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(54) **WOODEN BEAM WITH RECTANGULAR SECTION WITH SECTION DIMENSIONS IN THE RATIO 5/7 SUBJECTED TO BENDING AND SUBJECTED TO DEFORMATION**

(57) In wooden elements subjected to bending, a rectangular section (beams) is usually used with sides b and h approximately in the ratio 5/7; but the ratio 4/7 is also used: in reality we want to state here that this last ratio was erroneously derived, making the ratio 5/7 valid in any case.

From the point of view of deformations, however, the deflection of the deflected beam must be minimum: this occurs when the moment of inertia J of the section is maximum.

Called f the deflection deflection of the beam, it is worth:

$$F = pl^4/EJ$$

Which must be minimal to optimize the deformation behavior of the beam.

$$J = bh^3/12$$

Therefore, up to the constant 1/12, J' (b) = 0:

$$d(bh^3)/db = d\ b(h^2)^{3/2} \ / \ db = d\ b(D^2-b^2)^{3/2} \ / \ db = 0$$

Therefore,

$$d[b\,(D^2- b^2)^{2/2} \cdot (D^2- b^2)^{1/2}] = d\,[b\,(D^2- b^2)^{2/2}] \cdot (D^2- b^2)^{1/2} + [b\,(D^2- b^2)^{2/2}] \cdot [d\,(D^2- b^2)^{1/2}] = 0$$

$d(D^2- b^2)^{1/2} = 0$: always.

It is verified for:

$$b = D\sqrt{(1/3)} \text{ and } h = \sqrt{(D^2- b^2)} = \sqrt{(D^2-D^2/3)} = D\sqrt{(2/3)}$$

So:

$$b/h = \sqrt{(1/2)} = 0.7 = 5/7$$

Reference is made in particular to a trilithic system: two pillars with supported architrave, which has all the characteristics claimed by the invention.

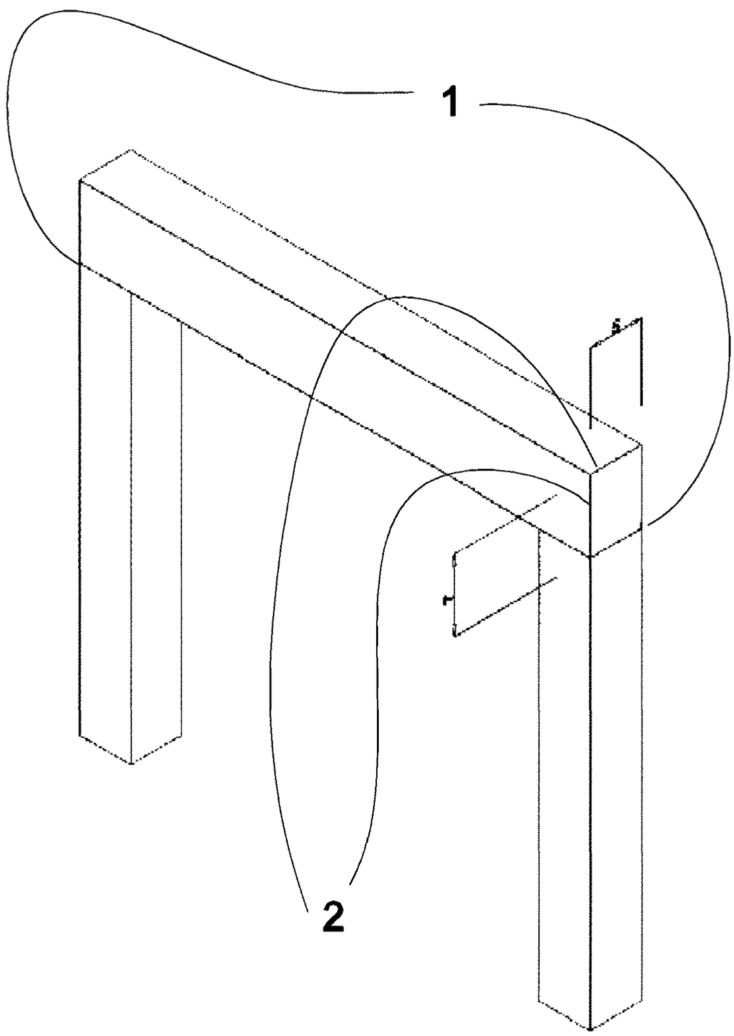

Fig. 1

Description

Technical field.

