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(54) PRE-STRESSED COMPACT BEAM AND METHOD FOR ITS MANUFACTURE

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Description

[0001] The invention relates to pre-stressed beams having compact cross-sectional areas where the structural elements comprises two bent,-pre-stressed, symmetrical or near symmetrical outer elements which are joined together in the bent, pre-stressed condition.

[0002] The invention also relates to a method for the manufacture of such pre-stressed beams.

[0003] By "outer elements" in this connection is understood long, compact elements of compact material such as woodwork or composite materials having a shape and properties making them useful as supporting beams.

Background

[0004] It is common to manufacture beams and floors with cross-sectional shapes that imply good material exploitation, such as the H-profile and the I-profile. It is also common to make beams with super elevation in order to obtain a reduction in the resulting deflection where the deformation requirements are decisive for the dimensioning.

[0005] In the production of concrete is known to cast beams and supporting elements with pre-stressed armouring steel rods in order to obtain super elevation and increased supporting ability, e.g. hollow core floorings.

[0006] Of earlier patented solutions we refer to US patent No 4 754 718, US patent No. 2 039 398 disclosing a pre-stressed compact beam according to the preamble of claim 1, DE 2 335 998, GB patent No. 1 305 645 and Norwegian patent No. 162124.

Objectives

[0007] The main objective of the present invention is to provide a method for pre-stressing and joining of compact beams for use in building constructions and plants, providing an optimal material exploitation as well as versatility in the choice of cross-sectional shape, so that available raw materials can be better exploited.

[0008] It is furthermore a significant object to be able to proportion the pre-stressing so that the initial shape (i. e. the super elevation) can be adapted to the relevant functional requirements with regard to user needs, span, load, governmental regulations etc.

The present invention

[0009] According to the present invention the above objectives can be achieved by the principle solution defined by claim 1, in which two outer beam elements are joined by means of a center element subsequent to bending and mutual sliding displacement of the elements.

[0010] According to another aspect the present invention concerns the method for the manufacture of such a beam as defined by claim 4.

[0011] By a "center element" in this connection is un-

derstood a shear transmitting element having shape and properties which allows it to hold the outer elements together in a pre-stressed, rigid structure.

[0012] The present solution is distinguished over the prior art by providing new possible cross-sectional shapes, versatility with regard to method of joining and a higher load capacity without increasing the material consumption.

[0013] The center element can be manufactured in the same material as the outer elements or by a material having a higher shear capacity. The joining is made mechanically by arranging the outer elements and the center element to be "locked" together at a certain pre-bending.

[0014] The finished, shear pre-stressed beam has in unloaded condition a tension(stress) reserve and super elevation which can be proportioned according to predetermined functional requirements. As an example the pre-stressing can be dimensioned such that a resulting deflection at normally occurring loads on the beam is minimal or near zero. With regard to beams for which requirements of deformation is decisive for the dimensioning, e.g. beams in wooden supporting elements, the method allows much larger spans than traditional methods.

Exemplary description

[0015] The invention is illustrated in the accompanying drawings, where:

Figure 1A is a schematic side view of assembled beam elements in non-loaded condition.

Figure 1B shows the elements of Figure 1A after pre-bending, mutual sliding, joining and unloading.

Figure 1C shows principle-detail of center element made in same material as outer elements and made with a shape providing mechanical force transmission.

Figure 1D shows principle-detail of center element made in a material of higher shear capacity than outer elements, made in a shape providing mechanical force transmission.

Figure 1E shows the joined beam of Figure 1B with an evenly distributed outer load.

Figure 1F shows principle-diagrams for bending and normal stresses in the joined beam of Figure 1E.

Figure 1G shows principle-diagrams for shear stresses in the joined beam of Figure 1E.

Figures 2A-B show examples of relevant cross-sections of pre-stressed compact supporting beams.

Figures 3A-B are perspectival views of relevant compact supporting beams.

Figures 4A-C show examples of supporting (floor?) elements in which the supporting beam of Figure 2A is used.

Symbol explanations

[0016]

Z_1 = neutral axis lower element, Z_2 = neutral axis upper element, Z_0 = neutral axis joined beam, a = distance between Z_1 and Z_2 , t = net thickness center element, f = bending and normal stress, and τ = shear stress.
Neutral axis refers to the position in a beam having zero length change when exposed to an elastic bending moment.

