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Končna uporaba lesenih izdelkov - Uporaba in izboljšanje obstoječih metod za oceno življenjske dobe

End use performance of wood products - Utilisation and improvement of existing methods to estimate service life

Leistungseigenschaften von Holzprodukten

Performance de fin d'utilisation de produits en bois - Utilisation et amélioration de méthodes existantes pour améliorer la vie de service

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End use performance of wood products - Utilisation and improvement of existing methods to estimate service life

Performance de fin d'utilisation de produits en bois - Utilisation et amélioration de méthodes existantes pour améliorer la vie de service

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (FprCEN/TR 16816:2014) has been prepared by Technical Committee CEN/TC 38 “Durability of wood and wood-based products”, the secretariat of which is held by AFNOR.

This document is currently submitted to the Technical Committee Approval.

1 Scope

The scope of WG28 Performance Classification is expressed in this Technical Report:

Guidance on the determination of end use performance of wood products: utilization and improvement of existing test methods to estimate service life, in order to give input to the harmonized product standards dealing with the durability requirement of the CPD and future CPR.

This Technical Report brings together the evaluations and discussions to date that have occurred within CEN/TC38/WG28 Performance Classification.

2 Background

2.1 General

The development of performance-based design methods for durability requires that models are available to predict performance in a quantitative and probabilistic format. The relationship between performance during testing and in service needs to be quantified in statistical terms and the resulting predictive models need to be calibrated to provide a realistic measure of service life, including a defined acceptable risk of non-conformity.

Service-life prediction or planning is a process for ensuring that, as far as possible, the service life of a building will equal or exceed its design life, while taking into account (and preferably optimising) its life-cycle costs (ISO 15686 [1]). For a long time, the international organizations CIB and RILEM have been leading this development, which has had an impact on standardization work nationally, regionally, and globally through ISO.

Service-life prediction should be integrated into the design process for constructions, but it is also applicable to existing buildings and other construction works.

Drivers for establishing service-life planning methodology and routines include the need for building owners to be able to forecast and control costs throughout the design life of a building or construction. It also influences the reliability of constructed assets, and hence the health and safety of users.

The construction sector is under pressure to improve its cost effectiveness, quality, energy efficiency and environmental performance and to reduce the use of non-renewable resources. A key issue for the competitiveness of wood is the delivery of reliable components of controlled durability with minimum maintenance needs and life-cycle costs.

The importance of service-life issues is reflected in the Construction Products Directive (CPD) with its six essential requirements, which should be fulfilled by construction products during a ‘reasonable service life’.

2.2 ISO/TC 59/SC14 “Design life”

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2.3 CEN/TC 350 Sustainability of Construction Words

CEN/TC 350 is responsible for the development of voluntary horizontal standardized methods for the assessment of the sustainability aspects of new and existing construction works and for standards for the environmental product declaration of construction products.

The objective is to ensure that LCA-based data for environmental product declarations are consistent, comparable, verifiable and scientifically based. Since the life cycle has to be defined, it is essential to include information on service lives, including reference service lives.

Methods for sustainability assessments should be based on a performance-based approach, and should cover environmental, social and economic performance.

2.4 CEN/TC 351 Construction Products: Assessment of release of dangerous substances

The work of CEN/TC 351 is directed to the area covered by the Biocidal Products Directive and REACH. Indicators, criteria and developed standards will have significant influence in the future on the materials available for construction products and on service-life design options.

2.5 COST Action E37 sustainability through new technologies for enhanced wood durability

The Task Force Performance Classification (TFPC) was established at the COST Action E37 workshop in Ljubljana in 2004 [2]. Its aim was to outline principles for a performance-based classification of wood durability, in particular in using the natural durability of untreated wood and for modified wood products, traditional and non-traditional treatments and non-biocidal measures for wood protection.

The COST Action ended in September 2008, and the TFPC submitted a final report for inclusion in the overall documentation of the Action [3]. Standards for durability of wood and wood-based products, not least those produced by CEN/TC 38 Durability of wood and wood-based materials, were of primary interest to the TFPC. They considered that the present standards could not deliver adequate performance-based data. One goal of the Task Force was therefore to address the way durability is treated in standardization. It was conceived that well-founded proposals on amalgamating modern, material-independent methods of service-life prediction and design with traditional wood assessment methods would be of direct use, e.g. to CEN/TC 38 and the construction industry.

