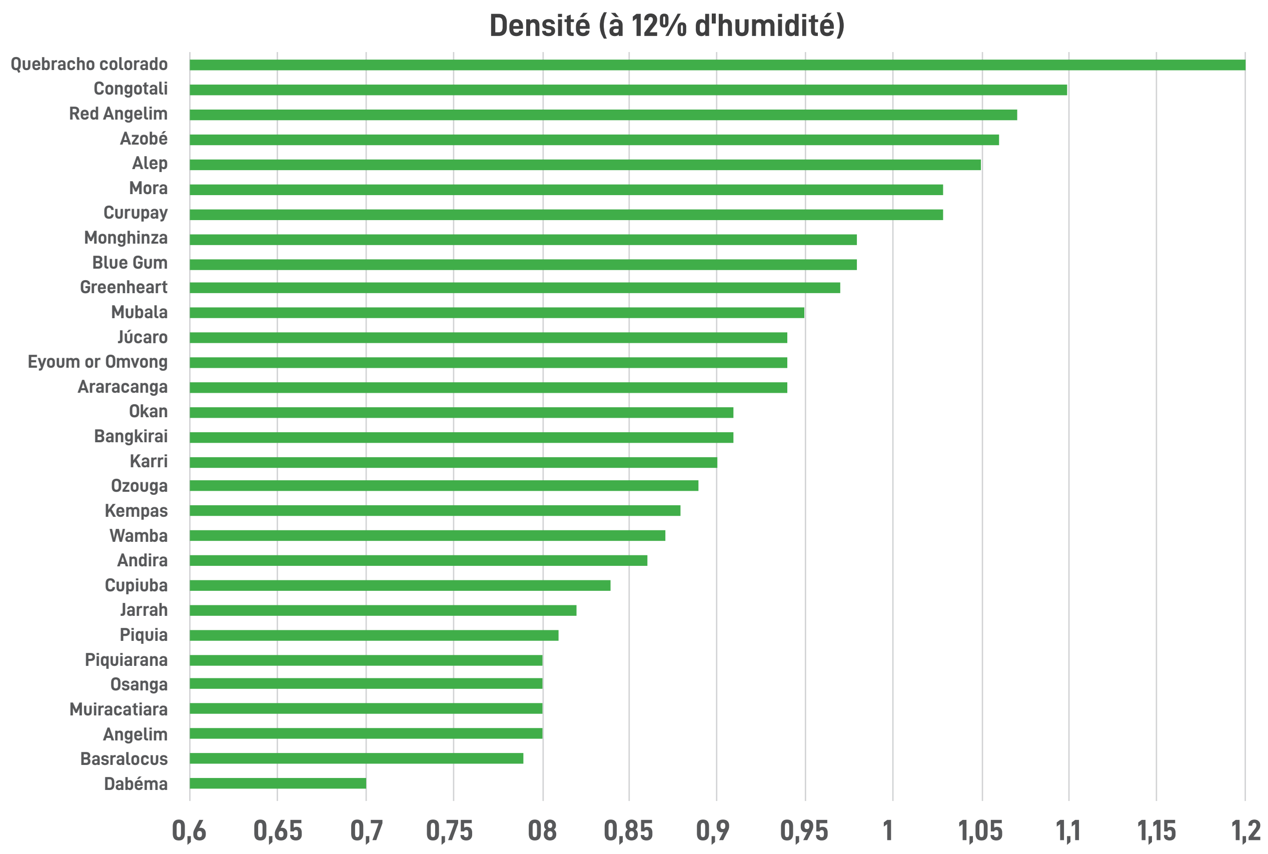


Figure 1. Distribution of densities of the main tropical species recommended for use in timber under rails - Source: Tropix 7 and CIRAD database

5.2. RESISTANCE TO LIGNIVOROUS FUNGI

Given the constraints which it is subjected to through its use in contact with the ground, timber used under rails must have a natural or conferred durability (after preservation treatment) that allows it to be used in risk class 4 as defined by the EN 335 standard (May 2013).

This usage class corresponds to outdoor uses in contact with the ground or fresh water characterised by frequent or permanent wetting, water retention and water stagnation.

