

Eurocode 5 – fasteners for timber structures

1. Rules and standards

The national rules and regulations deal with the fasteners used in load-bearing and reinforcing structures. The requirements for other fasteners shall be determined in contracts between the supplier and the customer, in which reference may be made to state regulations and voluntary requirements.

The **national standards** that deal with construction are set forth in the Finnish National Building Code (RakMK). The regulations for load-bearing structures are presented in series B of RakMK. Series B is being updated (spring 2011?): the technical design standards are being replaced with references to the CEN (Comité Européen de Normalisation) Eurocode design standards. However, the following will continue to be set forth at national level: resistance levels, design parameters dictated by local conditions (above all, loads), product approval requirements and job site supervision.

All of the Eurocode standards necessary for the design of structures were approved in conjunction with national annexes and translated into Finnish by at least 31 March 2010, the date on which Eurocode requirements can be completely adopted with regard to the design of structures. A similar situation exists in other EU countries. Eurocode-compliant design is subject to approval starting 1 April 2010. However, national standards may still be followed in parallel, e.g. in Finland, until at least the spring of 2011. Later, with the permission of the local official, other design systems for specific projects may also be approved, on condition that the durability level conforms to at least the Eurocode design requirements.

In Finland, European pre-standards have been permitted for use as parallel design norms in place of RakMK since 1995 (**ENV 1995**). Great leeway in interpretation of the prestandards has been allowed at national level; it has not been a requirement to follow them in full and it has been permitted to supplement them. The final Eurocode **EN-1995** for timber structures was adopted for use in Finland in autumn 2007. Only a few parameters in EN-1995 are regulated at national level. Eurocode 5 was rewritten in a more user-friendly format along with the guidelines for interpretation, encompassing the Finnish state's **decisions** in the Finnish Association of Civil Engineers publication **RIL 205-2009** "Standards for design of timber structures – Eurocode".

Under the EN-1995 standard, **products with the CE mark** are to be used in the design of structures. The CE mark is, for now, not yet obligatory in Finland. However, in accordance with the EN-1995 standard, only products that have the properties required of CE-marked products may be used. If industrial products do not have the CE mark, the VTT (Valtion teknillinen tutkimuskeskus) approval, the approval/opinion/description of usage issued by some other authorised institution or national type approval issued by VTT (Valtion teknillinen tutkimuskeskus) are appropriate references. VTT may only issue a type approval to products that do not have a CEN harmonised product standard and to which the Finnish Ministry of the Environment has thus issued a type approval regulation regarding the corresponding product group. A VTT type approval may not be sought for timber structure fasteners, but a type approval can be sought for special fasteners and characteristics thereof in conjunction with structures for stiffening siding products against wind or timber-concrete composite structures.

Please note: the CE mark denotes a product's properties and purpose of use. **Nevertheless, the CE mark does not denote the suitability for use of a structure, part of a structure or even a given product. Suitability for a building, i.e. adherence to state standards, is ensured by design in accordance with Eurocode requirements, where the product properties certified by the CE mark, such as strength => what kinds of nails, how many nails for each connection, what distances from the edge, possible protections, tolerances for installation, requirements for performing work and supervision => requirements for a suitable structure.**

If standard EN 1995 (Eurocode 5) is used for design, the product properties of the fasteners used in the load-bearing and reinforcing structures **must be set out based on the fastener**. The possibilities are defined in product standards (nails, staples, screws, nailing plates, punched metal plate fasteners), ETAG standards (shear plates) and the ETA CUAP standard to be prepared for special fasteners at the applicant's expense.

If the CE mark is not needed (the product is only marketed in Finland), the authorised institution will still follow the certification requirements established regarding the corresponding product group in the product standard, ETAG, or a CUAP that a competitor has had prepared. Forgoing the CE mark only achieves direct savings in the case of products that are not subject to certification => preparation of CUAP is waived along with required comments from the EOTA (European Organisation for Technical Approvals) institutions. Compared to the ETA; which allows the CE mark, an opinion/certificate can be obtained more rapidly for ETAG products (international comments are not necessary) but not more inexpensively.