The TFPC recognized the use of RSL as a basis for estimations of ESL. The estimates are not necessarily reached by use of the Factor Method as in ISO 15686, but the basic principle is useful. To develop a range of performance classes, the scientific community must connect better and cooperate with user groups and stakeholders and define reference products that can be evaluated under reference service conditions. Test results on any commodities, products and components will then be compared with agreed RSLs, and this can form the foundation for a range of performance classes. During this development, existing use classes have to be taken into account and, if necessary, adapted to suit a forthcoming system for performance classification. As an input to Factor A (Quality of components) in the Factor Method, it will be necessary to define a range of Resistance Classes to feed into the assessments. This work is carried forward in CEN/TC 38 WG28 and the WoodExter project.

2.6 WoodExter project

The WoodExter project [4] is a collaborative pan-European-funded research project supported by WoodWisdom-Net and the Building with Wood industry initiative. Its objective is to take the first steps towards introducing performance-based engineering design for wood and wood-based building components in outdoor above-ground situations. This enables capture of the benefits of 'design for durability' and has delivered a practical engineering tool for service-life estimation based on a novel methodology. The project focused on cladding and decking as two test case products to rigorously assess this methodology.

The project aims were to:

— characterize climatic influence on performance of timber cladding;

— characterize new and existing techniques as in-service indicators of performance prediction;

— combine the above in an engineering-based model;

— calibrate and rigorously test the model for the selected Use Class 3 products, cladding and decking;

— transfer knowledge to enable confident specification of timber cladding and decking.

A pilot model has been developed in the WoodExter project incorporating key input data and the interactions between them that influence performance of cladding www.kstr.lth.se/guideline. The consequence class depends on the severity of consequences in case of non-performance and is described by the factor γ_d.

The exposure index I_{sk} is conceived as a 'characteristic (safe) value' accounting for uncertainties. The exposure index is assumed to depend on:

— geographical location determining global climate;

— local climate conditions;

— the degree of sheltering;

— distance from the ground;

— detailed design of the wood component;

— use and maintenance of coatings.

2.7 Design value I_{Rd} for resistance factor depending on material

The design resistance index I_{Rd} for selected wood materials is determined on the basis of resistance class according to Table 1. This is a simplified first step for a material resistance classification based on a balanced expert judgment of moisture dynamics and durability class. The resistance class term is based on a combination of durability class data according to EN 350-2, test data, experience of treatability and permeability for wood species as well as experience from practice.

Biological durability is the key factor determining performance for wood in different use classes. The robust laboratory and field test methods that exist make it possible to assign a durability rating to timber linked to the intended use class according to EN 335, assuming a worst case scenario. Other factors determine the likelihood of the worst case scenario occurring in practice.

The natural durability of wood is classified into durability classes as described in EN 350-1 and presented as durability classes for heartwood of timber species in EN 350-2. Durability class is a classification on five levels from non-durable to very durable. This is based on decades of data from ground contact field trials for use class 4. The natural durability for a wood species can vary widely.

Table 1 — Resistance classification of selected wood materials and corresponding design resistance index

Material resistance class	Examples of wood materials[a]	I_{Rd}
A	Heartwood of very durable tropical hardwoods, e.g. afzelia, robinia (durability class 1) Preservative-treated sapwood, industrially processed to meet requirements of use class 3.	10,0
B	Heartwood of durable wood species e.g. sweet chestnut (durability class 2)	5,0
C	Heartwood of moderately and slightly durable wood species e.g. Larch and Scots pine (durability class 3 and 4,)	2,0
D	Slightly durable wood species having low water permeability (e.g. Norway Spruce)	1,0
E	Sapwood of all wood species (and where sapwood content in the untreated product is high)	0,7

[a] For the majority of wood materials there is variability in material resistance. The material resistance classification should defer to local knowledge based on experience of performance of cladding and decking and where this is not available field test data and then laboratory test data. It is possible that a classification with different design resistance indices may need to be adopted for specific regions or countries, based on practical experience e.g. from the use of a material in that region.

For out of ground contact (e.g. exterior wood cladding) the challenge is to translate durability class from use class 4 to use class 3. In EN 350-1 the term "markedly different" is used to describe the additional benefits of low permeability on the performance of wood out of ground contact. Expert advice is recommended for assigning the material resistance class for wood materials such as:

Preservative treated wood is often a combination of mixed treated heartwood and sapwood. The treated sapwood should be thoroughly treated and enhanced to durability class 1. The heartwood is more resistant to treatment and the enhancement of the heartwood can be considered to be slightly higher than the natural durability class of the heartwood for the species (EN 350-2). Therefore, for preservative treated decking it may be more sensible to take a mid-point between the resistance class of the treated sapwood and the treated heartwood. E.g. for pine heartwood treated (resistance class C) and pine sapwood treated (resistance class A) the overall batch of preservative treated wood should then be classified as resistance class B.