Figure 1. Principle drawing

Figure 1A shows schematically a side view of the beam elements 10, 11 and 12 in non-loaded condition.

The outer elements 10 and 12 are symmetrical or near symmetrical about axis Z_0 . This ensures a favourable stress distribution across the cross-section and correspondingly good material exploitation. The elements e.g. be made in woodwork, composite or other elastic material. The center element 11 can be made in same type of material as outer elements (Figure 1C) or in a material having a higher shear capacity (Figure 1D).

Figure 1B shows elements of Figure 1A after having been pre-bent, joined, and unloaded.

The pre-bending, which is performed with a hydraulic press or the like, known equipment, implies a sliding motion in the contacting surfaces of the elements. At the joining and unloading a shear flow occurs between the center element 11 and outer elements 10 and 12, as indicated with arrows in Figure 1B. The shear transmission is made mechanically with an adapted surface structure.

Figures 1C-D show principle-details of center element, designed with a surface structure which implies that the elements 10, 11, and 12 are locked together in a pre-stressed, rigid structure at a certain degree of pre-bending.

In addition to shear transmitting function (pre-stressing) the center element provides an increase of the beam's load capacity by increasing the distance between the neutral axes Z_1 og Z_2 . For some types of beams and dimensions this capacity increase amounts to more than 50%, see the enclosed calculation example.

If the center element is made in a sufficiently hard material, the shear transmitting (pre-stressing) can be obtained by pressing the elements together in a pre-bent condition. The beam thereby may be produced without milling.

The center element can be made in short lengths and e.g. be casted in moulds. It is assumed that the design allows a sliding motion between the elements when the pre-bending takes place.

For beams with a "narrowed" central section, the elements can be made with longitudinal grooves to obtain a sufficient contact area.

Figure 1E shows the joined beam when an external load has been applied.

Figure 1F shows principle-diagrams for bending and normal stresses from:

(1) Pre-bending/ unloading, (2) stresses from external load, and (3) resulting stress.

At high pre-stressing symmetrical cross-sections can achieve a substantially plastic stress distribution when an evenly distributed load is applied - without plastification of the material. This allows a maximum exploitation of the beam's cross-sectional area with regard to load capacity. In practice a reduced super elevation will be more relevant and the deformation requirements will be decisive for the choice of pre-stress.

Figure 1G shows principle-diagram for shear stresses from:

(1) pre-bending/ unloading, (2) stress from external load, and (3) resulting stress.

By the principle diagram 1F is shown that the beam bending stress reserve corresponds to the stress level after pre-bending and unloading. The beam must therefore be dimensioned for the sum of shear stress from pre-bending/ unloading and from external loads. For relevant beam types and spans this reduction has little practical significance.

Figure 2. Example of beam cross-sections

In Figure 2A a compact rectangular beam comprising outer elements 21 and 23 and center element 22 is shown. The beam is joined during pre-bending by means of adapted surface structures/ pressing.

In Figure 2B a compact beam with substantially circularly cross-section (e.g. round timber) comprising outer elements 24 and 26 and center element 25, is shown. The beam is joined during pre-bending by means of adapted surface struc-

tures / pressing.

Figure 3. Perspectival views of beams

Figures 3A to 3BC show examples of compact wooden beams. 5

Figure 4. Supporting beam in floor elements

Examples of floor elements based on the current principle as illustrated by Figure 2A. 10

Figure 4A shows an example of a "rib floor", Figure 4B shows an example of a "beam floor" while Figure 4C shows an example of a "compact floor". 15

Calculation example

[0017] Freely suspended beam with evenly distributed load and span $L = 6$ m. 20

Raw material: Round timber (i.e. limited availability at increasing dimensions).
Outer elements: Split round timber with 250 mm diameter. 25
Center element: Rectangular, net thickness = t
Cross-section: See Fig. 2B.
Basic value: Load capacity calculated for center element $t=0$ and pre-stressing corresponding to a super elevation of $L/100$, i.e. 6 cm after unloading. 30

[0018] Capacity increase for various thicknesses of center element: 35

Thickness $t=30$ mm: about 40 % increase
Thickness $t=40$ mm: about 55 % increase
Thickness $t=50$ mm: about 70 % increase

Advantages of the present invention 40

[0019] The beam as described above is distinguished from prior art techniques and patented solutions by:

1. Allowing compact beams to be produced with desired pre-stressing without adhering/ gluing, ref. Figs. 2A-B. 45
2. Allowing use of new pre-stressed cross-sectional shapes, see, Figs. 2C and 3C.
3. The method is well suited for beams in floor elements of increased spans, see Figs. 4A-C. 50
4. The method provides possibility of improved utilization of the basic material, see calculation example.

