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South America Timber Structures Code

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Introduction

- South America don't have a unified code for the design of timber structures
- European Standards
- hardwoods in South America
- Allowable Stress Design of 1982
- Limit States Design concept
- NBR7190 in 1997

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Loads

- Upper 95 characteristic value
- impact situation the code reduces the live load factor of 0.75 in the loads combination.
- maximum and minimum values used to produce the more critical combinations

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Material Properties

- The properties to consider in design of timber structures are: density, strength, stiffness and moisture content
- The specified properties of strength and stiffness corresponds to the class of moisture content of 12%, that is 25 degrees Celsius and 65% of relative humidity

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Characterization of Wood Properties

- complete and the minimum strength characterization of wood properties ,
- simplified characterization of strength ,
- compression parallel to grain tests ,
- normal stress allows a variation coefficient of 18%
- to tangential stress allows a variation coefficient of 28%

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Strengh Classes

- Eight classes are defined: three for softwoods, prefixed C, and five for hardwoods, prefixed D ,
- The softwood strength classes are C20(weakest), C25 and C30 ,
- The hardwood strength classes are D20, D30, D40, D50 and D60 ,
- characteristic compression parallel to grain stress for each strength class

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Hardwood Graded to NBR7190/2008(draft)

Table 1 Strength class for hardwoods.

Strengtł Classes	$f_{c0,k}$ (MPa)	$f_{v0,k}$ (MPa)	$E_{c0,m}$ (MPa)	$\rho_{bas,m}$ (kg/m3)	$\rho_{ap,m,12\%}$ (kg/m3)
C20	20	4	9500	500	650
C30	30	5	14500	650	800
C40	40	6	19500	750	950
C50	50	7	22000	770	970
C60	60	8	24500	800	1000

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Softwood graded to NBR7190/2007

Table 2 Strength class for softwoods.

Strength Classes	$f_{c0,k}$ (MPa)	$f_{v0,k}$ (MPa)	$E_{c0,m}$ (MPa)	$\rho_{bas,m}$ (kg/m3)	$\rho_{ap,m,12\%}$ (kg/m3)
C 20	20	4	3 500	400	500
C 25	25	5	8 500	450	550
C 30	30	6	14.500	500	600

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Representative Strength and Stiffness Values

$$X_d = k_{mod} \frac{X_k}{\gamma_w}$$

$$k_{mod} = k_{mod,1} \cdot k_{mod,2} \cdot k_{mod,3}$$

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load classes and types of materials

Table 3 – Values of $k_{mod,1}$

Load Classes	Sawn wood, Glulam, Plywood	Recomposed wood
Dead load	0,60	0,30
Long duration load	0,70	0,45
Médium duration load	0,80	0,65
Short duration load	0,90	0,90
Instantanous	1,10	1,10

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classes of moisture content and types of materials

Table 4 – Values of $k_{mod,2}$

Classes of moisture content	Sawn wood, Glulam, Plywood	Recomposed wood
(1) e (2)	1,0	1,0
(3) e (4)	0,8	0,9

(1) corresponds a 12% moisture content wood and relativity humidity < 65%

(2) corresponds a 15% moisture content wood and 65% < U_{amb} ≤ 75% relativity humidity

(3) corresponds a 18% moisture content wood and 75% < U_{amb} ≤ 85% relativity humidity

(4) corresponds a 25% moisture content wood and relativity humidity > 85%

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grading of wood

Table 5a. Proposed values of kmod, 3 for hardwoods.

Class	$k_{mod,3}$ (visual +proof test)	$k_{mod,3}$(visual+transversal vibration)	$k_{mod,\ 3}$ (visual + stress wave)
SE	1,00	0,95	0,90
S1	0,95	0,90	0,85
S2	0,90	0,85	0,80
S3	0,85	0,80	0,75

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grading of wood

Table 5b. Proposed values of kmod, 3 for softwoods - D.