The definitions of notions relating to natural durability classes, usage classes, and the relationships between natural durability classes and usage classes had been explained in the technical document entitled *Timber for hydraulic structures* (ATIBT 2021[6]).

It seemed appropriate to present these concepts again in this document as they are the basis for a rational use of timber. The definition of natural durability classes is given in the first part of Annex 1, and the definition of usage classes is given in the second part of this Annex.

The NF EN 13145 standard *mentions that timber with a natural durability of class 1 or 2* (according to EN 350-2) *has a natural durability that allows for its use in risk class 4.*

However, the European standard NF EN 460 (July 1994), which is still in effect, although it is currently under revision, states that for timber with class 2 natural durability, *the natural durability usually covers the usage class but for certain uses, a protective treatment may be recommended* (see box below).

6. https://www.atibt.org/files/upload/14-LES-BOIS-POUR-OUVRAGES-HYDRAULIQUES.pdf

Given the very high risk of attacks by lignivorous fungi that they are confronted with, we will consider that only timber falling under class 1 of natural durability can be used without a protective treatment.

For the record, durability characteristics only relate to the heartwood of mature timber. The sapwood must always be considered as non-durable against biological timber degradation agents.

Relationship between natural durability classes and usage classes

The European standard NF EN 460 (July 1994), **which is still in effect although it's undergoing revision** (draft prEN 460, December 2021), proposes a table of relationships between the natural durability levels of solid timber and their possible uses in a given usage class (see below table).

Note: In reality, this standard refers to the notion of *risk class* and not of *usage class*, notions that are almost equivalent. *Usage class* is the term that's currently in effect; it is defined in the French standard NF EN 335 (May 2013). In the following table, we will use the term "usage class" in accordance with the terminology that is currently used, even if this term is not the one mentioned in French standard NF EN 460 of July 1994.

For the Netherlands, it is necessary to refer to the NEN-EN 350:2016[7] standard.

Natural durability classes according to usage class

Usage class covered by natural durability	Natural durability class				
	1	**2**	**3**	**4**	**5**
1	Yes(1)	Yes	Yes	Yes	Yes
2	Yes	Yes	Yes	Yes but	Yes but
3	Yes	Yes	Yes but	On a case by case basis(3)	On a case by case basis
4	Yes	Yes but(2)	No but(4)	No(5)	No
5	Yes	No but	No but	No	No

(1) Yes: the natural durability covers the usage class.
(2) Yes but: the natural durability usually covers the usage class. But for certain uses, a preservative treatment may be recommended.
(3) On a case by case basis: the natural durability may be sufficient. But depending on the timber species, its permeability and its end use, a preservative treatment may be necessary.
(4) No but: a preservative treatment is usually recommended. But for certain uses, the natural durability may be sufficient to cover the usage class.
(5) No: the natural durability doesn't cover the usage class; a preservative treatment is necessary.

For usage classes 2 to 5, the equivalences aren't precisely defined for certain durability levels.

7. https://www.nen.nl/nen-en-350-2016-en-224409

6. SPECIES USED AND USABLE FOR TIMBER UNDER RAILS

Many species are potentially usable for the manufacture of railway sleepers and switch and crossing layouts.

In practice, the choice of species remains limited because it must simultaneously take into account several criteria:

1. The logs' diameter and physical composition, which must enable the cutting of large cross-section pieces. The amount of sapwood and non-hardened parts are also important factors.
2. The intrinsic characteristics of the timber in relation to the performance required for this type of use (mechanical strength, natural durability).
3. The price of timber whose prospects for use in sleepers and switch and crossing layouts may be limited by higher value applications.
4. Compliance with international standards, including the Washington Convention on protected species (CITES).

In the following two tables, the species commonly used for railway sleepers and for bearers in switch and crossing layouts in their production regions or in regions with a regular export flow are shown in green.