Claims

1. Pre-stressed compact beam of elastic material

where two outer elements (10, 12) which are symmetrical or near symmetrical about the total cross-section's neutral axis, are joined in pre-stressed condition by subsequent mutual sliding displacement of the elements, **characterized in that** the outer elements (10, 12) are held together by means of a shear transmitting center element (11) arranged for mechanical transmission of forces obtained by providing adjacent surfaces of the center element (11) and the outer elements (10, 12) with three-dimensional structures which are arranged to come into tight-fitting mutual interaction only when the elements are inflicted with a certain pre-stressing force to thereby mutually adhere the elements together in a curved condition.

2. Pre-stressed compact beam as claimed in claim 1, **characterized in that** the center element (11) is made in same material as the outer elements (10, 12) or in a material with a higher shear capacity.
3. Pre-stressed compact beam as claimed in claim 1, **characterized in that** at maximum degree of pre-stress, a substantially plastic distribution of the stress is obtainable over the cross-section.
4. Method for the manufacture of pre-stressed compact beam of elastic material according to any of the preceding claims comprising two outer elements (10, 12) which are symmetrical or near symmetrical along their neutral axis and which are joined in a curved condition, **characterized in that** shear transmitting, center element (11) is arranged between the two outer elements (10, 12) whereafter an elastic bending deformation is applied to the elements, implying a mutual sliding of the elements (10,12), the center element (11) and the outer elements (10, 12) being provided with three-dimensional structures which are arranged to come into tight-fitting mutual interaction only when the elements are inflicted with a certain pre-stressing force before they are mechanically joined and thereafter unloaded to thereby mutually adhere the elements together in a curved condition.
5. Method as claimed in claim 5, **characterized in that** the elements' (10-12) contacting surfaces are mechanically joined at a certain degree of bending, by means of a surface structure.

