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(71) Demandeur/Applicant: HUBER ENGINEERED WOODS LLC, US
(72) Inventeurs/Inventors: PEEK, BRIAN M., US; SCOVILLE, CHRISTOPHER R., US
(74) Agent: MOFFAT & CO.

(54) Titre : POUTRELLE EN I AMELIOREE
(54) Title: IMPROVED I JOIST

(57) Abrégé/Abstract:
An I-joist is provided comprising a first and a second flange interconnected by a webstock; the first flange has a first major surface upon which is formed a groove, so that the groove faces and receives the webstock; and a fiberous re-enforcing material impregnated with adhesive resin disposed in the groove.
ABSTRACT

An I-joist is provided comprising a first and a second flange interconnected by a webstock; the first flange has a first major surface upon which is formed a groove, so that the groove faces and receives the webstock; and a fiberous re-enforcing material impregnated with adhesive resin disposed in the groove.
TITLE OF THE INVENTION

Improved I joist

BACKGROUND OF THE INVENTION

A structural, weight-bearing floor system is constructed by laying a floor deck across a number of underlying, supporting I joists. The deck may be made of a variety of different materials, such as wood as well as concrete although for the present invention, which is directed primarily at residential home construction, the flooring deck will most typically be constructed of wood, such as wood panels set to lie across a series of underlying wood joists. It is very important that the combination of the wood panels and underlying wood joists create a strong, stiff floor to prevent unwanted "squeaks" from developing. Once such squeaks do occur, is often very difficult, time consuming and invariably expensive to fix.

Suitably strong and stiff wood joists are typically in the form of an "I joist" with three parts: two flange members with an interconnecting webstock member. The I joist is constructed by creating a groove in each of the flange members into which the webstock member is inserted. While at one time all of these pieces were formed from solid wood lumber, recently they have become increasingly more likely to be made from an alternative to solid wood lumber, engineered wood composites, because of both the cost of high-grade timber wood as well as a heightened emphasis on conserving natural resources. Plywood, particle board, laminated veneer lumber ("LVL"), oriented strand lumber ("OSL"), and oriented strand board ("OSB") are examples of wood-based composite alternatives to natural solid wood lumber that have replaced natural solid wood lumber in many structural applications in the last seventy-five years. These engineered wood composites not only use the available supply of timber wood more efficiently, but they can also be formed from lower-grade wood species, and even from wood wastes.

Typically though, the use of the wood composite materials in the construction of I joists has been limited to the webstock components of the I joist. This was because during manufacture (i.e., by hot-platen pressing) of strand-based composite, a density profile is created through the thickness dimension of the product, with the strand layers near the surfaces having a higher density than the strand layers at the core. Because lower density
generally means lower strength, the core strand layers of the wood composite material are generally the weakest part of the material. This makes wood composites particularly unsuitable for use as flange materials, because the groove into which the webstock is seated would be the weakest part (core) of the composite. Thus, when a load is placed on the I joist, the weakest part of the I joist is left to bear the greatest portion of the burden, thus reducing the maximum load that the I joist can carry without failing.

[0005] One way of overcoming this difficulty is described in US Patent 6,012,262. This patent discloses a two layered laminate material by bonding together two thinner pieces of hot-platen pressed, strand composite lumber together, creating a higher density, higher strength area in the center of the material. So that when the groove is cut into this two piece laminate, the bottom of the groove is in the higher density, higher strength area. While this method addresses the strength deficiencies that accompany the density profile of a strand composite material, there are also some notable disadvantages. Extra manufacturing steps are necessary, such as cutting the pieces to size, bonding the pieces together, waiting for the adhesive to set before it can be incorporated into the I-beam assembly process, and sanding the mating surfaces to improve adhesion between the laminated pieces. An additional and potentially very serious disadvantage is that during service there is the possibility of delamination of the flange when placed under load. This, of course, reduces the maximum load that can be placed upon the I joist.