Fasteners for load-bearing and reinforcing structures include all fasteners, the failure of which can cause bodily injuries. E.g., the same requirements apply to fastenings for suspended ceilings and barriers as for connections in load-bearing structures. Panel products (such as plasterboard, wood chipboard, porous windproof plasterboards and plywood) are generally used as stiffening structures in timber frames, and nails used for these boards are subject to strength requirements that ensure this. Flooring and decking board connectors are also frequently used for girder support, and thus only the required nails may be used in these connections.

The strength requirements are not applied to nails used for e.g. mouldings, interior panelling and external siding.

The **durability requirements and** corrosion resistance requirements set forth in design standards for load-bearing structures are **generally interpreted as also applying to non-load-bearing structures**, e.g. siding nails. Thus, manufacturers are advised to set forth the allowed service class or coating category for all nails. **CE marks may also be issued** for nails for non-load-bearing connections. In such a case, only corrosion resistance has to conform to the CE mark requirements.

Example: standards related to nails

Type	Standard	Description	Note
Obligatory	EN 1995-1-1 EN 1995-1-2 EN 1995-2	Design standard	Necessary properties
	EN 14592	Harmonised product standard	Requirements for and method of stating properties
	EN 14358	Determination and verification through testing of strength values	Followed in initial type testing and initial assessment and quality control tests
Optional product and material standards	EN 10230-1 EN 10016 EN 10088 EN ISO 1461	Steel nails Steel varieties Stainless steel Hot-dip galvanisation	Rules, requirements, measurements, shape, recommendations for material and tolerances

	ISO 2081	Electrical galvanisation	Obligatory in the extent of the harmonised product standard
Inspection standards	EN 409 EN 1382 EN 1383 EN 10218 EN 10244	Yield moment Withdrawal parameter Head pull-through, tensile capacity Steel wire testing Determination of thickness of zinc	Instructions for testing. Obligatory to the extent of the harmonised product standard
National product standards and other standards	(SFS 5081) DIN ????	Nail standards etc.	Not in force in accordance with EN 1995! Can be referred to in contracts/rules.

2. Requirements for fasteners

The **nails, staples and screws** used in load-bearing timber structures designed according to standard EN 1995 Eurocode 5 **must conform to the requirements of standard EN 14592** (Timber structures. Dowel type fasteners. Requirements, EN 14592). Standard EN 14592 notes that nails must also comply with the **requirements set forth in EN 10230-1:1999** (Steel wire nails. Part 1: Loose nails for general applications). The requirements of standard EN 10230-1 shall also apply to collated nails. Note: the nail shape established in standard EN 10230-1 and the recommendations as to measurements do not need to be followed. **Standard EN 14545 is to be followed in the use of nailing plates and punched metal plate fasteners.** There are two options for split rings: they can be considered to be nailing plates if the thickness is at least 0.9 mm and the material requirements are met, or the properties are set forth more extensively using ETA CUAP.

Coatings

As regards corrosion resistance, **the requirements set forth for service classes in Eurocode 5 (EN 1995-1-1)** (galvanisation or stainless steel) must be followed – furthermore, the surface treatment of nails must conform to standard EN 10230-1. The coatings for painted, resin or phosphate coatings are also defined in standard EN 10230.

Standard EN 14592 does not treat resin-coated nails.

The use of resin-coated nails in load-bearing structures requires a separate product-based European type approval (for the domestic Finnish market, VTT assessment is sufficient). Eurocode 5 does not deal with timber structures that come into contact with soil (service class 4) or salt water (service class 5), nor are corrosion resistance requirements related to their areas of use set forth in the standards dealing with timber structures. The Finnish guidelines for applying Eurocode 5 (RL 205-1 2009) include the supplementary standards set forth in the following table.