For untreated wood if there is a mixture of heartwood and sapwood present in the wood species then the material resistance can either be classified as the mid-point between the class of the heartwood (resistance class A to D) and the sapwood (resistance class E). If this risk is not acceptable then the material resistance class should be taken as the worst case (E), the least resistant competent of the overall material.

The durability of modified wood, e.g. acetylated, furfurylated and thermally modified, is specific to the technologies employed and may vary between specifications for the different materials. Expert advice is recommended for assigning the material resistance class for modified wood.

The input data are described by Thelandersson et al. [5] (2011) and the design of a detail is made in the following steps:

1) Choose consequence class to determine $\gamma_{d;}$

2) Determine a base value I_{S0} for the exposure index depending on the geographic location of interest;

3) Find a correction factor for the exposure index to account for the local climate conditions (meso- or micro-climate). Factors of importance are orientation, overall geometry of the structure, nature of the surroundings;

4) Find appropriate correction factors for:

— Sheltering conditions;

— Distance from ground;

— Detailed design of the wood component considered.

Steps 2–4 give a characteristic value I_{Sk} for the exposure index.

5) Choose material to determine a design value I_{Rd} for the resistance index;

6) Check performance by the condition:

$$I_{Sd} = \gamma_d \cdot I_{Sk} \leq I_{Rd}$$

7) If non-performance, change inputs in some or all of steps 2, 3, 4 and 5.

Work in this area continues in the Swedish led project Woodbuild.

3 CEN/TC38 Standards: requirements for efficacy

3.1 Preservative treated wood

The majority of CEN/TC38 efficacy tests are relevant to preservative treated wood. The CEN/TC38 system involves a framework in which specifications for preservation can be made on a country-by country basis depending on the requirements of any given country, yet using the same set of efficacy tests. This framework for specification is laid down in European standards EN 351-1 and EN 599-1. Of these it is EN 599-1 which governs the choice of appropriate test methods depending on the use class in which the treated wood is to be used.

EN 599-1 ensures the appropriate efficacy tests are performed for each use class (including the correct choice of artificial aging procedure). Some efficacy tests are considered “minimum requirements” while others are considered to be “additional / local tests”, which are not necessarily required in all European countries. Tests differ if the preservative is a penetrating preservative or a superficial preservative. The table below summarizes the requirements for the testing of a penetrating preservative in accordance with EN 599-1.

Minimum and additional test requirements for penetrating preservatives according to Use Class, as specified in EN 599–1

Use Class	**Pre-conditioning requirement**	**Minimum requirements**	**Additional / local tests**
1	EN 73	EN 47 and/or EN 49–2 and/or EN 20–2	EN 117
2	EN 73	EN 113 (brown rot fungi only)	UC1 tests EN 152
3	EN 73	EN 113 (brown rot fungi only)	UC1 tests

	EN 84 (EN 84 not required if EN 330 conducted)		EN 152 EN 113 (on *C versicolour*) EN 330
4	EN 73 EN 84	EN 113 (brown rot fungi and *C. versicolour*) ENV 807	UC1 tests EN 152 EN 252
5	EN 73 EN 84	As UC4 plus EN 275	UC1 tests EN 152

The vast majority of the efficacy tests are conducted on small blocks of pine sapwood that are defect-free. They are mainly conducted in conditions where the test organism is the only organism present (e.g. in the case of basidiomycetes pure cultures are used) and in conditions conducive to the wood degrading activity of that organism.

All the minimum requirement tests are laboratory efficacy tests, with the exception of EN 275 for UC5. It is not possible to conduct efficacy tests against all organisms which may attack wood in practice. Test organisms have been chosen to be representative of the types of organism that are encountered in the relevant use class.

The results from each of the relevant efficacy tests are assessed using guidelines given in EN 599-1 and a "biological reference value" (brv) is calculated for each test in terms of the application of preservative required to pass the test. The highest of the brv's from the tests required for a particular use class is known as the "Critical Value" (CV) of that preservative for the given use class.

