**ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE**

COMPARATIVE DESIGN OF THE SUPERSTRUCTURE OF TIMBER BRIDGES, USING NORM NP 005 - 2003 AND PROVISIONS OF EUROPEAN STANDARDS

Corina Chiotan, Lecturer, PhD Eng., UTCB - CFDP
Dumitru Daniel Morlova, Assistant Eng., UTCB - CFDP

Rezumat

Proiectarea podurilor din lemn, ca de altfel şi a celorlalte structuri construite din acest material, a suferit o perioadă lungă de timp de lipsa unor normative şi standarde de proiectare revizuite, standardele de proiectare utilizate datând din anii 1978-1980. Introducerea normelor europene a creat un cadru legislativ nou în domeniul proiectării construcţiilor din lemn şi a podurilor executate din acest material.

În prezent pentru proiectarea unor astfel de construcţii se folosesc Normativul NP 005-2003 şi SR EN 1995-1-1:2004 Eurocod 5: Proiectarea structurilor de lemn. Partea 1-1: Generalităţi. Reguli comune şi reguli pentru clădiri şi SR EN 1995-2:2005 Eurocod 5: Proiectarea structurilor de lemn. Partea 2: Poduri, împreună cu anexele lor naţionale.

Lucrarea îşi propune să analizeze proiectarea unor elemente de rezistenţă ale suprastructurilor podurilor din lemn realizate pe grinzi, în paralel, utilizând pe de o parte normativul NP 005 - 2003, iar pe de altă parte prevederile din standardele europene.

Vor fi prezentate atât prescripţiile de proiectare cuprinse în cele două norme, cât şi rezultatele obţinute pentru studiul de caz, reprezentat de un element de rezistenţă al unui pod.

Cuvinte cheie: pod, lemn, suprastructură, grindă

Abstract

The norms and standards for design of timber bridges, as well as other structures built from this material, were obsolete, design standards that were used dated from 1978 to 1980. The introduction of European Standards has created a new legislative framework in the field of designing and building timber bridges.

Currently the design of such constructions use Norm NP 005-2003 and SR EN 1995-1-1: 2004 Eurocode 5: Design of timber structures. Part 1-1: General. Common rules and rules for buildings, SR EN 1995-2: 2005 Eurocode 5: Design of timber structures. Part 2: Bridges, along with their national annexes.

The aim of this paper is to analyze the design of the beams for timber bridges in parallel, using on one hand Norm NP 005 - 2003, and on the other hand provisions of European standards.

ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE

Corina Chiotan, Dumitru Daniel Morlova
Comparative design of the superstructure of timber bridges, using norm NP 005 - 2003 and provisions of
European standards

The design requirements for both norms as well as the results of a case study for a structural element of a timber bridge will be presented.

Keywords: bridge, timber, superstructure, beam

1. CURRENT LEGISLATION FOR THE DESIGN OF THE SUPERSTRUCTURE OF TIMBER BRIDGES

In Romania there are currently used European norms, but also some norms and standards which were written before the implementation of EUROCODES. For the design of the superstructure of timber bridges are used:

- SR EN 1995-1-1-2004. Eurocode 5: Design of timber structures. Part 1-1: General - Common rules and rules for buildings;
- SR EN 1995-1-1-2004/A1:2008. Eurocode 5: Design of timber structures. Part 1-1: General - Common rules and rules for buildings. Amendment
- SR EN 1995-1-1-2004/AC:2006. Eurocode 5: Design of timber structures Part 1-1: General - Common rules and rules for buildings. Errata
- SR EN 1995-1-1-2004/NB:2008 Eurocode 5: Design of timber structures Part 1-1: General - Common rules and rules for buildings. National Annex
- SR EN 1995-1-2-2004. Eurocode 5: Design of timber structures - Part1 -2: General. Structural fire design
- SR EN 1995-1-2-2004/ AC:2006. Eurocode 5: Design of timber structures - Part1 -2: General. Structural fire design. Errata
- SR EN 1995-1-2-2004/ NB:2008. Eurocode 5: Design of timber structures - Part1 -2: General. Structural fire design. National Annex
- SR EN 1995-2-2005. Eurocode 5: Design of timber structures - Part 2: Bridges
- SR EN 1995-2-2005/NB:2008. Eurocode 5: Design of timber structures - Part 2: Bridges. National Annex
- SR EN 336:2014. Structural timber. Sizes, permitted deviations
- SR EN 338:2010. Structural timber. Strength classes
- SR EN 14081. Timber structures. Strength graded structural timber with rectangular cross section

ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE

Corina Chiotan, Dumitru Daniel Morlova
Comparative design of the superstructure of timber bridges, using norm NP 005 - 2003 and provisions of
European standards

− SR EN 1912:2012. Structural timber. Strength classes. Assignment of visual grades and species
− STAS 857-83. Wood pieces and elements for buildings. Classification and technical requirements for quality
− STAS 1040-85. Coniferous round timber for buildings. Posts and poles
− STAS 4342-85. Round broad-leaved wood for buildings
− STAS 3416-75. Round logs for piles.

There is also NP 005-2003 "Design of timber structures" which is applied to solid wood structural elements, used for civil, industrial and agricultural buildings, but it can also be applied to the design of timber constructions having other purposes, such as the design of the superstructure of timber bridges.

2. SOLID WOOD PRODUCTS USED FOR BRIDGE CONSTRUCTION

The broad-leaved species which are used for building bridges are: hornbeam, beech, ash, birch, sycamore maple, oak, durmast, acacia and poplar.

The coniferous species which are used are: fir, larch, spruce, pine.

Wood products are classified by different quality classes. According to STAS 857-83, timber structural elements are divided into three categories, by the flaws they have. Each category is recommended for a specific usage.

In the same standard there are presented the flaws and anomalies that lumber and round logs can have and the admissibility conditions for each quality category.

There are presented tolerance limits for each category with respect to manufacturing and storage flaws of large timber pieces. There can also be found maximum humidity values and maximum admissible deviations with respect to the base dimensions of elements.

On the other hand, SR EN 338:2010 classifies coniferous structural timber into 12 quality classes (C14-C50) and broad-leaved into 9 classes (D18-D70), according to the conditions imposed by SR EN 1912:2012 Structural timber. Strength classes. The machine grading in strength classes should fulfill the requirements from EN 14081-1, 2, 3.

ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE

Corina Chiotan, Dumitru Daniel Morlova
Comparative design of the superstructure of timber bridges, using norm NP 005 - 2003 and provisions of
European standards

3. TIMBER STRENGTHS TO DIFFERENT LOADS

The characteristic strengths of different species are computed by applying the Normal Type Distribution Function, considering a minimum value which excludes 5% of the inferior values from an experimentally determined group.

In NP 005-2003 "Design of timber structures", are given characteristic strength values for timber in the cases of: bending, tension parallel to the fiber, tension normal to the fiber, compression parallel to the fiber, compression normal to the fiber, shearing parallel to the fiber, shearing normal to the fiber, function of wood species and quality class.

The design strength for different timber species in several loading cases, function of exploitation conditions of the designed construction elements, is determined by relation (1):

$$R_i^c = m_{ui} \cdot m_{di} \cdot R_i / \gamma_i \qquad (1)$$

where:

m_{ui} - working conditions coefficients regarding the equilibrium humidity of the timber, defined by the micro-climate conditions in which the construction elements are exploited;

m_{di} - working conditions coefficients, established by the time duration of significant intensities of loads. In the case of several actions, its value is established by how much of each action participates in the total value;

R_i - characteristic strength for different loads and species;

γ_i - partial safety coefficients, defined by the load type.

On the other hand, in SR EN 338:2010 are given characteristic strength values for bending, tension parallel and normal to the fiber, compression parallel and normal to the fiber and shearing, function of the strength class of the timber piece.

According to SR EN 1995-1-1-2004, the design value of a strength property is computed using relation (2):

$$X_d = k_{mod} \cdot X_k / \gamma_m \qquad (2)$$

where:

X_K - characteristic value of the strength property;

γ_i - partial safety coefficient, defined exclusively by the material;

k_{mod} - modification factor, function of the time duration of the load and function of humidity.

ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE

Corina Chiotan, Dumitru Daniel Morlova
Comparative design of the superstructure of timber bridges, using norm NP 005 - 2003 and provisions of
European standards

There are some differences with respect to the Romanian norm NP 005 - 2003:

- A material (ex: solid wood) has the same partial safety coefficient regardless of the loading type;

- The effects of humidity and time duration are combined into one coefficient k_{mod} , which changes function of the timber species. It is specified that for load combinations which have different time durations, k_{mod} is chosen by taking into account the load having the smaller time duration.

4. CHECKING STRUCTURAL ELEMENTS FOR TIMBER BEAMS BRIDGES

Due to the fact that the majority of structural elements belonging to the superstructure of timber bridges are subjected to bending, there will be presented checks for solid wood elements loaded in this manner.

4.1. Checking bent elements at ULS of strength

4.1.1. Checking bent elements at ULS of strength according to NP 005-2003 [6]

The check consists in comparing the maximum design bending moment, M_{Ed}, to the bearing capacity in bending of the element, M_{Rd}. The check is:

$$M_{Rd} \geq M_{Ed} \tag{3}$$

M_{Ed} is determined by the static scheme of the element and by loads.

$$M_{Rd} = R_i^c \times W_{calculus} \times m_{Ti} \times m_L \tag{4}$$

where:

R_i^c - design bending strength of timber;

$W_{calculus}$ - strength modulus computed for the most loaded cross section of the element;

m_{Ti} - coefficient regarding the strength variation caused by the applied treatment of the wood;

m_L - lateral stability coefficient.

In NP 005-2003, the lateral buckling problem of elements subjected to bending is solved by imposing maximum h/b ratio values, by the way the stiffness of the compressed side is ensured.

**ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE**

Corina Chiotan, Dumitru Daniel Morlova
Comparative design of the superstructure of timber bridges, using norm NP 005 - 2003 and provisions of
European standards

4.1.2. Checking bent elements at ULS of strength according to SR EN 1995-1-1-2004 [1]

The checking relations are:

$$k_m \times \frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}} \leq 1 \tag{5}$$

$$\frac{\sigma_{m,y,d}}{f_{m,y,d}} + k_m \times \frac{\sigma_{m,z,d}}{f_{m,z,d}} \leq 1 \tag{6}$$

where:

$\sigma_{m,y,d}, \sigma_{m,z,d}$ - tensions coming from bending with respect to the principal axes;

$f_{m,y,d}, f_{m,z,d}$ - design bending strengths.

The k_m factor takes into account the redistribution of tensions on the section and certain heterogeneities of the material. It has the value 0.7 for rectangular transversal sections and 1.0 for other types of transversal sections.

It is necessary to check the lateral stability condition:

$$\sigma_{m,d} \leq k_{crit} \times f_{m,d} \tag{7}$$

where:

$\sigma_{m,d}$ - design value of tension from bending;

$f_{m,d}$ - design value of the bending strength;

k_{crit} - factor which takes into account the strength reduction due to buckling;

$$
\begin{aligned}
k_{crit} &= 1 , \quad for \ \lambda_{rel,m} \leq 0.75 \\
&= 1.56 - 0.75 \times \lambda_{rel,m} , \quad for \ 0.75 < \lambda_{rel,m} \leq 1.4 \\
&= \frac{1}{\lambda_{rel,m}{}^2} , \quad for \ 1.4 < \lambda_{rel,m}
\end{aligned}
\tag{8}
$$

$$\lambda_{rel,m} = \sqrt{\frac{f_{m,k}}{\sigma_{m,crit}}} \tag{9}$$

where:

$\lambda_{rel,m}$ - relative slenderness;

$\sigma_{m,crit}$ - critical tension coming from bending, computed by the classical stability theories.

For soft timber and full rectangular sections:

$$\sigma_{m,crit} = \frac{0.78 \times b^2}{h \times l_{ef}} \times E_{0.05} \tag{10}$$

ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE

Corina Chiotan, Dumitru Daniel Morlova
Comparative design of the superstructure of timber bridges, using norm NP 005 - 2003 and provisions of
European standards

4.2. Checking bent elements at Serviceability Limit State of deflection

4.2.1. Checking bent elements at SLS of deflection according to NP 005-2003 [6]

The checking relation is:

$$f_{max.final} \leq f_{adm} \tag{11}$$

where:

f_{adm} - admissible deflection,

$f_{max.final}$ - maximum deflection in bending, computed using the realation::

$$f_{max.final} = f_1 + f_2 + f_i \tag{12}$$

where:

$$f_1 = f_{1inst} \times \left(1 + k_{def}\right) \text{ - deflection caused by permanent loads;} \tag{13}$$

$$f_2 = f_{2inst} \times \left(1 + k_{def}\right) \text{ - deflection caused by variable loads;} \tag{14}$$

f_i - deflection caused by the deformability of connections.