[0006] Another way of adapting wood composite materials for use in flanges is carefully selecting a higher strength wood composite material and apply minor modifications that provide additional strengthening without significant reconfiguration of the wood composite material or the process to produce. For example, one can bond a sheet or strip of fiber reinforced plastic to the bottom of a strand-based composite of sufficiently high stiffness and strength to make it suitable as flange stock on engineered I joists as is discussed in Ford. While this method is less expensive and difficult than the aforementioned two layered laminate (in particular it is simpler to manufacture) it also suffers from many of the same liabilities. Notably it adds significant cost, an additional manufacturing step, and still poses the problem of possible delamination of the reinforced plastic piece during service.
Moreover it doesn’t address the problem that for certain materials, like OSB, the low density, weak core, must bear the load transferred from the webstock.

[0007] Accordingly, there is a need in the art for a wood composite material that is constructed to have sufficient strength in its core strand layers to serve as the flange in a three part I joist construction.

BRIEF SUMMARY OF THE INVENTION

[0008] The present invention includes an I joist comprising: a first and a second flange interconnected by a webstock; the first flange has a first major surface upon which is formed a groove, so that the groove faces and receives the webstock; and a fibrous re-enforcing material impregnated with adhesive resin disposed in the groove.

DETAILED DESCRIPTION OF THE INVENTION

[0009] All parts, percentages and ratios used herein are expressed by weight unless otherwise specified. All documents cited herein are incorporated by reference.

[0010] As used herein, “wood” is intended to mean a cellular structure, having cell walls composed of cellulose and hemicellulose fibers bonded together by lignin polymer.

[0011] By “laminated”, it is meant material composed of layers and bonded together using resin binders.

[0012] By “wood composite material” or “wood composite component” it is meant a composite material that comprises wood and one or more other additives, such as adhesives or waxes. Non-limiting examples of wood composite materials include oriented strand board (“OSB”), laminated veneer lumber (LVL), oriented strand lumber (OSL), structural composite lumber (“SCL”), waferboard, particle board, chipboard, medium-density fiberboard, plywood, and boards that are a composite of strands and ply veneers. As used herein, “flakes”, “strands”, and “wafers” are considered equivalent to one another and are used interchangeably. A non-exclusive description of wood composite materials may be found in the Supplement Volume to the Kirk-Othmer Encyclopedia of Chemical Technology, pp 765-810, 6th Edition, which is hereby incorporated by reference.

[0013] In residential construction a floor is typically built upon a conventional foundation (for the first story), which supports a floor comprised of a series of parallel,
spaced apart floor I joists, with a wood decking fastened upon them. The I joists, commonly made of wood, consist typically of three sections: two flange members that are interconnected by a webstock member. Typically the cross-sections of the flange are rectangular and have a pair of wider (or major) faces of between one inch to two inches, and a dimension along the other pair of faces (or minor faces) of between one inch to three inches. (Common cross section dimensions are 1.5” x 1.5”, 1.5” x 2.5”, and 1.5” x 3.5. Most typically the flanges are made from solid wood lumber, while engineered wood composites have become the most typical material from which to form the webstock, although not all engineered wood composites are suitable as flange materials. For example, aminated veneer lumber (LVL) has been a preferred engineered wood composite for flange materials because of its strength and uniform properties. Another suitable engineered wood composite that has been used as a flange material is oriented strand lumber (OSL), which makes use of a special manufacturing process using steam-injection pressing that creates a uniform density profile throughout the thickness of the product. These materials also benefit from having longer strands—with lengths of up to twelve inches, which enhances their strength performance. While longer strands and special steam processing allowing these engineered wood materials to be used as flanges, they also contribute to the expense and complication of making the material. Unfortunately, engineered wood materials such as OSB, which are not subjected to such steam treatment and are not composed of long strands, have generally not been a suitable material to form flanges.

[0014] However, this problem has been addressed in the present invention by the use of a resin impregnated fibrous re-enforcing material. Specifically, joints are formed between the opposing ends of each webstock member and grooves located in the wider face of each flange piece to receive the webstock. Typically, these joints will be glued together with an adhesive resin to hold the I joist together. As compared to previous composite I joist construction, in the present invention the grooves are slightly larger to allow a fibrous re-enforcing material to be inserted into the groove. This fibrous re-enforcing material is saturated with epoxy resin, the resin impregnated fibrous re-enforcing material is placed over the flange groove, and then the webstock is fit into the groove so that the cloth is wedged into the webstock-to-flange joint. The I joists are then placed in clamps until the adhesive in
the joint is set. If desired, both flanges on opposing ends of the webstock may be reinforced with the fibrous re-enforcing material, or only a single flange may be so reinforced.