Patentansprüche

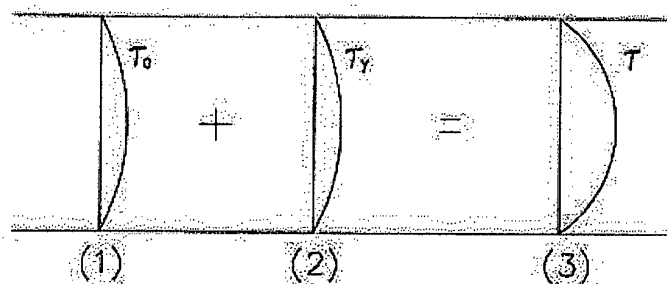
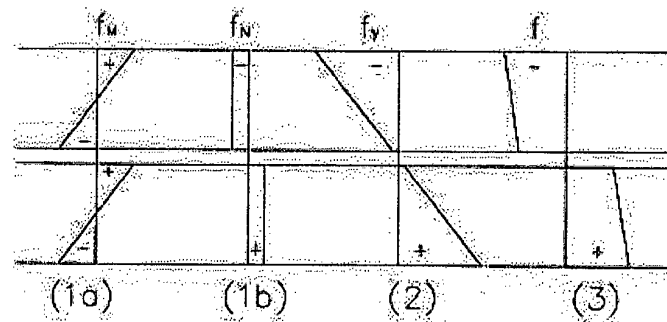
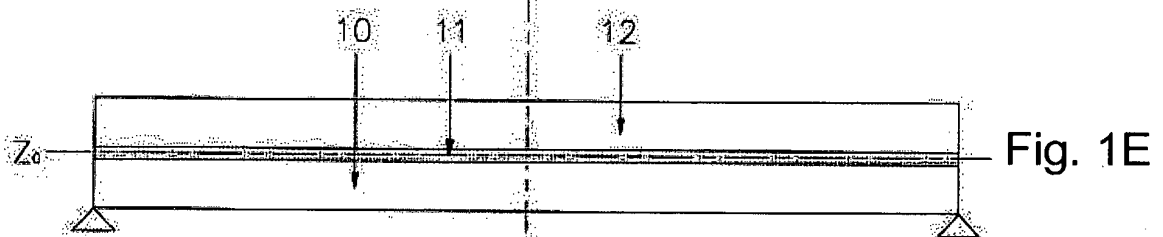
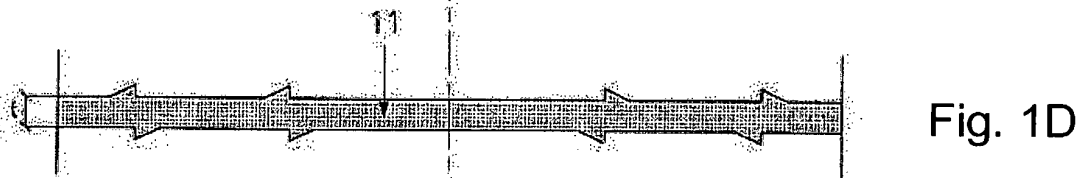
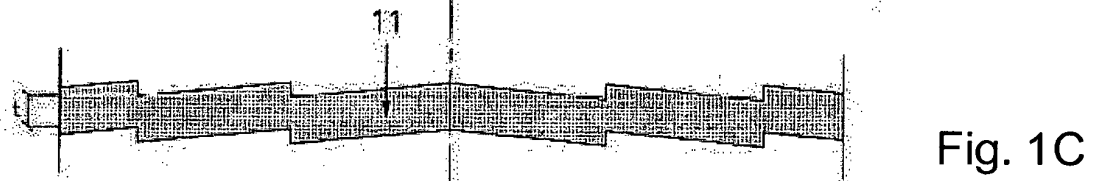
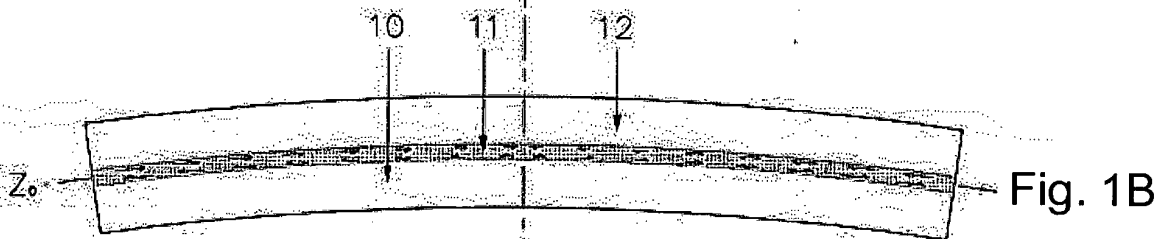
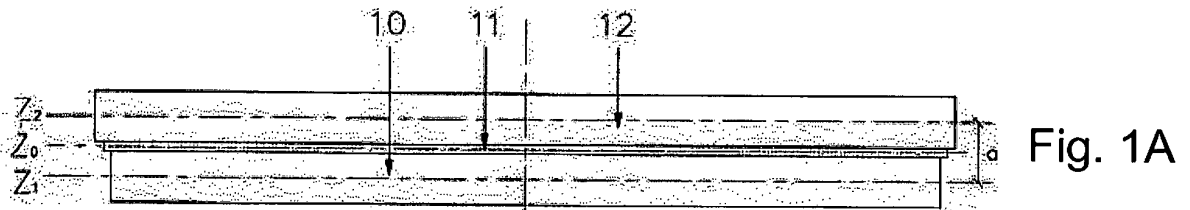
1. Vorgespannter kompakter Balken aus elastischem Material, bei dem zwei äußere Elemente (10, 12), die um die neutrale Achse des Gesamtquerschnitts symmetrisch oder annähernd symmetrisch sind, durch eine anschließende wechselseitige Gleitver-

schiebung der Elemente in vorgespanntem Zustand verbunden sind, **dadurch gekennzeichnet, dass** die äußeren Elemente (10, 12) mittels eines Scherkraft-übertragenden mittleren Elementes (11) zusammengehalten werden, das für eine mechanische Übertragung von Kräften angeordnet ist, wobei diese dadurch erzielt wird, dass benachbarte Flächen des mittleren Elementes (11) und der äußeren Elemente (10, 12) mit dreidimensionalen Strukturen versehen sind, die angeordnet sind, um in engliegende wechselseitige Interaktion zu kommen, und zwar lediglich wenn die Elemente einer gewissen Vorspannkraft unterzogen werden, um dadurch die Elemente in gekrümmtem Zustand miteinander zu verbinden.