Deformation caused by permanent and variable loads are based on the instantaneous elastic deflection (f_{inst}), taking into account the creep phenomena and the exploitation mode, by adding the coefficient k_{def}.

4.2.2. Checking bent elements at SLS of deflection according to SR EN 1995-1-1-2004 [1]

The final deformation u_{fin} is computed for the quasi-permanent actions combination. If the structure has structural elements, components or connections having the same behavior in creep and can be considered a linear relation between actions and deformations they produce, the final deformation u_{fin} is determined thus:

$$u_{fin} = u_{fin,G} + u_{fin,Q_1} + \sum u_{fin,Q_i} \tag{15}$$

where:

- for permanent actions, G:

$$u_{fin,G} = u_{inst,G} \times (1 + k_{def}) \tag{16}$$

- for the dominant variable action, Q_1

$$u_{fin,Q_1} = u_{inst,Q_1} \times (1 + \psi_{2,1} \times k_{def}) \tag{17}$$

- for secondary variable actions O_i (i>1):

$$u_{fin,Q_i} = u_{inst,Q_i} \times (1 + \psi_{2,i} \times k_{def}) \tag{18}$$

$u_{inst,G}$, u_{inst,Q_1} , u_{inst,Q_i} - instantaneous deformations for actions G, Q_1, Q_i

ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE

Corina Chiotan, Dumitru Daniel Morlova
Comparative design of the superstructure of timber bridges, using norm NP 005 - 2003 and provisions of
European standards

$\psi_{2,1}, \psi_{2,i}$ - quasi-permanent variable actions coefficients;

k_{def} - creep and exploitation class coefficient.

5. CASE STUDY

It was chosen for the case study to check a sidewalk bearing beam of a road bridge (figure 1).

Sidewalk bearing beams are bent elements, simply supported on the transversal beams. The computation span is considered equal to the distance between the transversal beams, in this case 2.00m. Bearing beams are subjected to self weight, weight of the floor, weight of the ledge (permanent actions), actions caused by pedestrian traffic - uniformly distributed load 5 kN/m^2 (dominant variable load). The bearing beam is fabricated from resinous timber, quality class II, fireproofed and has a 12x12cm section. Based on the characteristic strength equivalence, this timber falls into C16 quality class, according to SR EN 338:2010.
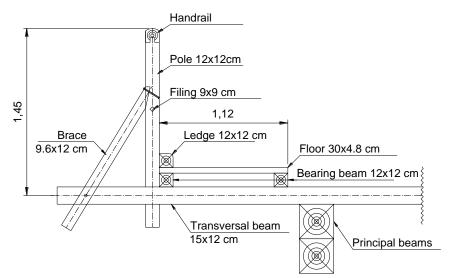

Figure 1. Sidewalk structure

5.1. Checking the sidewalk bearing beam at ULS of strength

5.1.1. Checking the sidewalk bearing beam at ULS of strength according to NP 005-2003

The bearing beam is subjected to:

ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE

Corina Chiotan, Dumitru Daniel Morlova
Comparative design of the superstructure of timber bridges, using norm NP 005 - 2003 and provisions of European standards

- permanent actions:

$$g_{perm,k} = g_{longrină,k} + g_{podină,k} + g_{lisă,k} = 513,60 \, N/m$$

$$g_{perm,d} = g_{perm,k} \times 1.35 = 693,36 \, N/m$$

- pedestrian traffic:

$$r_{o/t,k} = 5000 \, N/m^2 \times \frac{1.00}{2} m = 2500 \, N/m$$

$$r_{o/t,d} = r_{o/t,k} \times 1.35 = 3375 \, N/m$$

The design bending moment is:

$$M_{Ed} = \frac{g_{perm,d} \times L_{longrină}^2}{8} + \frac{r_{o/t,d} \times L_{longrină}^2}{8} = 346.68 \, Nm + 1687.5 \, Nm$$
$$= 2034.18 \, Nm$$