[0001] The object of the present invention is a wooden beam with a rectangular section with dimensions of the same section in the ratio 5/7 (where 5 units for the base and 7 for the height) subjected to bending and subject to deformation.

State of art.

[0002] Wood is the only organic material used for structural elements in construction.
[0003] The mechanical resistance of wood is the force that it opposes to the deformation and detachment of the parts from each other.
[0004] This strength is influenced by various elements: the species to which it belongs, the density of the wood (with an increase in density the resistance of the wood increases), humidity, the excessive duration of the load. Another factor that determines the resistance of wood is the direction in which the load acts.
[0005] The empirical determination of the E modulus occurs with measurements that detect the variation in length undergone by a wooden test piece as a function of different axial loads; i.e. with determination of arrows of test pieces subjected to bending (these arrows are a function of E).
[0006] Remaining in the elastic field, Hooke's law also occurs for wood (the deformations are strictly proportional to the stresses).
[0007] The breakage occurs by dragging two flat and inclined faces with respect to the vertical, to which, sometimes, a V-shaped crack is added, i.e. a separation of the layers with relative sliding in the subaxial direction. In failure, the dimensions of the specimen are decisive (which manifest themselves on secondary stresses): for this reason the tests are carried out with a parallelepiped with a height 3 to 6 times greater than the base, in order to obtain an unambiguous evaluation of the test at breakage.
[0008] As regards the ideal bending resistance, it can be seen (considering that the compressive and tensile resistance are different) that in an element subjected to simple bending, equal tensile and compressive stresses do not occur and the neutral axis does not coincide with the axis of symmetry of the section.
[0009] Two hypotheses of stress distribution are made in a bent beam: a parabolic distribution (compressed side) and a trapezoidal distribution. A determining element for evaluating the displacement of the neutral axis and the axis of symmetry is the ratio between the compressive strength and the tensile strength.
[0010] As mentioned above, wood does not have symmetrical behavior in tension and compression, since its resistance to compression is different from that to tension. For this reason there is a small deviation of the neutral axis from the symmetry axis.
[0011] When considering the "ideal resistance to bending", these behaviors are neglected and wood is considered a material that resists compression and traction equally and therefore the neutral axis is considered to coincide with an axis of symmetry of bending.
[0012] Simple bending; means the stress of prismatic elements subjected to equal and opposite couples acting in the same longitudinal plane. The analysis of simple bending is important in the study of beams, i.e. prismatic elements subjected to various types of transverse load. The internal forces in each cross section of a symmetric element in simple bending are equivalent to a torque.
[0013] The moment M of this couple is the "bending moment" in the section.
[0014] The distribution of normal stresses in a given section depends on the value of the bending moment M of the section and on the geometries of the section.
[0015] It is assumed:

$$\sigma_m = M\,c\,/I$$

$$\sigma_c = M\,y\,/I$$

with:

c = maximum distance from the neutral surface,
I = moment of inertia of the cross section with respect to a center of gravity perpendicular to the torque plane,

$$S = I\,/\,c$$

$$\sigma_m = M / S$$

S for beams with rectangular section the following applies:
S =(1/6) -b $\cdot h^2$; where b and h represent the width and height of the cross section.

[0016] The fact that σ_m is inversely proportional to S highlights that cross-sectional beams with high section modulus resist bending better.

[0017] However, making the necessary calculations, it is clear that certain ratios between h and b guarantee greater resistance.

[0018] It is also true that in solid mechanics manuals we read that: as regards simple bending (flexions and deformations in the elastic field) in the example of a wooden beam with a rectangular cross section of width b and height h, S being the elastic modulus of the section with S =(1/6) -A $\cdot$h; the beam with the greater height h will have a greater elastic modulus and will therefore resist bending better. However, it should be noted that if the h/b ratio is too high, phenomena of lateral instability of the beam can arise.

[0019] To design a wooden beam, proceed as follows: first carry out a precise analysis of the loads that bear on the beam (including its own weight); they are distinguished into:

- distributed load (in kg/cm), that is,
- concentrated load (in kg), carefully reporting its position.

[0020] The maximum bending moment is then calculated (wooden beams are always calculated simply supported).

