Exemplary fire resistant construction members disclosed herein can comprise an engineered wood product I-joint and at least two panels comprising gypsum board secured to the I-joint. The member can comprise a first gypsum board panel secured to a first side of the member and a second gypsum board panel secured to a second, opposite side of the member. In some embodiments, gypsum board panels are secured to opposite sides of a web of the I-joint. In some embodiments, gypsum board panels are secured to opposite sides of upper and lower flanges of the I-joint.
FIRE RESISTANT CONSTRUCTION MEMBERS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 61/772,284, filed Mar. 4, 2013, which is incorporated herein by reference.

FIELD

[0002] This application is related to fire resistant construction members.

BACKGROUND

[0003] Wood-based construction members can be vulnerable to fire damage. For example, some unfinished basement floor/ceiling assemblies are constructed using wood-based load-bearing construction members, such as I-joists. When a fire occurs in a basement having an unfinished floor/ceiling assembly that includes such construction members, the floor/ceiling assembly can be severely damaged by the fire and fail prematurely. Therefore there is a need for construction members having improved fire-resistance.

SUMMARY

[0004] Exemplary fire resistant construction members disclosed herein can comprise a wood-based I-joist, such as comprising an engineered wood product, and at least two panels comprising gypsum board secured to the I-joist. The member can comprise a first gypsum board panel secured to a first side of the member and a second gypsum board panel secured to a second, opposite side of the member. In some embodiments, gypsum board panels are secured to opposite sides of a web of the I-joist. In some embodiments, gypsum board panels are secured to opposite sides of upper and lower flanges of the I-joist. Wood-based members other than I-joists can also be protected with gypsum board panels to provide fire resistance.

[0005] In some embodiments, gypsum board panels are secured to opposite sides of the web only, leaving the flanges exposed. The gypsum board panels can have a height about equal to the height of the web. The thickness of the gypsum board panels can vary depending on the amount of fire-resistance required.

[0006] In other embodiments, the gypsum board panels are secured to the flanges, such that each panel spans from an upper flange to a lower flange, one on each side of the flanges. This can leave a hollow cavity between the gypsum board panels and the web. The height of the panels can be about equal to the overall height of the I-joist, such that the flanges and the web are protected by the panels.

[0007] The gypsum board panels can be applied to an I-joist in the field using, for example, nails or screws. Some panels can be nailed or screwed directly to the web, while other panels can be nailed or screwed directly to the sides of the flanges. Some embodiments can comprise one or more web holes passing transversely through the web and the gypsum board panels, such as to allow for plumbing and wiring.

[0008] The foregoing and other features and advantages of the disclosure will become more apparent from the following detailed description, which proceeds with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a side view of a portion of an exemplary construction member.
[0010] FIG. 2 is a cross-sectional view of the construction member of FIG. 1 taken along section line 2-2.
[0011] FIG. 3 is a side view of a portion of another exemplary construction member.
[0012] FIG. 4 is a cross-sectional view of the construction member of FIG. 3 taken along section line 4-4.

DETAILED DESCRIPTION

[0013] For purposes of this description, certain aspects, advantages, and novel features of the embodiments of this disclosure are described herein. The disclosed methods, apparatuses, and systems should not be construed as limiting in any way. Instead, the present disclosure is directed toward all novel and nonobvious features and aspects of the various disclosed embodiments, alone and in various combinations and sub-combinations with one another. The methods, apparatuses, and systems described are not limited to any specific aspect or feature or combination thereof, nor do the disclosed embodiments require that any one or more specific advantages be present or problems be solved.

[0014] Although the operations of some of the disclosed methods are described in a particular, sequential order for convenient presentation, it should be understood that this manner of description encompasses rearrangement, unless a particular ordering is required by specific language. For example, operations described sequentially may in some cases be rearranged or performed concurrently. Moreover, for the sake of simplicity, the attached figures and descriptions may not show the various ways in which the disclosed methods can be used in conjunction with other methods.

[0015] As used herein, the term “coupled” generally means physically coupled or linked and does not exclude the presence of intermediate elements between the coupled items absent specific contrary language.