Class	$k_{mod,3}$ (visual +proof test)	$k_{mod,3}$(visual+transversal vibration)	$k_{mod,3}$ (visual + stress wave)
SE-D	1,00	0,90	0,85
S1-D	0,95	0,85	0,80
S2-D	0,90	0,80	0,75
S3-D	0,85	0,75	0,70

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grading of wood

Table 5c. Proposed values of kmod, 3 for softwoods - ND.

Classe	$k_{mod,3}$ (visual +proof test)	$k_{mod,3}$(visual+transversal vibration)	$k_{mod,\ 3}$ (visual + stress wave)
SE-ND	1,00	0,85	0,80
S1-ND	0,95	0,80	0,75
S2-ND	0,90	0,75	0,70
S3-ND	0,85	0,70	0,65

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Partial Safety Factors for Ultimate Limit States

-the partial factor for compression parallel and normal to grain is

$$\gamma_{wc} = 1{,}4$$

-the partial factor for tension parallel to grain is

$$\gamma_{wt} = 1{,}8$$

-the partial factor for shear is

$$\gamma_{wv} = 1{,}8$$

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Stiffness

the elasticity modulus parallel to grain must be taken as:

$$E_{co,ef} = k_{mod,1} \cdot k_{mod,2} \cdot k_{mod,3} \cdot E_{co,m}$$

And the transversal modulus as:

$$G_{ef} = E_{c0,ef} / 20$$

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Design Considerations in Stability of Compression Elements

- accidental eccentricity loads and geometrical lumber imperfections

- accidental eccentricity value of L/300

- $\lambda > 40$ must be designed for bending and compression

$$e_i = \frac{M_{1d}}{N_d}$$ - design eccentricity

$$e_1 = e_i + e_a \qquad e_a = L_o / 300$$ - accidental eccentricity

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Mechanical Connections

For mechanical connections of wood members the code presents three types of elements:

- steel dowels or bolts

- wood dowels

- steel rings and metal plate connectors

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design of dowels function of a ratio

$$\beta = \frac{t}{d}$$

where t is the thickness of the wood piece and d the diameter of the dowel.

$$\beta_{lim} = 1{,}25\sqrt{\frac{f_{yd}}{f_{ed}}}$$

Corresponds to the limit of the wood embedment and the steel dowel bending.

If $\beta \le \beta_{lim}$ that means wood embedment than $R_{vd,1} = 0{,}40\,\frac{t^2}{\beta}\,f_{ed}$

If $\beta > \beta_{lim}$ that means dowel steel bending than

$$R_{vd,1} = 0{,}625\,\frac{d^2}{\beta_{lim}}\,f_{yd} \qquad (\text{com } \beta = \beta_{lim})$$

where $f_{yd} = \frac{f_{yk}}{\gamma_s}$ and $\gamma_s = 1{,}1$

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Serviceability Limit States

$$E_{co,ef} = k_{mod,1} \cdot k_{mod,2} \cdot k_{mod,3} \cdot E_{co,m}$$

- The total displacement must be less than l/300 of the span neither l/150 of the cantilever beam length.
- The displacement of dead loads can be compensate by given a camber during construction.

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Constructive Recommendations

- static system must be clearly defined;

- to avoid deterioration of wood, no durable woods, must be treated with preservatives;

- the minimum areas and width of simple principal structural elements must be 50 cm2 and 5 cm and 18 cm2 and 2.5 cm for secondary structural elements, respectively;

- the minimum area and width of multiple principal structural elements must be 35 cm2 and 2.5 cm, and 18 cm2 and 1.8 cm for secondary structural elements, respectively;

- the minimum bolts diameter is 10 mm;

- the minimum number of dowels in a connection must be two;

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Code Annexes

- drawing of timber structures;

- strength and stiffness properties of Brazilian timbers,

- test methods for strength and stiffness determination of properties of timbers;

- test methods for strength and stiffness determination of timber joints;

- recommendations of preservative treatment of wood;

- calibration of 2007 Limit States Design versus 1982 Allowable Stress Design

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