2. Vorspannter kompakter Balken nach Anspruch 1, **dadurch gekennzeichnet, dass** das mittlere Element (11) aus dem gleichen Material wie die äußeren Elemente (10, 12) oder aus einem Material mit einer höheren Scherkraftkapazität hergestellt ist.
3. Vorspannter kompakter Balken nach Anspruch 1, **dadurch gekennzeichnet, dass** bei einem maximalen Grad einer Vorspannung eine im Wesentlichen plastische Verteilung der Spannung über dem Querschnitt erzielt werden kann.
4. Verfahren zur Herstellung eines vorgespannten kompakten Balkens aus elastischem Material nach einem der vorhergehenden Ansprüche, aufweisend zwei äußere Elemente (10, 12), die um ihre neutrale Achse symmetrisch oder annähernd symmetrisch sind und die in gekrümmtem Zustand verbunden sind, **dadurch gekennzeichnet, dass** ein Scherkraftübertragendes mittleres Element (11) zwischen den zwei äußeren Elementen (10, 12) angeordnet wird, wonach eine elastische Biegeverformung auf die Elemente aufgebracht wird, die eine wechselseitige gleitende Verschiebung der Elemente (10, 12) mit sich bringt, wobei das mittlere Element (11) und die äußeren Elemente (10, 12) mit dreidimensionalen Strukturen versehen sind, die angeordnet sind, um in engliegende wechselseitige Interaktion zu kommen, und zwar lediglich wenn die Elemente einer gewissen Vorspannkraft unterzogen werden, bevor sie mechanisch verbunden werden und danach entlastet werden, um dadurch die Elemente in gekrümmtem Zustand miteinander zu verbinden.
5. Verfahren nach Anspruch 5, **dadurch gekennzeichnet, dass** die Kontaktflächen der Elemente (10-12) bei einem gewissen Biegungsgrad mechanisch verbunden werden, und zwar mittels einer Oberflächenstruktur.

Revendications

1. Poutre compacte précontrainte de matériau élastique où deux éléments externes (10, 12) qui sont symétriques ou presque symétriques par rapport à l'axe neutre de la section transversale totale, sont reliés dans un état précontraint par un déplacement couissant mutuel ultérieur des éléments, **caractérisée en ce que** les éléments externes (10, 12) sont maintenus ensemble au moyen d'un élément central de transmission de cisaillement (11) agencé pour une transmission mécanique de forces obtenue en dotant des surfaces adjacentes de l'élément central (11) et des éléments externes (10, 12) de structures tridimensionnelles qui sont agencées pour venir en interaction mutuelle à ajustement serré uniquement lorsque les éléments se voient infliger une certaine force de précontrainte pour faire adhérer ainsi mutuellement les éléments ensemble dans un état incurvé.
2. Poutre compacte précontrainte selon la revendication 1, caractérisée en ce l'élément central (11) est constitué d'un même matériau que les éléments externes (10, 12), ou d'un matériau à capacité de cisaillement plus élevée.
3. Poutre compacte précontrainte selon la revendication 1, **caractérisée en ce que**, à un degré maximal de précontrainte, une répartition sensiblement plastique de la contrainte peut être obtenue sur la section transversale.
4. Procédé de fabrication d'une poutre compacte précontrainte de matériau élastique selon l'une quelconque des revendications précédentes, comprenant deux éléments externes (10, 12) qui sont symétriques ou presque symétriques le long de leur axe neutre et qui sont reliés dans un état incurvé, caractérisé en ce qu'un élément central de transmission de cisaillement (11) est agencé entre les deux éléments externes (10, 12), après quoi une déformation de courbure élastique est appliquée aux éléments, impliquant un couissement mutuel des éléments (10, 12), l'élément central (11) et les éléments externes (10, 12) étant dotés de structures tridimensionnelles qui sont agencées pour venir en interaction mutuelle à ajustement serré uniquement lorsque les éléments se voient infliger une certaine force de précontrainte avant qu'ils soient mécaniquement reliés et ensuite déchargés pour faire ainsi adhérer mutuellement les éléments ensemble dans un état incurvé.
5. Procédé selon la revendication 5, **caractérisé en ce que** les surfaces de contact des éléments (10, 12) sont mécaniquement reliées à un certain degré de courbure, au moyen d'une structure de surface.