[0021] The calculation of the section occurs with the Navier formula

$$\sigma = My/J_n = M/W$$

Where:

M = maximum bending moment of the supported beam
σ = K = allowable bending stress
W = modulus of resistance

[0022] Knowing that:
W = $bh^2/6$ (rectangular section normally used to construct a wooden beam).

$$M/K = bh^2/6$$

[0023] From here the formula b=5/7 h applies; for the following. For the bending stress, at the tensional level, the maximum convenience is obtained by placing the resistance modulus at the maximum of its value: we therefore set W=bh6/6 equal to zero after differentiating it with respect to b. (Since the maximum condition of a function: y'=0); therefore unless the constant 1/6 results:

$$dW/db = d\ (bh^2)/db$$

[0024] If we set D as the diameter of the trunk from which the beam of dimensions b and h is obtained, the result is.

$$h^2 = D^2 - b^2$$

[0025] From which substituting:

$$db(D^2 - b^2)\ /\ db = d(D^2b - b^3)\ /\ db = 0$$

[0026] Therefore:

$$D^2 - 3b^2 = 0$$

$$b = D\sqrt{(1/3)} \text{ and } h = \sqrt{(D^2 - b^2)} = \sqrt{(D^2 - D^2/3)} = D\sqrt{(2/3)}$$

So:

$$b/h = \sqrt{(1/2)} = 0.7 = 5/7$$

Technical problem to be solved.

[0027] In wooden elements subjected to bending, a rectangular section (beams) is usually used with sides b and h approximately in the ratio 5/7; but the 4/7 ratio is also used if deformation occurs following bending: in reality we want to state here that this last ratio was erroneously derived, making the 5/7 ratio valid in any case; which is supported here by proposing as the found object of the invention a beam with a rectangular section with section dimensions in the ratio of 5/7, where 5 units for the base and 7 units for the height. The indication of the aforementioned ratio with which to shape the beam allows any expert in the field to implement it.

[0028] From the point of view of deformations, however, the deflection of the deflected beam must be minimum: this occurs when the moment of inertia J of the section is maximum.

[0029] Called f the deflection deflection of the beam, it is worth:

$$F = pl^4/EJ$$

[0030] Which must be minimal to optimize the deformation behavior of the beam.

[0031] To achieve this, the moment of inertia J is set as maximum, since the other quantities are given (external loads, span of the beam, modulus of elasticity of the wood):

$$J = bh^3/12$$

[0032] Therefore,

$$d[b(D^2 - b^2)^{2/2} \cdot (D^2 - b^2)^{1/2}] = d[b(D^2 - b^2)^{2/2}] \cdot (D^2 - b^2)^{1/2} +$$

$$[b(D^2 - b^2)^{2/2}] \cdot [d(D^2 - b^2)^{1/2}] = 0$$

uce of the beam, modulus of elasticity of the wood):

$$J = bh^3/12$$

[0033] Therefore, up to the constant 1/12, J' (b) = 0:

$$d(bh^3)/db = d\ b(h^2)^{3/2} / db = d\ b(D^2 - b^2)^{3/2} / db = 0$$

[0034] Therefore,

$$d[b(D^2 - b^2)^{2/2} \cdot (D^2 - b^2)^{1/2}] = d[b(D^2 - b^2)2/2] \cdot (D^2 - b^2)^{1/2} +$$

$$[b(D^2 - b^2)^{2/2}] \cdot [d(D^2 - b^2)^{1/2}] = 0$$

$d(D^2 - b^2)^{1/2} = 0$: always.

[0035] It is verified for:

$b = D\sqrt{(1/3)}$ and $h = \sqrt{(D^2 - b^2)} = \sqrt{(D^2 - D^2/3)} = D\sqrt{(2/3)}$

[0036] So:

$$b/h = \sqrt{(1/2)} = 0.7 = 5/7$$

Brief description of the drawings

[0037]

- Figure 1 represents a beam with a rectangular section with dimensions in the proportions of 5/7 (2). In particular, the base has a dimension of 5 units while the height has a dimension of 7 units.

Detailed description.

[0038] With reference to the attached drawings it is possible to deduce that the subject of the present invention is a beam with constraints in the different possibilities of statics. With reference to the resistant section it is possible to deduce that this section must present, to guarantee the aforementioned resistance performance, a ratio between its dimensions of 5/7 (2). More precisely: 7 units for the height and 5 units for the base.