Species shown in black are of potential interest for these uses or are mentioned in reference documents.
The FD P20-651 Documentation Booklet "*Durabilité des éléments et ouvrages en bois*" (Durability of timber elements and structures) (July 2011) defines assessments of a wide range of tropical and temperate species in terms of their longevity against fungal risks, by usage class8.
These ratings are defined as follows:
L3: Longevity greater than 100 years,
L2: Longevity of approximately 50 to 100 years for its originally intended use,
L1: Longevity of approximately 10 and 50 years for its originally intended use,
N: Longevity uncertain and always under 10 years, these solutions are not to be recommended.

6.1. SPECIES REQUIRING A PRESERVATIVE TREATMENT

The main recommendations mentioned in the standards and technical documents for preservation treatment operations are as follows:

Treatment
The timber must be free of any peculiarities that prevent the proper application of the preservative treatment. All straightening, pre-cutting, notching, planing and drilling operations must be carried out prior to the preservative treatment. If local machining is required after the treatment, a local protective treatment should be provided. Prior to planing, drilling or the preservative treatment, the timber's humidity content must be within the range required by the preservative and by the treatment method that is used.

8. Refer to it for the species mentioned hereafter

Preservatives
The preservatives used must be creosote or comply with the performance requirements of risk class 4 products according to the 599+A1 standard.
Product penetration
After a preservation treatment, impregnated sleepers and bearers must meet the class 8 (P8: full sapwood penetration) penetration requirements the EN 351-1 standard.
Retention
After a preservation treatment, the minimum retention requirement shall be the critical value of risk class 4 of the preservative used as defined by the 599+A1 standard.

Pilot name	Botanical name	Density[9]	Origin	Comments
European oak	*Quercus robur* *Quercus petraea* *Quercus pubescens*	0,74	Temperate	Mentioned in the EN 13145 standard
American white oaks	*Quercus alba* *Quercus lobata* *Quercus michauxii*	0,73	Temperate	
Douglas	*Pseudotsuga menziesii*	0,54	Temperate	Mentioned in the EN 13145 standard
Beech	*Fagus sylvatica*	0,71	Temperate	Mentioned in the EN 13145 standard
Larch	*Larix* p.p.	0,60	Temperate	Mentioned in the EN 13145 standard
Pinus nigra	*Pinus nigra*	0,58	Temperate	Mentioned in the EN 13145 standard
Maritime pine[10]	*Pinus pinaster*	0,55	Temperate	Mentioned in the EN 13145 standard
Parasol pine[10]	*Pinus pinea*	0,58	Temperate	Mentioned in the EN 13145 standard
Scots pine	*Pinus sylvestris*	0,55	Temperate	Mentioned in the EN 13145 standard
Andira	*Andira coriacea* *Andira inermis* *Andira parviflora* *Andira* p.p.	0,86	South America	
Angelim (= Angelim pedra)	*Hymenolobium elatum* *Hymenolobium excelsum* *Hymenolobium petraeum* *Hymenolobium* p.p.	0,80	South America	
Cupiuba	*Goupia glabra*	0,84	South America	
Dabéma	*Piptadeniastrum africanum*	0,70	Africa	
Piquia	*Caryocar nuciferum* *Caryocar villosum* *Caryocar* p.p.	0,81	South America	
Piquiarana	*Caryocar glabrum*	0,80	South America	
Blue Gum	*Eucalyptus microcorys*	0,98	Asie	

9. Average density at 12% humidity..
The density of timber in temperate hardwood and softwood species varies according to their growth rates, sometimes with opposite effects depending on the species; some species are denser the faster they grow (e.g. Oak), whereas the opposite effect is observed in others (as in the case of Larch); this phenomenon should be taken into account when selecting a temperate species for use in timber under rails.
10. They are anecdotal in nature.