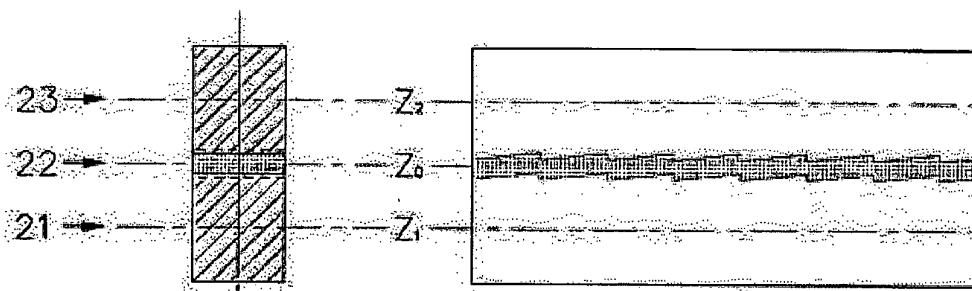


Fig. 2A

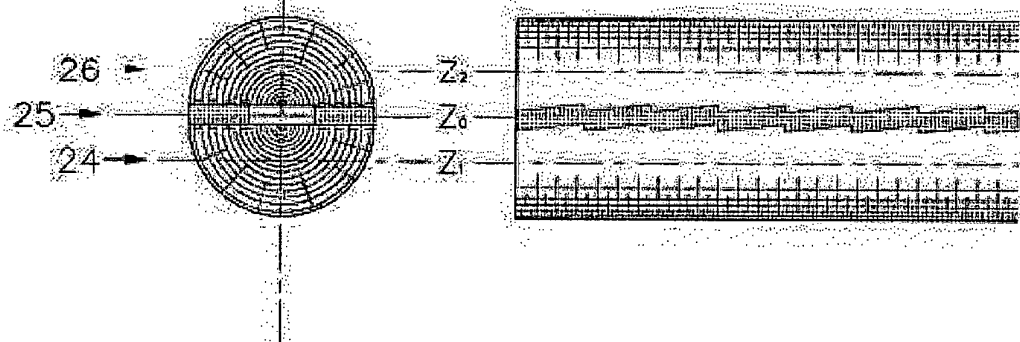


Fig. 2B

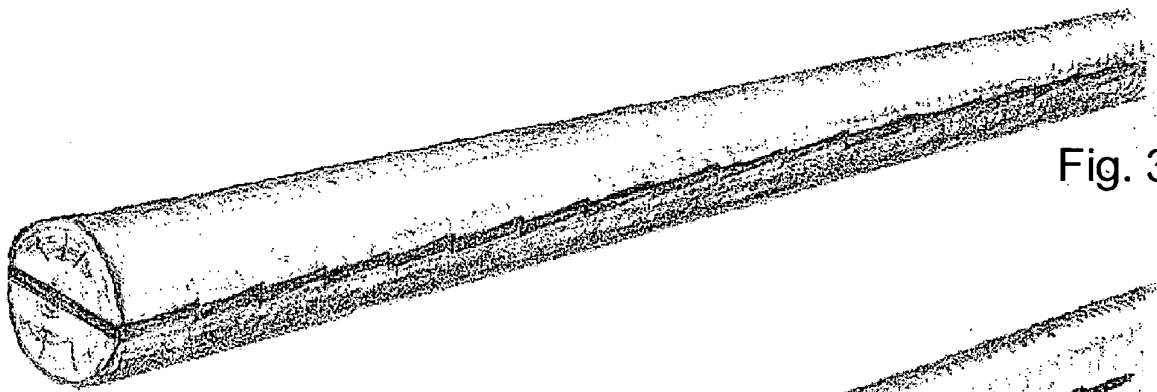