The CV is not necessarily the retention requirement. In order to calculate the retention requirement for a preservative the CV can be adjusted. This adjustment is done within a given country to take account of local conditions and expectations.

3.2 Naturally durable wood

The natural durability classes of timber species commonly traded in Europe are given in EN 350-2. These durability classes are based on long term experience and on field performance in UC4 exposure. EN 350-1 describes assessment methods for naturally durable species for which the same experience is not necessarily available and that are not listed in EN 350-2. The assessment of these species is based on EN 252 (ground contact field test), though a laboratory test based on EN 113 (basidiomycete fungi) is permitted to derive a provisional natural durability class which can be used until the field test results become available. Two further technical specifications have been developed by CEN/TC 38 to test natural durability. CEN/TS 15083-1 is a laboratory test against basidiomycete fungi, and CEN/TS 15083 is a laboratory test against soft rot fungi.

4 Guidance on the determination of end use performance of wood products

Certain aspects peculiar to wood products should be taken into account when estimating the service life of construction products and planning the service life of buildings and constructions. These include:

— biological durability: a key factor for wood products in service;

— service conditions: period of wetness of the substrate, and what influences this, is the main factor in determining risk of decay. ISO 21887:2007 [6] defines a system of 'service classes' for wood products called Use Classes;

— insect hazard: damage by wood-boring insects and termites is affected more by whether the insects are present in the geographical region than by the service conditions;

— assessment procedures: standard tests for the biological durability of wood, especially of treated wood products, already exist (EN 599);

— natural variability: as wood is a natural material with large inherent variations, it is more realistic to define broad service classes than precise service life in years.

Broadly, for each Use Class the expected service life is determined by a combination of the biological durability of the timber and the physico-chemical factors that put the products at risk of biological degradation. The intended or designed service life can be met by selecting a timber of suitable biological durability or by reducing or eliminating the factors that put wood at risk of degradation. In practice, service life is usually met by a combination of the two.

By assigning values to these two characteristics it is possible to derive a value equivalent to a service class. This approach is in keeping with the aims of the factor method and compatible with it.

Considering two unique features of wood products more closely:

— Biological durability is the key factor determining performance in different use classes. Existing laboratory and field test methods make it possible to assign a durability rating to any timber product linked to the intended Use Class, assuming a worst-case scenario. Other factors determine the likelihood of the scenario. In assessing the biological durability the principle is to determine performance against reference service products for each use class and service-life period;

— Period of wetness of the substrate is key for the development of timber decay. This is affected by environmental parameters (including design, building physics, exposure, and maintenance) which have a marked effect on performance and vary greatly across Europe. No internationally agreed methods for assessing these parameters exist, but various national approaches based on experience take them into account. Any one of these parameters or a combination thereof can have an over-riding influence on performance.

At present, a single value for each factor should be allocated at a national approval level. This allows national experience for certain products to play a key role. For example, untreated spruce, a non-durable timber, is known to achieve the desired service life when used as painted exterior cladding in the Nordic countries, but this is not always the case in other European countries. Therefore in that region, a high rating can be allocated to the product making it unnecessary to invoke enhanced durability. The national schemes may well follow the ISO methods in detail.

Notwithstanding the above, if factors outside the control of moisture risk exist, such as the risk of wood-destroying beetles or termites, then this invokes the need for enhanced durability or protective design measures to eliminate the risk.

This information concentrates on the biological performance of wood-based products. Although this is a most important aspect, other factors in ISO 15686 also need to be taken into account.

A significant, if not the most significant, challenge is to be able to predict the performance of **products** (e.g. window, woodpole, timber deck, structural beam) from tests that by their very nature do not consider the primary influences of service life such as design, exposure and maintenance. CEN/TC38 tests almost exclusively consider only the **material**, and an idealised material (e.g. preservative treated sapwood), and the primary influence of material resistance not the moisture risk. Termites and insects might present a special case. They have to be present so there is a need to consider the product use location (e.g. South France) and insects and termites as an ‘add on’ to service life prediction. Beyond that we may just accept that the reliable material resistance (durability + permeability) data is the only influence CEN/TC 38 may have over performance classification and service life prediction. In which case our insect and termite tests should have a high predictive ability and be good at classifying the performance of wood and wood-based materials.

The primary two means of delivering performance for a UC3 wood product are design of the product (and its execution in the real building) and the exposure aspects (meso, macro, micro). Design and exposure can be