[0015] An I joist having this resin-impregnated fibrous re-enforcing material reinforcement in a joint is considerably stronger than prior art I joists, because this resin impregnated fibrous re-enforcing material acts to reinforce the I joist at a critical part of the I joist structure, the joint, where because of the high tension forces a prior art I joist is most likely to fail. (The resin impregnated in the cloth also acts as an adhesive to bind the webstock to the flange and thus hold the I joist together). Indeed, this reinforcement between the web and flange so significantly improves the performance of the I joist, that it actually changes the failure mode of the composite wood I joist to the failure mode that is commonly seen with solid lumber flanges. This means that failure usually occurs by the top flange splitting under load (basically, the load reached was the force needed to crush lumber). This failure mode is preferred since the bottom flange and web remain intact and still be able to support the load on the floor deck. Additionally, this failure mode means that the I joists prepared according to the present invention have the capability of reaching the maximum strength properties of the materials from which they are formed.

[0016] As has been mentioned above, the preferred material for both the flange and webstock is oriented strand board ("OSB"). OSB is preferred for many reasons, but particularly because OSB is stronger than most other materials (especially solid wood lumber) when placed in a compression load. As has been mentioned above, the failure mode generally observed in the I joists prepared according to the present invention is that of the flange splitting or being crushed under a heavy compression load. Thus, strength performance is likely to be enhanced by the use of a material like OSB that performs well (or even superior to commonly used flange materials like solid wood lumber) under compression.

[0017] Processes for making OSB are well-known to those skilled in the art. The webstock portion is preferably made from a wood composite material. Particularly suitable is 3/8 inch thickness Advantech ® OSB available from Huber Engineered Woods, Charlotte, N.C. The webstock should have a density of from about 44 to about 48 pcf . Typical thicknesses include 3/8″ and 7/16″, or 1/2″ can also be used. Resins or binders used
include those typical for OSB; phenolic (PF) and pMDI are most common. Resin loading will vary depending on desired performance; loading should be at least 2% of either of the above binders. pMDI is preferred for line speed and weatherability performance. Wax can be included was a water repellent at a 0.2% - 2.0% loading level. All levels are expressed as a percent of oven dry wood.

[0018] The adhesive resin used in the present invention may be selected from a variety of different polymer materials such as epoxies, phenolic, resorcinol, acrylic, urethane, phenolic-resorcinol-formaldehyde resin, and polymeric methylenediisocyanate (“pMDI”). The selection will largely depend on the cost and performance targets specified. Some examples of specific resin systems that are suitable for use in the present invention include ISOSET® UX-100 Adhesive, available from Ashland Specialty Chemical Company, Columbus, Ohio. ISOSET is a two-part resin system, based on a 100-percent solids polyurethane adhesive, blended with conventional ISOSET adhesive. This system offers faster strength and faster complete cure times, while providing excellent strength performance. Also suitable is the two-part adhesive system from Borden Chemical Company, Columbus, Ohio, containing phenolic-resorcinol-formaldehyde resin, PRF 5210J and FM7340, a formaldehyde activator necessary to harden the resin at room temperature. Also suitable is Huntsman 1075 polyurethane adhesives for I joists available from Huntsman, Salt Lake City, UT.

[0019] The fibrous re-enforcing materials may be selected from a variety of different materials, such as for example fiberglass. Suitable fiberglass materials are available from Fiberglass Coatings, Inc., in particular the 1.5 inch, 6 oz. glass cloth tape. Suitable substitutions for glass cloth are other fibrous re-enforcing materials such as Kevlar®, carbon fiber, and similar such materials.

[0020] The inventors believe that it should be possible to use equipment that is conventionally used for profile wrapping to place the adhesive/cloth piece into place in an automated manufacturing line. Such equipment is manufactured by Stiles Machinery, Grand Rapids, Michigan.