Fire Resistance of Wood-Based Construction Members

[0016] Unprotected light-frame wood buildings do not have the natural fire resistance achieved with heavier wood members. Recently, language was added to the 2012 International Residential Code (IRC) requiring passive membrane protection in an effort to increase the fire-resistance of unprotected basement ceilings. Specifically, section R501.3 of the 2012 IRC requires that floor assemblies include a 0.5" gypsum wallboard (GWB) membrane, a 0.625" wood structural panel (WSP) membrane, or equivalent on the underside of the floor framing member. Section R501.3, however, provides certain exceptions to this rule, including wood floor assemblies using dimension lumber or structural composite lumber (SCL) equal to or greater than 2"x10" nominal dimension, or other approved floor assemblies demonstrating equivalent fire performance.

[0017] Within the membrane protection requirement, equivalence may be shown by comparison to 0.5" GWB or 0.625" WSP. Equivalence may also be shown by comparison to 2x10 assembly framing. Recent work by the American Wood Council (AWC) has sought to define the performance of a 2x10 assembly and define the test method for making any kind of equivalence comparison. The “AWC Policy and Guidelines on IRC Membrane Protection Equivalency” (October 2011) suggests that “to be considered equivalent to
2x10 sawn lumber or SCL, the framing members should support a load corresponding to 50% of the full bending design of the framing members, while being subjected to an ASTM E 119 time/temperature heating regime. All components utilized in the manufacture of the framing members (fasteners, plates, hardware, etc.) should be utilized during testing. The test end criteria should be structural member failure.” The AWC further suggests that “the most straightforward and accurate means of determining the required minimum fire resistance time would be to estimate that time using the calculation methodology specified in National Design Standard (NDS) Chapter 16 for unprotected solid-sawn 2x10 floor joists assuming a 3-sided exposure, a nominal char rate of 1.5 inches/hour, a bending strength to allowable strength design (ASD) ratio of 2.85, and supporting a load corresponding to 50% of full bending design.”

[0018] The calculation methodology specified in NDS Chapter 16 and the AWC assumptions above can be used to establish a fire-resistance benchmark of approximately 15 minutes for 2x10 joist, as shown in Table 1 below. The result shown in Table 1 assumes a 3-sided exposure, nominal char equal to 1.5 inches per hour, strength to ASD ratio of 2.85, and 50% of full bending design.

<table>
<thead>
<tr>
<th>Calculated Fire-Resistance of 2 x 10 Joint</th>
<th>Calculated Fire-Resistance (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x 10 (1.5” x 9.25”)</td>
<td>15.00</td>
</tr>
</tbody>
</table>

[0019] The calculation methodology specified in NDS Chapter 16 and the AWC assumptions above can also be used to estimate the fire resistance of an I-joist flange element, as shown in Table 2 below. The results shown in Table 2 assume a 4-sided exposure, nominal char equal to 1.5 inches per hour, strength to ASD ratio of 2.85, and 50% of full tension design.

<table>
<thead>
<tr>
<th>Calculated Fire-Resistance of I-Joist Flange</th>
<th>Calculated Fire-Resistance (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5” x 2.5”</td>
<td>13.14</td>
</tr>
<tr>
<td>1.125” x 2.0”</td>
<td>9.39</td>
</tr>
</tbody>
</table>

[0020] The calculation methodology specified in NDS Chapter 16 can also be used to estimate the fire resistance of an I-joist web element, as shown in Table 3 below. The results shown in Table 3 assume a 2-sided exposure, nominal char equal to 1.5 inches per hour, and that the web is completely or nearly completely consumed at failure. At lower applied loads, the web element primarily functions to maintain the distance between the tension flange and compression flange and to brace the compression flange against bending failure.

<table>
<thead>
<tr>
<th>Web Thickness (inches)</th>
<th>Calculated Fire-Resistance (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.375</td>
<td>3.71</td>
</tr>
<tr>
<td>0.500</td>
<td>5.29</td>
</tr>
<tr>
<td>0.625</td>
<td>6.86</td>
</tr>
<tr>
<td>0.750</td>
<td>8.71</td>
</tr>
<tr>
<td>0.875</td>
<td>10.53</td>
</tr>
<tr>
<td>1.000</td>
<td>12.41</td>
</tr>
</tbody>
</table>

Improving Fire-Resistance of Wood-Based Construction Members

[0021] Disclosed herein are methods of increasing the fire resistance of wood-based construction members, such as engineered wood construction members (e.g., I-joists). These methods can involve application of gypsum board to the wood-based members. The following examples can be used to provide equivalent fire-resistant performance per Exception 4 to Section R501.3 of the 2012 IRC (see above).