The bearing capacity in bending of the bearing beam is [6]:

$$M_{Rd} = R_i^c \times W_{calcul} \times m_{Ti} \times m_L$$

$$R_i^c = \frac{(R_i \times m_{di} \times m_{ui})}{\gamma_i} = 10.538 \, MPa$$

$$R_i = 16.8 \, ^N/_{mm^2} \qquad m_{ui} = 0.75 \qquad \gamma_i = 1,10$$

$$m_{di} = \frac{m_{d \, Perm,i} \times M_{Ed \, Perm} + m_{d \, SD,i} \times M_{Ed \, SD}}{M_{Ed}} = 0.92$$

$$W_{calcul} = \frac{b \times h^2}{6} = 288000 \, mm^3$$

$$m_L = 1, \qquad m_{Ti} = 0.90$$

$$M_{Rd} = R_i^c \times W_{calcul} \times m_{Ti} \times m_L = 2731,45 \, Nm \geq M_{Ed} = 2034.18 \, Nm$$

$$\frac{M_{Rd}}{M_{Ed}} = 1.342$$

5.1.2. Checking the sidewalk bearing beam at ULS of strength according to SR EN 1995-1-1-2004

$$\sigma_{m,y,d} = \frac{M_{Ed}}{W_{calcul}} = 7,063 \, MPa$$

$$f_{m,y,k} = 16 \, MPa$$

$\gamma_M = 1,30$ – partial safety coefficient for solid timber;

$k_{mod} = 0,90$ – modification factor, function of the time duration of the load and function of humidity;

ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE

Corina Chiotan, Dumitru Daniel Morlova
Comparative design of the superstructure of timber bridges, using norm NP 005 - 2003 and provisions of European standards

$$f_{m,y,d} = k_{mod} \times \frac{f_{m,y,k}}{\gamma_M} = 11.077 \; MPa$$

$$\frac{\sigma_{m,y,d}}{f_{m,y,d}} = 0.637 \leq 1$$

Stability check:

$$\sigma_{m,y,d} \leq k_{crit} \times f_{m,y,d}$$

$$\sigma_{m,crit} = \frac{0{,}78 \times b^2}{h \times l_{ef}} \times E_{0.05} = 280.8 \; MPa$$

$$l_{ef} = 0.9 \times L_{longrină} = 1.80 \; m$$

$$E_{0.05} = 5{,}4 \; GPa$$

$$\lambda_{rel,m} = \sqrt{\frac{f_{m,y,k}}{\sigma_{m,crit}}} = 0.239 \leq 0.75$$

$$k_{crit} = 1$$

$$\sigma_{m,y,d} \leq k_{crit} \times f_{m,y,d}$$

$$7{,}063 \; MPa \leq 11.077 \; MPa$$

$$\frac{f_{m,y,d}}{\sigma_{m,y,d}} = 1.568$$

5.2. Checking the sidewalk bearing beam at SLS of deflection

5.2.1. Checking the sidewalk bearing beam at SLS of deflection according to NP 005-2003

$$f_{max.final} \leq f_{adm}$$
$$f_{adm} = \frac{L_{longrină}}{300} = 6{,}67 \; mm$$
$$f_{max.final} = f_1 + f_2 + f_i$$
$$E_{0.05} = 9000 \; MPa$$
$$k_{def1} = 1.00$$
$$k_{def2} = 0$$
$$f_{1inst} = \frac{5}{384} \times \frac{g_{perm,k} \times L_{longrină}^{\;4}}{E_{0.05} \times I} = 0.688mm$$
$$f_1 = f_{1inst} \times (1 + k_{def1}) = 0.688 \times (1 + 1.00) = 1.376 \; mm$$
$$f_{2inst} = \frac{5}{384} \times \frac{r_{o/t,k} \times L_{longrină}^{\;4}}{E_{0.05} \times I} = 3.349 \; mm$$

ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE

Corina Chiotan, Dumitru Daniel Morlova
Comparative design of the superstructure of timber bridges, using norm NP 005 - 2003 and provisions of
European standards

$$f_2 = f_{2inst} \times (1 + k_{def2}) = 3.349(1 + 0) = 3.349 \; mm$$
$$f_i = 0$$
$$f_{max.final} = f_1 + f_2 + f_i = 4{,}725 \; mm$$
$$f_{max.final} \leq f_{adm}$$

5.2.2. Checking the sidewalk bearing beam at SLS of deflection according to SR EN 1995-1-1-2004

$$u_{fin} \leq u_{adm}$$
$$u_{fin} = u_{fin,G} + u_{fin,Q_1} + u_{fin,Q_i}$$
$$k_{def} = 2.00$$
$$\psi_{2,1} = 0$$
$$E_{0.05} = 5.4 \; GPa$$
$$u_{inst,G} = \frac{5}{384} \times \frac{g_{perm,k} \times L_{longrină}{}^4}{E_{0.05} \times I} = 1{,}147 \; mm$$
$$u_{fin,G} = u_{inst,G} \times (1 + k_{def}) = 3.441 \; mm$$
$$u_{inst,Q_1} = \frac{5}{384} \times \frac{r_{o/t,k} \times L_{longrină}{}^4}{E_{0.05} \times I} = 5{,}582 \; mm$$
$$u_{fin,Q_1} = u_{inst,Q_1} \times (1 + \psi_{2,1} \times k_{def}) = 5{,}582 \; mm$$
$$u_{fin,Q_i} = 0$$
$$u_{fin} = u_{fin,G} + u_{fin,Q_1} + u_{fin,Q_i} = 9.023 \; mm$$
$$u_{adm} = \frac{L_{longrină}}{300} = 6{,}67 \; mm$$
$$u_{fin} \nleq u_{adm}$$

The check for this limit state is not fulfilled, so it is necessary either to increase the section of the bearing beam or to use a higher quality class.

6. CONCLUSIONS

There are similarities between NP 005-1003 and Eurocodes both from computational algorithm and for limit states used.

Because for a long period of time timber was not considered a viable construction material which has a long life-time, research related to this subject in Romania was brought to a standstill and the existing standards before the implementation of Eurocodes were written and published in the 1980's or earlier.

One important difference is the classification in quality classes. From the strength point of view, NP 005-2003 states 12 quality classes, 3 for each category, while SR EN 338:2010 states 20 quality classes. From the point of view of the elasticity modulus, SR EN 338:2010 has distinct values for each one

ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE

Corina Chiotan, Dumitru Daniel Morlova
Comparative design of the superstructure of timber bridges, using norm NP 005 - 2003 and provisions of
European standards

of the 20 classes, while NP 005-2003 has distinct values only for the four categories.

With respect to the limit state of strength in bending, for the same characteristic strength, the NP 005-2003 check leads to a ratio between the bearing capacity and the design bending moment equal to 1.342; but the SR EN 1995-1-1-2004 leads to a ratio between the design resistance and the unitary stress equal to 1.568. Checking according to NP 005-2003 is more restrictive, because there are taken into account more correction coefficients.

Referring to deflection checking, the fact that each class resistance of wood has a certain value for elasticity modulus in SR EN 338:2010, ranging from 4700 to 10700 MPa for resinous timber, results in a more restrictive check compared to the norm NP005-2003, in which the value for elasticity modulus has an unique value of 9000 MPa, for the same timber.

The classification of timber in multiple strength classes, each being characterized by both characteristic strengths for different loads and by their density and stiffness properties like elasticity modulus, leads to a more precise calculation of timber elements when the European design rules are used, in comparison to the norm NP 005-2003.

REFERENCES

[1].   *SR EN 1995-1-1-2004. Eurocode 5: Design of timber structures. Part 1-1: General - Common rules and rules for buildings.*

[2].   *SR EN 1995-1-1-2004/NB:2008. Eurocode 5: Design of timber structures. Part 1-1: General - Common rules and rules for buildings. National Annex.*

[3]   *SR EN 1995-2-2005. Eurocode 5: Design of timber structures. Part 2: Bridges.*

[4]   *SR EN 1995-2-2005/NB:2008. Eurocode 5: Design of timber structures. Part 2: Bridges.. National Annex.*

[5]   *SR EN 338:2010. Structural timber. Strength classes.*

[6]   *NP 005 - 2003. Design of timber structures*