Service class (object)	EN 1995-1-1 requirement	Minimum solution
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service class 1 (dry interior)	- none - staples Fe/Zn 12c	- uncoated - electrical galvanisation 12 μm
service class 2 (protected from rain) If the $d \leq 4$ mm (fastener) Or $t \leq 3$ mm (plate/panel)	Fe/Zn 12c or Z275	electrical galvanisation 12 μm Hot dip galvanisation 20 μm (275 g/m^2)
service class 2 If $d > 4$ mm or $t > 3$ mm	none	uncoated
service class 3 (periodic exposure to rain or damp interior RH > 85%)	- Fe/Zn 25c or Z350 - stainless steel staples	Electrical galvanisation 25 μm Hot dip galvanisation 25 μm (350 g/m^2) - stainless steel
<i>service class 3.2</i> EN 335 (regularly becomes wet, e.g. exterior siding exposed to flowing rain water)	Manufacturer's recommendation	Recommended thickness category for hot dip galvanisation pursuant to EN 14592 - 25 μm (Z600: 600 gr/m^2)
service class 4 (exposed to soil or fresh water)	Finnish supplementary standard	Stainless steel EN 1.4301
service class 5 (salt water)	Finnish supplementary standard	Acid-proof steel EN 1.4401
Pressure-treated wood in damp conditions (UC3, 4 or 5)	Finnish supplementary standard	Stainless steel EN 1.4301

Hot dip zinc coating of nails may be substituted by barrel plating if the nail's diameter > 2.6 mm.

Material

Nails: tensile strength of wire at least $600 \text{ N}/\text{mm}^2$. In accordance with Part 1-4 of the unalloyed steel standard EN 10016 or in accordance with standard EN 10083-1 or 10088-2 for stainless austenite steel. In addition, initial type testing of threaded nails must also be performed.

Staples: minimum tensile strength of wire $800 \text{ N}/\text{mm}$.

Screws: Initial type testing and initial assessment shall always be performed.

Nailing plates (split rings): structural steel $\geq \text{S235}$ or hot-dip galvanised sheet metal made from structural steel $\geq \text{S220-Z275}$ or stainless steel.

Shear plate fasteners: hot dip galvanised DX51+Z275 (+ manufacturer guaranteed yield limit), $\geq \text{S220+Z275}$ or stainless steel.

Punched metal plate fasteners: minimum specification DX51 (+ guaranteed yield limit). The parameters for punched metal plate fasteners are always to be determined by testing (a series of at least 100 test-pieces).

Geometric requirements, e.g. for nails

Nominal thickness **$d = 1.9 \dots 8.0 \text{ mm}$** . Thickness without coating. In the case of square nails, d is the shortest lateral measurement. In the case of threaded nails, d is the diameter of the smooth part of the shank.

The area of the nail head $A_h \geq 2,5d^2$ and the thickness of the nail head $h_t > 0,25d$.

Length of the point $l_p = 0.5-1.5d$.

No other requirements are set forth for the shape of the nail. The standards for the type of nail, point, shank and head are set forth in the optional standard EN 10230-1.

The EN 14592 designation **Threaded nail** is used if the length of the threaded or helical part of the nail is ≥ 4.5 (length measured from the point) and the specific withdrawal strength is $f_{ax,k} \geq 4.5 \text{ N/mm}$ (if the timber is 350 kg/m and moisture RH65). If these conditions are not met, the nail is considered under EN 14592 to be a **Plain shank nail** even if the shank is ringed or threaded etc.

Shank nails may not be used in places where they are under long-term and permanent loads (such as batten for suspended ceiling).

Tolerances

Length: nominal length $L \pm 0,5d$.

Thickness: nominal thickness $d = \pm 2.5\%$ (uncoated nail).

The diameter and thickness of the nail head and the length of the slanted part of the point: $\pm 5\%$.

3. Data to be presented regarding fasteners

The product standard or ETA certificate states which fastener properties must be stated (in the case of CE mark). These properties must be known for designing pursuant to Eurocode requirements.

