ABSTRACT

Disclosed is an I joist including 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 reinforcing aluminum sheet material disposed in the groove.
I JOIST WITH REINFORCING ALUMINUM SHEET

BACKGROUND OF THE INVENTION

[0001] 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 "squawks" from developing or to prevent the feeling of a bouncy floor when walked upon. Once such squawks do occur, is often very difficult, time consuming and invariably expensive to fix, and moreover homeowners don't like the feeling of a bouncy floor as well as a bouncy floor's accompanying problems like the rattling of a china cabinet when someone walks by.

[0002] 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. At one time flanges were made from solid wood lumber and webs were made from plywood. In particular, the flange was made from visually and/or machine stress rated dense softwood lumbers such as from the black spruce tree which grows in Canada's northern boreal forests. However, recently these I joist components 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, 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.

[0003] Typically though, strand-based wood composite materials were only suitable for use as the webstock components of the I joist. The bending properties of strand-based wood composite materials are considerably less than MSR lumber, LVL, or some OSL materials. Further, 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 strand-based wood composite material are generally the weakest part of the material. This makes strand-based 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.

[0004] One way of overcoming this difficulty is described in U.S. Pat. No. 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.

[0005] 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. 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.

[0006] 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

[0007] The present invention relates to 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 reinforcing aluminum sheet material disposed in the groove.

BRIEF DESCRIPTION OF THE DRAWING

[0008] The foregoing summary, as well as the following detailed description of preferred embodiments of the invention, will be better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, there is shown in the drawings embodiments which are presently preferred. It should be understood, however, that the invention is not limited to the precise arrangements and instrumentalities shown. In the drawings:

[0009] FIG. 1 is a front view of the first flange and the second flange interconnected by a webstock.
DETAILED DESCRIPTION OF THE INVENTION

[0010] All parts, percentages and ratios used herein are expressed by weight unless otherwise specified. All documents cited herein are incorporated by reference.

[0011] 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.

[0012] By “laminated”, it is meant material composed of layers and bonded together using resin binders.

[0013] 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 (IVL), 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.

[0014] In residential construction a floor is typically built upon a conventional foundation (for the first story), which supports a floor comprising 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"x1.5", 1.5"x2.5", and 1.5"x3.5") Most typically the flanges are made from solid wood lumber; although engineered wood composites have become the most typical material from which to form the webstock, only certain forms of engineered wood composites are suitable as flange materials. For example, laminated veneer lumber (LVL) has been 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 such as steam-injection pressing which 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.

[0015] However, this problem has been addressed in the present invention by the use of aluminum sheet 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 the aluminum sheet material to be inserted into the groove.

[0016] The aluminum sheet material preferably has a thickness of about 12 gauge to about 38 gauge, more preferably about 26 gauge to about 34 gauge. The aluminum sheet is first pressed into the shape of the flange groove and is then glued together with an adhesive such that the shaped aluminum sheet is between the webstock and the flange groove and covers at least a portion of the groove bottom, sides and optionally the surfaces of the flange on either side of the groove or joint. This is shown in FIG. 1, where the groove is represented by line segments ‘b’, and ‘c’. An aluminum sheet (represented by the darker line) is shown inserted into the groove, and also extending out over all or a portion of the major surfaces (represented by line segment ‘a’) of the flange on both sides of the groove or joint. (Note that the present invention is not limited to the shape of the groove illustrated in FIG. 1; the groove can have any shape suitable to receive a webstock).

[0017] 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 aluminum sheet material, or only a single flange may be so reinforced.

[0018] An I joist having this aluminum sheet reinforcement in a joint is considerably stronger than prior art I joists, because this aluminum sheet 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. In particular, reinforcing the joint in this manner reduces the tendency of the web to knife through the flange as the bearing loads are increased. Additionally, by extending the aluminum sheet along the opposing flange surfaces on either side of the joint, the aluminum sheet further reinforces the flange against high axial compression forces on the top flange and high axial tension forces on the bottom flange and increases the contribution of the flange in increasing overall stiffness of the I-beam. This means that failure is mostly likely to occur as a result of shear forces in the web, which is preferred over knife splitting of the bottom flange since the bottom flange and web remain intact and are still 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.

[0019] 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 including ease of manufacturability and ability to design specific OSB products to meet specific design needs. However, OSB is much lower in axial compression (compression parallel to grain) and in axial tension (tension parallel to grain) compared to typical flange stock, such as MSR lumber, OSL, or LVL. As has been mentioned above, when I joists are prepared according to the present invention, by reinforcing
the groove (and optionally the portions of the flange on either side of the joint) with a thin aluminum sheet, the resulting system will be much stiffer, resist deflection under heavy loads, and can reach much higher ultimate loads. 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 with conventional flange materials (lumber) 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 perpendicular to the grain.