[0021] The invention will now be described in more detail with respect to the following, specific, non-limiting examples.
Example 1

[0022] In this example, I joists prepared having conventional solid wood flanges were prepared by starting with lumber 2x4s as the solid lumber flange material. A laminating epoxy was prepared by mixing the laminating epoxy with a 2:1 Non-corrosive activator, available from Fiberglass Coatings, Inc. Then, a first set of the I joists were assembled as according to the present invention so that the groove cut in the flanges for joining to the webstock was slightly enlarged, a bead of 31.2 g of epoxy resin (available from Fiberglass Coatings, Inc.) was placed in the groove and then a piece of fiberglass tape (available from Fiberglass Coatings, Inc.) weighing approximately 13.3 g and saturated with 27.0 g of epoxy resin was placed over the groove and then the webstock and flange were fit together with the help of a deadblow hammer. The webstock was Advantech having a thickness of about 0.375 inch or 3/8 inch. The I joists were set aside to cure with approximately 350 lbs of dead weight on top to keep them together while the epoxy cured accompanying webstock.

[0023] A second set of I joists representing the prior art were assembled in the same manner as described above with respect to the first set of I joists, except that no fiberglass tape was used.

[0024] Each set of I joists was then tested using a universal test frame from Measurements Technology Inc., Roswell, GA following the test protocols outlined in ASTM D 198 ("Standard Test Methods of Static Tests of Lumber in Structural Sizes") and ASTM D 5055 ("Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I joists").

[0025] The results of these tests are as follows:
Table 1

Test results for I joists prepared according to present invention

<table>
<thead>
<tr>
<th></th>
<th>EI (x10⁶ lbs.-in²)</th>
<th>Max Force (lbs.)</th>
<th>MOR (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present Invention</td>
<td>123</td>
<td>8735</td>
<td>2644</td>
</tr>
<tr>
<td>Prior Art</td>
<td>111</td>
<td>5153</td>
<td>1560</td>
</tr>
</tbody>
</table>

[0026] As can be seen in Table 1, the I joists prepared according to the present invention (being re-enforced with epoxy resin-saturated glass cloth) were 11% stiffer (EI), carried 70% higher load (Max Force), and were 70% stronger (MOR) than prior art I joists. The increase in Max Force and MOR where statistically relevant when compared to the prior art (95% confidence level, p=0.003 and 0.003, respectively.)

Example 2

[0027] In this example, OSB material 1.5" thick was cut to form flange materials. Then, a first set of the I joists were assembled as according to the present invention, so that the groove cut in the 1.5" thick OSB flanges for joining to the webstock was slightly enlarged, a bead of 31.2 g of epoxy resin (available from Fiberglass Coatings, Inc.) was placed in the groove and then a piece of fiberglass tape (available from Fiberglass Coatings, Inc.) weighing approximately 13.3 g and saturated with 27.0 g of epoxy resin was placed over the groove and then the webstock and flange were fit together with the help of a deadblow hammer. The I joists were set aside to cure with approximately 350 lbs of dead weight on top to keep them together while the epoxy cured accompanying webstock.

[0028] A second set of I joists with OSB flanges and representing the prior art were assembled in the same manner as described above in present example 2, except that no fiberglass tape was used.

[0029] Each set of I joists was then tested in the same manner as describe above in Example 1. The results were as follows:
Table 2.

Test results for I-beams using composite flanges, reinforced vs. Prior Art

<table>
<thead>
<tr>
<th></th>
<th>EI (x10^6 lbs.-in^2)</th>
<th>Max Force (lbs.)</th>
<th>MOR (lbs.-in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-enforced</td>
<td>93</td>
<td>7808</td>
<td>1904</td>
</tr>
<tr>
<td>Prior Art</td>
<td>89</td>
<td>6303</td>
<td>1664</td>
</tr>
</tbody>
</table>

[0030] As can be seen in table 2, the I joists prepared according to the present invention (being re-enforced with epoxy resin-saturated glass cloth) were 4.5% stiffer (EI), carried 24% higher load (Max Force), and were 12% stronger (MOR) than the I joists prepared according to the prior art.

Example 3

[0031] In this example, samples were made in which the top flange piece was made from 1.5” thick OSB, and a bottom flange piece was made from solid lumber.