6.2. SPECIES NOT REQUIRING A PRESERVATIVE TREATMENT (4-SIDED EDGED TIMBER)

Pilot name	Botanical name	Density[9]	Origin	Comments
Alep	*Desbordesia glaucescens*	1,05	Africa	Thick sapwood
Angelim vermelho	*Dinizia excelsa*	1,07	South America	
Araracanga	*Aspidosperma album* *Aspidosperma desmanthum* *Aspidosperma* p.p.	0,94	South America	
Azobé	*Lophira alata*	1,06	Africa	
Bangkirai / Yellow Balau	*Shorea glauca* *Shorea laevis* *Shorea maxwelliana* *Shorea superba* *Shorea* subgen. *Eushorea* p.p.	0,91	Asia	Mentioned in the EN 13145 standard but sold for other higher value uses
Basralocus	*Dicorynia guianensis* *Dicorynia paraensis*	0,79	South America	Mentioned in the EN 13145 standard but sold for other higher value uses
Congotali	*Letestua durissima*	1,1	Africa	
Curupay	*Anadenanthera colubrina*	1,03	South America	
Eyoum or Omvong	*Dialium pachyphyllum*	0,94	Africa	Very high hardness level, need for adapted sawing. To be validated.
Greenheart	*Chlorocardium rodiei*	0,97	South America	Mentioned in the EN 13145 standard
Jarrah	*Eucalyptus marginata*[12]	0,82	Asie et Océanie	Mentioned in the EN 13145 standard
Júcaro	*Terminalia buceras*	0,94	South America	
Karri	*Eucalyptus diversicolor*	0,90	Asie et Océanie	Mentioned in the EN 13145 standard
Kempas	*Koompassia malaccensis*	0,88	Asia	
Monghinza	*Manilkara mabokeensis* *Manilkara obovata* *Manilkara* p.p.	0,98	Africa	
Mora	*Mora excelsa* *Mora paraensis* *Mora* p.p.	1,03	South America	Mentioned in the EN 13145 standard
Mubala	*Pentaclethra macrophylla*	0,95	Africa	
Muiracatiara	*Astronium fraxinifolium* *Astronium graveolens* *Astronium lecointei* *Astronium* p.p.	0,80	South America	

11. Average density at 12% humidity.
12. In Australia, a wide range of Eucalyptus species are used for railroad sleepers, https://extranet.artc.com.au/docs/eng/track-civil/procedures/sf/ETA-02-01.pdf

Okan (= Adoum)	*Cylicodiscus gabunensis*	0,91	Africa	
Osanga	*Pteleopsis hylodendron* *Pteleopsis myrtifolia*	0,80	Africa	
Ozouga	*Sacoglottis gabonensis*	0,89	Africa	
Quebracho colorado	*Schinopsis balansae* *Schinopsis lorentzii*	1,20	South America	
Wamba	*Tessmannia africana* *Tessmannia anomala* *Tessmannia lescrauwaetii*	0,87	Africa	

• Some species have the technical characteristics that are required for use under rails (mechanical resistance, natural durability, etc.) but aren't mentioned in the above list for the following reasons:
- they are species used for applications with higher added value and therefore more profitable than timber under rails, in particular in interior and exterior flooring, and in joinery (Cumaru, Doussié, Ipé, Itauba, Maçaranduba, Moabi, Mukulungu, Padauk, Tali...),
- they are species used locally for uses other than timber (example: the Coula whose fruits play an important role in the diets of local populations),
- their logs have an insufficient diameter for large cross-section cuts (example: Niové),
- their logs have non-hardened internal areas (example: Eveuss).

• For the manufacture of sleepers or for bearers in switch and crossing layouts, certain little-known and hardly-used African species could be of potential interest. However, their use for this type of product remains to be validated: Brown Kanda (*Beilschmiedia congolana, B. corbisieri, B. letouzeyi, B. oblongifolia, Beilschmiedia p.p.*), Pink Kanda (B*eilschmiedia gabonensis, B. grandifolia, B. hutchinsonia, B. mannii, B. obscura, Beilschmiedia p.p.*), Nganga (*Cynometra ananta, C. hankei, Cynometra p.p.*), Oguomo (*Lecomtedoxa klaineana*), Rikio (*Uapaca guineensis, U. heudelotii, U. vanhouttei, Uapaca p.p.*), Vesambata (*Oldfieldia africana*)...