For example, in accordance with standard EN 14592, at least the following data must be stated on sales packaging for nails:

- manufacturer
- reference to shank or threaded nail pursuant to EN 14592
- type of nail (reference to EN 10230-1, if the nail conforms to it) for instance – “**ring shank flat head nail, standard EN 10230-1**”
- nominal thickness and nominal length in mm
- material and coating
- nail's yield moment $M_{y,k}$ (Nmm)
- withdrawal parameter $f_{ax,k} > (\text{N/mm}^2)$ and wood density (and moisture) corresponding to it or timber product for which the relevant parameter is defined
- head pull-through $F_{head,k}$ (N/mm^2) and corresponding wood density (and moisture) or timber product for which the relevant parameter is defined
- tensile capacity $F_{tens,k}$ (kN).

It is also recommended to set out the purpose of use of the fastener and the service class per EN 1995-1-1 to which the fastener's corrosion resistance conforms. In the case of shank nails, it should be noted that they must not be used in conditions where they are under long-term or permanent longitudinal load.

Note: If the nail, staple or screw does not conform to standard EN 14592, the sale packaging should clearly state that the fastener is not meant for use for connections of load-bearing or reinforcing structures. In this case, other relevant data should be stated: nail manufacturer, type, measurements, manufacturing material, coating and corrosion resistance.

4. CE mark

Product standards and the ETAGs have been developed and it is possible to obtain a CE mark for all fasteners of timber structures.

In the majority of EU member states, this has in fact been obligatory since April 2011.

CE-mark labelled fasteners must have a uniform declaration of conformity (DoC) to the requirements, which states the following:

- name and address of the manufacturer
- product description (type, approval, use...) and copy of the CE mark
- properties to which the product conforms mechanical strength and/or durability
- special conditions for the product (e.g. restrictions on use in certain conditions)
- name and address of the laboratory that performed the initial type testing and initial assessment
- signature, name and position of the person representing the manufacturer

The DoC shall be stated in an official language (English, German or French) or the language of the member states in which the product will be used.

The CE mark for package labelling sets out the data specified in the product standard or the ETA.

AnyCo Ltd, PO Box 21, DK-1050 04 (=2004 – year of CE mark)	
EN 14592 Circular plain shank nails Diameter = 4 mm, Length = 50 mm Non-alloy steel	
Yield moment	$M_{y,k} = 6610 \text{ Nmm}$
Withdrawal parameter	$f_{ax,k} = 2.45 \text{ N/mm}^2$ in timber of characteristic density 350 kg/m
Head pull-through parameter	$f_{head,k} = 8.57 \text{ N/mm}^2$ in timber of characteristic density 350 kg/m ³
Tensile capacity	$f_{tens,k} = \text{No Performance Determined}$

Figure 1. Example of CE mark for a nail

Data on properties may be stated in a separate document to which the package's CE mark refers.

6. Initial type testing and initial assessment of fasteners

The initial type testing of fasteners shall be performed by an authorised testing institution (in Finland, VTT). In the initial testing, **measurements, calculations and experiments** are used to demonstrate that the stated parameters can be approved: From the standpoint of strength parameters, initial testing means actual determination of the stated parameters.

The testing institution performs the tests according to the relevant testing standards and calculates special values according to standard EN 14358. The measurements, calculations and tests performed and the results thereof, specific values and comparisons to stated values shall be performed in the report issued by the testing institution.

Table 3. Example of verification (=determination) a nail's yield moment, withdrawal parameter and head pull-through parameter minimums inspection at initial type testing
Note: in general, a larger number of test-pieces should be selected =>more precise values.