Fig. 3A

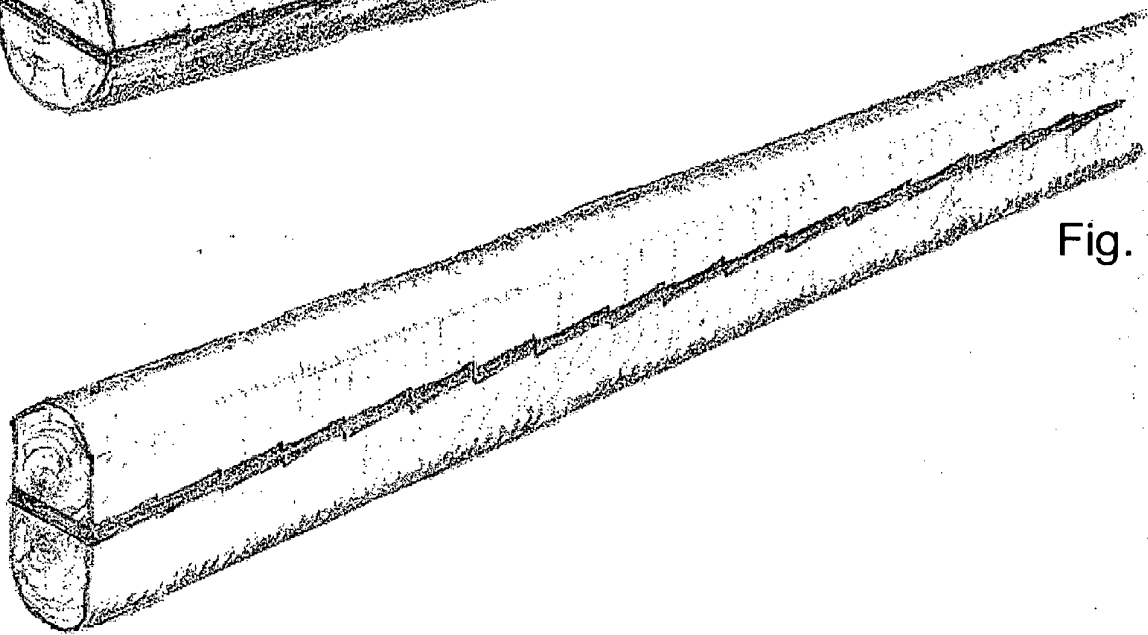


Fig. 3B

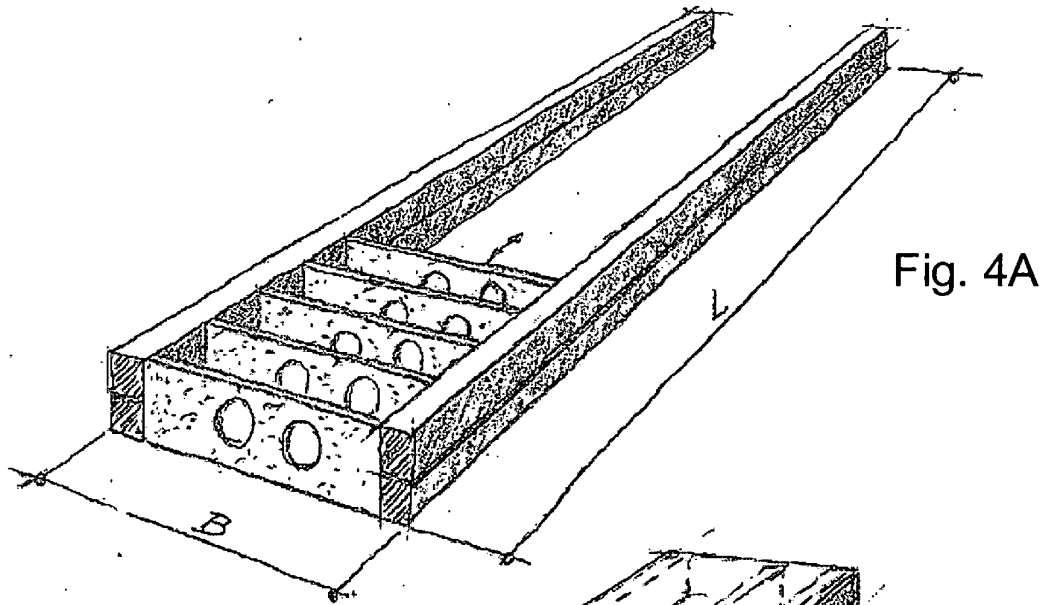


Fig. 4A

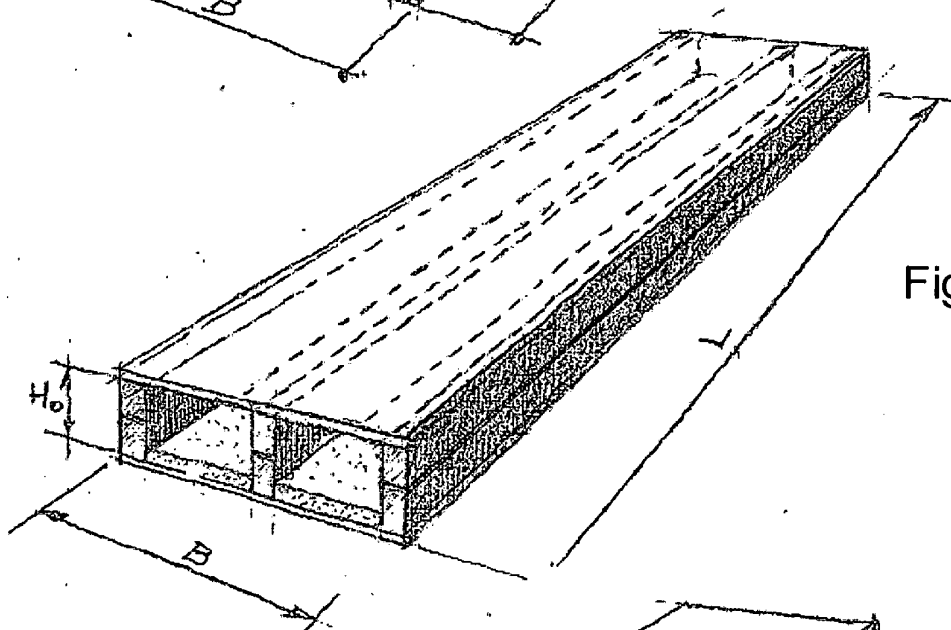