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 ¼ 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 lbs. per cubic foot. Typical thicknesses include ⅝", ¾", or ⅞" 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 fine 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.

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-resorcinal-formaldehyde resin, and polymeric methylolmelamine (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-resorcinal-formaldehyde resin, PRF 52100 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, Utah, and PL Premium polyurethane adhesive, available from OSI Sealants, Inc., Mentor, Ohio.

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

EXAMPLE 1

In this example, conventional wood I joists were prepared by starting with solid wood No. 2 SPF lumber flanges. PL premium adhesive was applied to the grooves formed in the flange faces and also to the webstock.

Additionally, in these examples I joists were prepared representing the present invention. As above, these I joists were prepared by starting with No. 2 SPF lumber flanges. 30 gauge (0.012 inch) aluminum sheet material was first pressed into the shape of the groove, and then pressed into the groove formed in the No. 2 SPF lumber flange face and glued to the groove using PL Premium polyurethane adhesive. The webstock material, ¼-inch board produced by Huber Engineered Woods, is also glued with PL Premium adhesive and inserted into the aluminum-laminated groove. Once assembled, the aluminum was laminated to the flanges at roughly 1000 lbs per I joist and allowed to cure overnight. In production, it would be anticipated the adhesive curing and pressure would be applied more rapidly.

Each set of I joists was then tested using a universal test frame from Measurements Technology Inc., Roswell, Ga. following the test protocols for four point bending outlined in ASTM D 5055 §6.3.3 ("Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I joists"). Measurements were made for the EI and the MOR.

The results were as follows:

<table>
<thead>
<tr>
<th></th>
<th>EI (x10³ lbs.-in²)</th>
<th>Max Force (lbs.)</th>
<th>MOR (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present Invention</td>
<td>415</td>
<td>8735</td>
<td>3005</td>
</tr>
<tr>
<td>Prior Art</td>
<td>252</td>
<td>5153</td>
<td>3839</td>
</tr>
</tbody>
</table>

As can be seen in Table 1, the I joists prepared according to the present invention (being re-enforced with aluminum sheet material) were 60% stiffer (EI) than prior art I joists. Although from the above table it can be seen that the MOR values of the prior art I joists are greater than the MOR values of the I joists prepared according to the present invention, this does mean that the I joists of the present invention are weaker than prior art I joists; more likely the respective MOR values are indicative of the fact that the materials which are less stiff (e.g., the I joists prepared according to the prior art) often have higher MOR values because they have considerable flexibility to bend before breaking. On the other hand stiffer materials (e.g., the I joists prepared according to the present invention) are more likely to fail at lower MOR values.

(Additionally, it should be noted that the span tested was 90 inches, rather than the span of 17 to 21 times the joint depth as recommended by the standard. Since this shorter span was used, the samples may have a greater propensity to fail in shear mode. Given that all of the samples prepared according to the present invention with the aluminum sheet reinforcement failed in shear mode, the above bending strength performance of the I joists prepared according to the present invention may be even better when executed on a longer span.)

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.
1. An I joist comprising:
a first and a second flange interconnected by a webstock;
the first flange comprising a variable density wood composite has a first major surface upon which is formed a
groove which extends into a lower density portion of the variable density wood composite, so that the groove
faces and receives the webstock; and
a reinforcing aluminum sheet material covering at least a
portion of 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 reinforcing
aluminum sheet material has a thickness of about 12 gauge
to about 38 gauge.

6. The I joist according to claim 1 further comprising an
adhesive resin to secure the reinforcing aluminum sheet to at
least the groove.

7. The I joist according to claim 6, wherein the adhesive
resin is selected from the group consisting of epoxies,
phenolics, resorcinols, acrylics, urethanes, phenolic-resorci-
ol-formaldehyde resins, and methane diisocyanates.

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

9. The I joist according to claim 1, wherein the aluminum
sheet material fully covers the groove.

10. The I joist according to claim 1, wherein the aluminum
sheet material covers at least a portion of the first major
surface.

11. The I joist according to claim 1, wherein the reinforcing
aluminum sheet material has a thickness of about 26
gauge to about 34 gauge.

12. The I joist according to claim 2, wherein the groove
extends into a core portion of the oriented strand board.

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