Strength	Square shank or rounded wire nail	Other shank nails, such as ring shank nails	Other nails, i.e. threaded nails, with $f_{a,k} \geq 4.5 \text{ N/mm}^2$
Yield moment $M_{y,k}$	determined mathematically	10 per test	10 per test
Withdrawal parameter $f_{ax,k}$	determined mathematically	determined mathematically	10 per test
Head pull-through parameter $f_{head,k}$	determined mathematically	determined mathematically	10 per test

7. Verification of production quality

Either the manufacturer solely checks the production quality (AC3) or the authorised testing institution has to confirm it as well (AC2+). **No quality control outside of the company is required for nails, staples and screws** (AC category 3) The production of nailing plates and punched metal plate fasteners, split rings and shear plate connectors are categorised in AC2+ and require quality control to be performed outside the company, just as in the case of special fasteners with ETA approval, via CUAP.

To ensure the properties required for products introduced on the market, the manufacturer must develop, document and update a quality control system. The quality control system must provide for relevant regular inspections and testing and/or assessment and use of the results for oversight of the raw materials, means of production, processes and products. **The results of inspections, tests and assessments must be documented and retained.** The measures taken if quality control criteria were not met must also be recorded and archived. The quality control documents must be **retained for at least 5 years.**

Everyday quality control

Everyday quality control includes the inspection of raw material, geometry and tolerances, any coatings and the mark in the scope required in the product standard or ETA approval.

Testing of nail quality control every 6 months

The withdrawal parameter for **threaded nails** must be certified every 6 months by **withdrawal tests of at least 10 nails** pursuant to standard **EN-1382**. The manufacturer may perform the test itself and verify approval conditions.

8. Other issues

Ribbon and cartridge nails

The surface of EN 14592 compliant nails may not be coated with resin. That means that marketed EN 14592 compliant ribbon nails may not be affixed using adhesive or adhesive/sticky paper. Mechanical bindings that detach automatically when a nail gun is fired (such as plastic band or wire weld collation) are appropriate for nails used in load-bearing and reinforcing timber structures designed in accordance with Eurocode 5. In the case of nails that are intended for nail gun installation, the test-pieces for testing the withdrawal parameter of the nails shall be fashioned so that a nailing device and collated nails are used.

Resin-coated nails

The withdrawal parameter of nails with resin-coated points may be inferior to that of ordinary nails. Even if the adhesive liquefies and hardens when installed using a nailing device in favourable conditions, the glue may break down upon subsequent hammering or due to loads or deformations caused by removal of a structural element (an adhesive bond is always very fragile). The weather resistance and durability of adhesive bonds used in construction fastenings must be verified and approved. Besides this, strict out-of-house quality control (AC category 1) and regular quality control testing is required in the case of the production of adhesive joints.

Nails with resin coatings may only be approved in European product certification authorities via the European Type Approval (ETA) proceedings, first developing EOTA approval proceeding requirements CUAP. The procedure is complicated and very costly for first-time applicants. For Finnish domestic markets, the VTT assessment is suitable, but obtaining this will also likely require long-term withdrawal parameter testing and limitation of the use of nails to the **use as fasteners that work on that particular segment** without taking into consideration the withdrawal parameter.

The use of test results in materials introducing the product

If the test results stated in materials introducing the product refer to the name VTT without the relevant VTT report being presented/added as a whole, the VTT must be given an opportunity to verify the product introduction. To do so, the draft of the introductory text must be sent to VTT, to the investigator mentioned as a contact person. An unchanged text referring to the VTT does not have to be checked separately again even if different product introduction versions/advertisements. It is wise to have the VTT check the explanation approved for a product with a CE mark if the initial type testing was also done at the VTT.

VTT is interested in seeing its name used in company ads and for the VTT report to be available as a whole, e.g. on the company website.

Withdrawal parameter of nails for installation using a nail gun

Since 1990, about 10 suspended ceilings in public buildings and commercial spaces have collapsed as they were fastened with nails under load in the longitudinal direction (in particular, school buildings and stores). In two cases, the collapse of a department store ceiling was categorised as situation involving the risk of a major accident, the reasons for which were investigated at the accident investigation centre. The reason for such collapses has generally been that the said connections were not included in

design documentation and they were nailed together in an ordinary manner that did not ensure sufficient withdrawal strength.