Fig. 4B

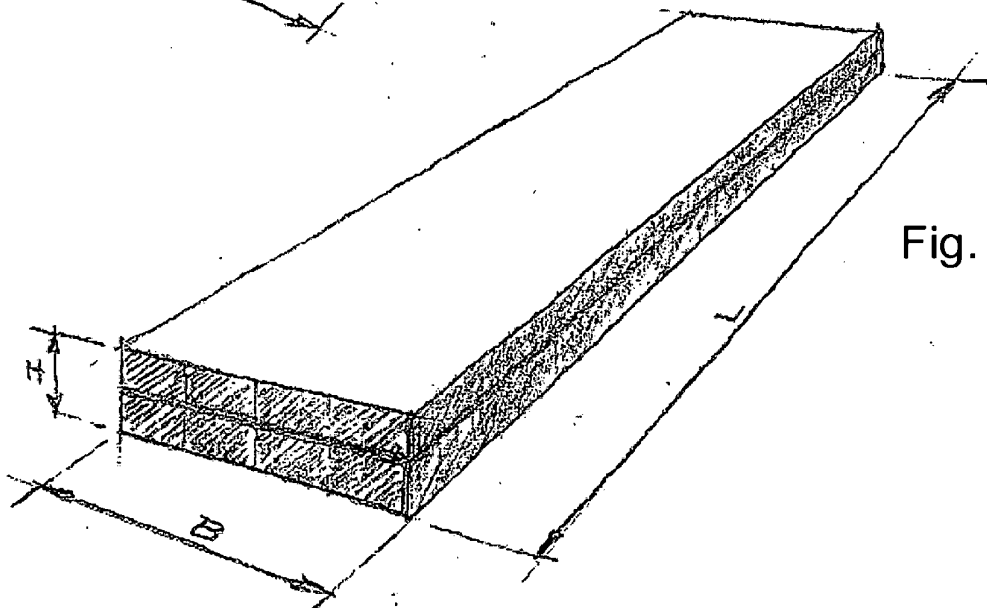


Fig. 4C

REFERENCES CITED IN THE DESCRIPTION

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