[0032] A first set of the I joists were assembled as according to the present invention, so that the groove cut in the 1.5” thick OSB flanges for joining to the webstock was slightly enlarged, a bead of 31.2 g of epoxy resin (available from Fiberglass Coatings, Inc.) was placed in the groove and then a piece of fiberglass tape (available from Fiberglass Coatings, Inc.) weighing approximately 13.3 g and saturated with 27.0 g of epoxy resin was placed over the groove and then the webstock and flange were fit together with the help of a deadblow hammer. Similarly, the groove cut in the solid bottom flange piece for joining to the webstock was slightly enlarged, a bead of 31.2 g of epoxy resin was placed in the groove and then a piece of fiberglass tape weighing approximately 13.3 g and saturated with 27.0 g of epoxy resin was placed over the groove and then the webstock and the bottom flange were fit together with the help of a deadblow hammer.

[0033] [0034] The I joists were set aside to cure with approximately 350 lbs of dead weight on top to keep them together while the epoxy cured accompanying webstock.
[0035] A second set of I joists with top OSB flanges and bottom solid lumber flanges were prepared as described above, except that the enlarged groove, epoxy resin bead, and fiberglass tape were prepared for the bottom groove-webstock joint only.

[0036] Each set of I joists was then tested in the same manner as describe above in Example 1. The results were as follows:
Table 3

<table>
<thead>
<tr>
<th>Condition</th>
<th>EI (x10^6 lbs.-in^2)</th>
<th>Max Force (lbs.)</th>
<th>MOR (lbs.-in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Set</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both top and bottom Re-enforced</td>
<td>120</td>
<td>9,883</td>
<td>2,753</td>
</tr>
<tr>
<td>Second Set</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottom only Re-enforced</td>
<td>110</td>
<td>10,217</td>
<td>2,853</td>
</tr>
</tbody>
</table>

[0037] As can be seen in table 3, the 1 joists prepared according to example 3 carried substantially heavier loads (Max Force) and were stronger (MOR) than the 1 joists prepared in examples 1 and 2. This is to be expected, as the top piece in the presently constructed I joist is made from OSB which performs very well under compression loads.

[0038] However, stiffness performance was not significantly improved overall compared to the prior art samples in examples 1 and 2. Finally, it is interesting to note that the samples with only the bottom joint reinforced ("Second set") performed nearly as well as (or even better in some categories of performance) than the samples with both the top and bottom joints reinforced ("First set").

[0039] It will be appreciated by those skilled in the art that changes could be made to the embodiments described above without departing from the broad inventive concept thereof. It is understood, therefore, that this invention is not limited to the particular embodiments disclosed, but it is intended to cover modifications within the spirit and scope of the present invention as defined by the appended claims.
CLAIMS

We claim:

1. An I joist comprising:
   a first and a second flange interconnected by a webstock;
   the first flange has a first major surface upon which is formed a groove, so
   that the groove faces and receives the webstock; and
   a fiberous re-enforcing material impregnated with adhesive resin disposed
   in the groove.

2. The I joist according to claim 1, wherein the first and second flange are
   composed of oriented strand board.

3. The I joist according to claim 1, wherein the first and second flange, and
   webstock are composed of oriented strand board.

4. The I joist according to claim 1, wherein the first and second flange are
   composed of strands having a length of between about 2 inches to about 6 inches.

5. The I joist according to claim 1, wherein the fibrous re-enforcing
   material is selected from the group comprising fiberglass, Kevlar®, and carbon fiber.

6. I joist according to claim 1, wherein the adhesive resin is selected from
   the group comprising: epoxies, phenolics, resorcinols, acrylics, urethanes, phenolic-
   resorcinol-formaldehyde resins, and methane disocyanates.

7. The I joist according to claim 1, wherein the glass cloth is fiberglass.

8. The I joist according to claim 1, wherein the first and second flange are
   composed of OSB, wherein strands in the OSB have a length of between about 2 inches to
   about 6 inches.

9. The I joist according to claim 1, wherein the second flange has a
   second major surface upon which is formed a second groove, so that the second groove faces
   and receives the webstock, and a second glass cloth impregnated with adhesive resin is
   disposed in the second groove.