Due to these accidents, the Ministry of the Environment ordered that VVT conduct an investigation of the withdrawal parameter of all nails. In the course of the investigation, it was noted that nails for installation using a nail gun were sold under various names, all promising good withdrawal strength values, such as toothed nails, adhesive nail, tooth cut nail and adhesive point nail, although the withdrawal parameter value was so low that it should have been categorised as a shank nail under EN 14592.

The importer/producer of nails can also be held liable for misleading names if there is a trend of collapse in suspended ceilings with a designed structure. Under the new design standards (the RIL 120-2004 based on Eurocode 5 and RakMK B10), a shank nail may not be used if it is under a permanent or long-term load in the longitudinal direction as in the case of suspended ceilings.

A second key conclusion of the withdrawal parameter studies was the fact that **the withdrawal parameter of nails decreases significantly as the wood dries**. This was not taken into account in Eurocode 5 or in determining withdrawal values. It is recommended to add series B coefficients to the new RakMK to be used by the designer to convert the withdrawal parameters determined in ordinary conditions (RH65) to suit dry indoor conditions (= Eurocode 5 national supplementary standard).

Customer requirements <=> properties of fasteners

The general principle is that the fastener product standard (**EN 14545, EN 14592**) **must be adhered to** in order to ensure the mechanical durability of the fastener. If the customer desires a type of fastener that does not conform to the requirements of the product standard or initial type testing has not been performed for the fastener in the manner set forth in the product standard, it must be clearly indicated on the packaging that the fastener is not meant for connections where mechanical durability is required.

The requirements set out by the customer for the fasteners' installability, geometry, overall dimensions (dxL) and exterior appearance of the connection are not in contravention with the product standard. Yet it should be taken into consideration that **the nails of different types and thicknesses required by the customer must first be tested by each manufacturer in order to determine design parameters**.

The tested nail types may nevertheless be produced in different lengths without initial type testing if the length of the threaded part of threaded nails meets the requirements.

Customers may set out **requirements for coating material** that vary from the design standards for timber structures, e.g. the coating requirements set forth in the steel structure standards. The seller/manufacturer of the fastener must notify the customer regarding the requirements of timber structures. In any case, it is a good idea to indicate the field of use on the packaging as the **service class for which the corrosion resistance of the nail would meet the Eurocode 5 (EN 1995) requirements**. In cases involving special use, the customer may have information, based on its experience, regarding corrosion resistance not contained in any standard. Note: if **special coatings** or a different raw material to the one that underwent initial type testing are used, prior testing must be conducted **before** use of the nail in load-bearing or reinforcing structures.

Stainless steel fasteners

In the case of pressure treated wood, metals and materials more valuable than zinc (such as copper, arsenic and chromium) and some new impregnation agents that contain organic ingredients cause galvanised fasteners to rust in moist conditions => **stainless steel fasteners (RIL 205 supplementary standards) must be used in pressure treated products in the case of service class 3**. Note: the service class of the lower part is usually 2.

Stainless steel fasteners are recommended in the **agriculture sector** – in the ceiling structures of animal housing and manure storage facilities with high ammonia and hydrocarbon concentrations (the main variety A2 / EN 1.4301 is sufficient). In raw feed storage facilities containing acetic and formic acid, acid-proof fasteners should be used (A4 / EN 1.4401).

Due to electrolytic corrosion, the main varieties of stainless steel (EN 1.4301, 1.4401 or 1.4432) should not be used in the internal structures of **swimming pools**. Suitable varieties are EN 1.4529, 1.4547, 1.4539 and 1.4565.

Due to the risk of galvanic corrosion, fasteners of the same metal variety should be used to fasten metal connecting plates or posts. Thus, in damp conditions, both should be stainless steel or both should be galvanised.

In the case of acid-proof nailing plates and shear plates + acid-proof anchor nails (A4 4 x 60), **fire resistance** is R30.