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ANNEX 1 : EXCERPT ADAPTED FROM THE TROPICAL TIMBER ATLAS (2016)

NATURAL DURABILITY

Unless specifically mentioned in relation to the sapwood, the durability characteristics relate to the heartwood of mature timber. Sapwood should always be considered as being non-durable with respect to biological timber degradation agents. Timber whose current moisture content is less than approximately 20% it is unlikely to be attacked by fungi. Temperatures below approximately 5°C prevent the growth of fungi. Timber that has been immersed in water or brought to high temperatures (around 60°C) are never attacked by fungi, regardless of their natural durability.

Resistance to fungi

The resistance of timber to fungi is determined using samples of standard dimensions in the presence of fungal strains under controlled environmental conditions. These tests take several months.
The NF EN 350 standard, which is being revised at the time of publication, defines classes of natural timber durability against lignivorous fungi:

- highly durable timber: class DC1 (durability class 1), named "class 1";
- durable timber: class DC2, named "class 2";
- moderately durable timber: class DC3, named "class 3";
- poorly durable timber: class DC4, named "class 4";
- non-durable timber: class DC5, named "class 5".

Resistance against dry timber insects (lyctus, bostrychus, beetles)

The vast majority of tropical timber on the market is not attacked by dry timber insects, provided that the timber is used without sapwood. When sapwood is not very distinct, it is preferable to treat the timber against dry timber insects. Some tropical species are attacked throughout the timber and require special care in their dry state. Sawn timber or finished products are only attacked if they still contain sapwood and sufficient starch content. According to the EN 350 standard, a species is classified as vulnerable (class DC S, named "class S") if it is attacked during the laboratory test. If it is not, it is considered to be durable (class DC D, named "class D").

Resistance against termites

The conditions for determining the resistance of timber against termites are similar to those for determining resistance against fungi. Samples of standard dimensions are exposed to termites. The intensity of the termite attacks and therefore the natural resistance of the timber is quantified by measuring the depth of the timber's penetration in the sample. The EN 350 standard defines three classes of natural durability against termites:

- durable timber: class DC D (durability class D), named "class D";
- moderately durable timber: class DC M, named "class M";
- vulnerable timber: class DC S, named "class S".

USAGE CLASS

The usage class refers to a degree of exposure to various biological degradation agents resulting from the situational use of a timber element or structure. It may change after modification of the structure's design or situation. It doesn't systematically define a service life, but simply the conditions of a potential biological attack. Within a usage class, the treatment specifications and the choice of species have a direct impact on the service life.

The service life must therefore be interpreted according to the species and the severity of the exposures. It depends on the timber's natural durability, but also other factors such as a structure's design details (risk of water traps, ventilation of the timber, etc.), the nature of planned maintenance and local climatic conditions.

The use of a timber with a natural durability that is greater than that which is recommended by standard NF EN 460 (July 1994) for a given use, allows the service life of the structure to be extended. Conversely, for elements with a very short service life (temporary construction) temporary construction), species with a natural durability lower than that which is specified in standard EN 460 may be recommended.

Note. **Do not confuse the notions of "fungus resistance class" and "usage class", which have different qualification scales.**

The timber usage situations have been grouped into usage classes (standard NF EN 335, May 2013). Each class refers to a category of use associated with a risk of biological degradation of the same level.

Categories grouping classes according to employment conditions

Usage class	General use
1	Indoors, in a dry environment
2	Indoors or under shelter, no exposure to bad weather. Water condensation may occur.
3	Outside, above ground, exposure to bad weather. Class 3 can be subdivided into 2 subclasses: 3.1 Short wetting conditions 3.2 Prolonged wetting conditions
4	Outside, with contact with the ground or fresh water
5	Immersed in salt water on a regular or permanent basis

Specificities of class 5

The classification of a species in class 5 is mentioned separately. A species that covers class 5 generally covers class 4, except for a few rare species that only cover class 3 or class 2 (Basralocus, Garapa, Iroko, Louro vermelho, Sougué).

The European standard NF EN 460 (July 1994) proposes a correlation table between the natural durability of solid timber and their potential uses within a given risk class (above table). This standard predates the replacement of the "risk class" notion by that of a "usage class" (NF EN 335, May 2013), as these two notions are almost equivalent.