Gypsum Applied to Web

[0022] An exemplary construction member 10 is shown in FIGS. 1 and 2, in which gypsum panels 20, 22 are applied directly to an I-joist web 12. The member 10 comprises an upper flange 14, a lower flange 16, a web 12 extending between the flanges, and gypsum panels 20, 22 applied to either side of the web 12. The panels 20, 22 can comprise gypsum, gypsum wallboard, predecorated gypsum board, gypsum backing board, coreboard, and shaf tinier board, water-resistant gypsum backing board, exterior gypsum soffit board, gypsum sheathing board, gypsum base for veneer plaster, gypsum lait, gypsum ceiling board, and/or other gypsum-based materials. The flanges 14, 16 can comprise a wood-based material, such as structural composite lumber and/or solid-sawn lumber. In some embodiments, the web 12 can comprise oriented strand board (OSB) or structural plywood.

[0023] The web 12 can have a thickness T1 of any size, such as from about 0.25” to about 1”, and a height H1 of any size, such as from about 9.5” to about 21”, or larger. The flanges 14, 16 can have a width W1 of any size, such as at least about 1.5”, or at least about 3.5”, and can have heights H2, H3, respectively, of any size, such as at least about 1.125”, or at least about 1.5”. The panels 20, 22 can have thicknesses T2, T3, respectively, of any size, such as from at least about 0.25” to about 0.75”, or larger. In some embodiments, the panels 20, 22 can comprise plural layers coupled together to form a single panel. For example, a 1” thick panel can comprise two 0.5” thick panels layered together. The panels 20, 22 can have a height equal to the height H1 of the web 12, such that the panels 20, 22 substantially cover the entire height of the web 12 between the flanges 14 and 16 and/or provide a snug-fit between the flanges.

[0024] The panels 20, 22 can be secured to the web 12 in any suitable manner, such as with fasteners, adhesives, positive locking mechanisms, friction fits, other manners, or combinations thereof. In the illustrated example, the panels 20, 22 are secured to the web 12 with fasteners 24 and 26, which can comprise nails, screws, bolts, other fasteners, or combinations thereof. For example, the fasteners 24, 26 can comprise Type W drywall screws. The length of the fasteners 24, 26 can
be selected based on the values of T1, T2, and T3. In the illustrated example in FIGS. 1 and 2, each fastener 24, 26 extends through the panel 20, the web 12, and into the other panel 22 in order to secure both panels to the web. In other embodiments, one or more of the fasteners can be applied from the opposite side of the web 12, extending through the panel 22, the web 12, and into the panel 20. In one example, fasteners used to secure both panels to the web can have a length of about 1.375". In some embodiments, the panel 20 can be secured to the web 12 with a first set of fasteners applied through the panel 20 and into the web, while the panel 22 can be secured to the web 12 with a second set of fasteners applied through the panel 22 and into the web. In one example, fasteners used to secure only one of the panels 20, 22 to the web can have a length of about F.

[0025] The construction member 10 can be constructed, such as in the field, by securing the gypsum panels 20, 22 to a wood-based I-joist. Because the gypsum panels 20, 22 primarily protect the web 12, the flanges 14, 16 can remain exposed to fire damage. Thus, sufficiently sized flanges can be provided in addition to the gypsum panels to provide the required level of overall fire resistance. Based on testing results, in order to provide "equivalent fire-resistant performance" and/or in order to survive for the duration of the fire test described above, the flanges 14, 16 can have a minimum width W1 of about 2.3", about 2.5", or about 3.5", and/or minimum heights H1, H2 of about 1.5".

[0026] As shown in FIG. 1, the fasteners 24, 26 can be applied at intervals along the length of the member 10. FIG. 1 shows that, for example, fasteners 24A, 26A can be spaced an interval L1 from the fasteners 24B, 26B, and fasteners 24C, 26C can be spaced a similar or different interval from the fasteners 24B, 26B. The interval L1 between fasteners can be any size, such as from about 12" o.c. to about 24" o.c.