Industrial application.

[0039] Reference is made in particular to a trilithic system: two pillars with supported architrave, which has all the characteristics claimed by the invention. (1) and (2).

[0040] Since the beam is shaped so as to implement a resistant section (as previously described) with a size ratio of 5/7 (where 5 units for the base and 7 for the height), the found object of the invention is easily replicable industrially so that any expert in the field can implement it.

Claims

1. Obtaining a maximization of the resistance to deformation of wooden beams with a rectangular section **characterized by** the ratio of the dimensions of the section no more than 4/7 but to the extent of 5/7: 7 units for the height and 5 units for the base

2. Maximization of the resistance of a beam with consequent greater durability and therefore saving of material (timber) through the achievement of greater resistance to deformation of the rectangular section wooden beams with section dimensions in the ratio 5/7 rather than 4/7 .

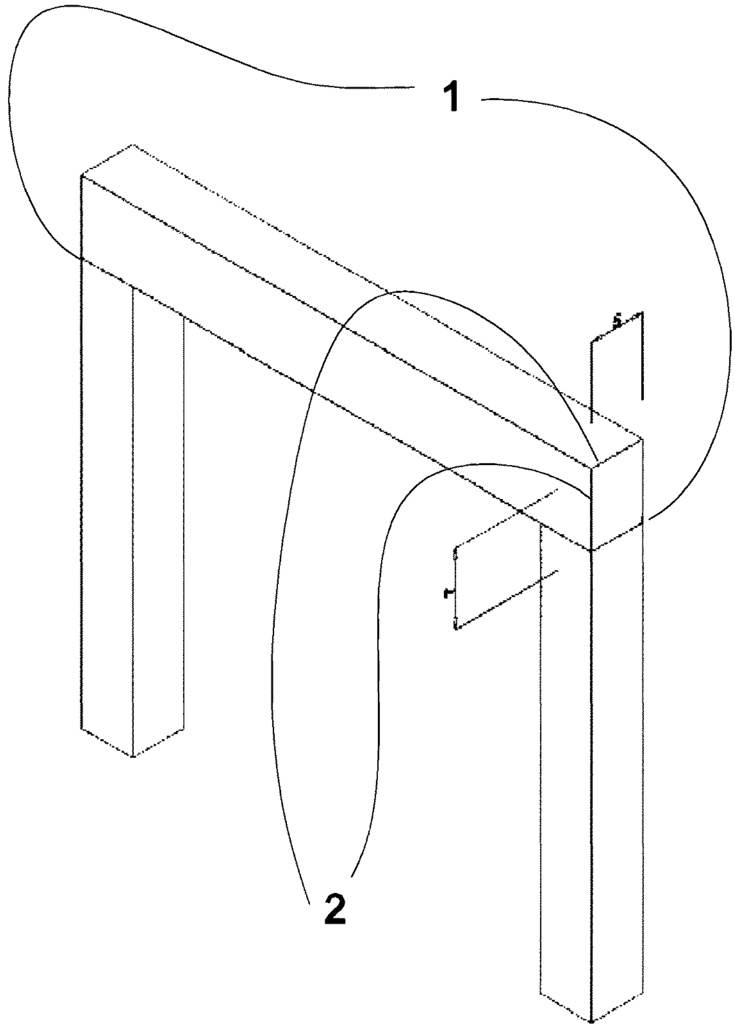

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 24 02 0237

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	Jennie Ward Jennie: "Know your timber sizes and tolerances : Timber Development UK", , 22 April 2024 (2024-04-22), XP093229393, Retrieved from the Internet: URL:https://timberdevelopment.uk/know-your-timber-sizes-and-tolerances/ * the whole document * -----	1,2	INV. E04C3/14
X	Anonymous: "Standard sizes: thicknesses, widths and lengths - Puuinfo", , 29 July 2020 (2020-07-29), XP093229364, Retrieved from the Internet: URL:https://puuinfo.fi/puutieto/sawn-timber/standard-sizes-thicknesses-widths-and-lengths/?lang=en * the whole document * -----	1,2	
			TECHNICAL FIELDS SEARCHED (IPC)
			E04C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	2 December 2024	Petrinja, Etiel

CATEGORY OF CITED DOCUMENTS

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