[0027] The fasteners 24, 26 can be positioned at various vertical locations along the height H1 of the web 12. For example, in the example of FIGS. 1 and 2, the fasteners 24A can positioned a distance H4 below the upper flange 14, and the fasteners 26 can be positioned a distance H5 above the lower flange 16. H4 and H5 can be any size, such as about F.

[0028] As shown in FIG. 1, the member 10 can include a web hole 28 that passes through the web 12 and both panels 20, 22. The web hole 28 can allow traverse access through the member 10, such as for plumbing and wiring. The web hole 28 can have a diameter of up to the height H1 of the web. The member 10 can have any number of such web holes along its length, and the web hole(s) can be located between the fasteners 24, 26 when present. The impact of a web hole on the fire-resistance of the member 10 can be minimal. The exposed web material around the perimeter of the web hole 28 can fall at its normal rate when the member 12 is exposed to fire and/or high temperatures. However, the charming of the web material around the perimeter of the web hole 28 may only make the hole slightly larger between the panels 20, 22.

[0029] Table 4 below provides exemplary ratios relating how much raw material (gypsum board) is required on a per square foot basis of floor area using the web-protected members 10 versus installing the membrane protection currently required in the International Residential Code. A ratio greater than one indicates that it takes more gypsum board material to protect the web than to install a ceiling.

<table>
<thead>
<tr>
<th>Ratio of Gyp. Board Usage as Web Protection vs. Ceiling Membrane</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-Joist O.C.</td>
</tr>
<tr>
<td>Spacing</td>
</tr>
<tr>
<td>12&quot; o.c.</td>
</tr>
<tr>
<td>16&quot; o.c.</td>
</tr>
<tr>
<td>19½&quot; o.c.</td>
</tr>
<tr>
<td>24&quot; o.c.</td>
</tr>
</tbody>
</table>

Gypsum Applied to Flanges

[0030] Another exemplary construction member 40 is shown in FIGS. 3 and 4, in which gypsum panels 50, 52 are applied to the sides of the flanges 44, 46 of an I-joist. The construction member 40 comprises an upper flange 44, a lower flange 46, a web 42 extending between the flanges, and gypsum panels 50, 52 applied to either side of the web 42. The gypsum panels 50, 52 can comprise gypsum, gypsum wallboard, predecorated gypsum board, gypsum backing board, coreboard, and shaftliner board, water-resistant gypsum backing board, exterior gypsum soffit board, gypsum sheathing board, gypsum base for veneer plaster, gypsum lath, gypsum ceiling board, and/or other gypsum-based materials. The flanges 44, 46 can comprise a wood-based material, such as structural composite lumber and/or solid-sawn lumber. In some embodiments, the web 42 can comprise oriented strand board (OSB) or structural plywood.

[0031] The web 42 can have a thickness T4 of any size, such as from about 0.25" to about 1", and a height H6 of any size, such as from about 9.5" to about 21", or larger. The flanges 44, 46 can have a width W2 of any size, such as at least about 1.5", and can have heights H7, H8, respectively, of any size, such as at least about 1.125". The gypsum panels 50, 52 can have thicknesses T5, T6, respectively, of any size, such as from at least about 0.25" to about 0.75", or larger. In some embodiments, the panels 50, 52 can comprise plural layers coupled together to form a single panel. For example, a ½" thick panel can comprise two 0.5" thick panels layered together. The panels 50, 52 can have a height about equal to the sum of H6, H7, and H8, such that the panels 50, 52 substantially cover the entire side surfaces of the flanges 44 and 46.

[0032] The gypsum panels 50, 52 can protect both the web 42 and the flanges 44, 46 from fire and/or high temperatures. Because the flanges 44, 46 are not exposed, as in the member 40 above, the size of the flanges is less significant to the overall fire resistance of the member. Thus, a wider variety of sizes of I-joists can be used to construct the member 40 while still providing sufficient fire resistance.

[0033] The construction member 40 can be constructed in the field by securing the gypsum panels 50, 52 to a wood-based I-joist. The panels 50, 52 can be secured to the flanges 44, 46 in any suitable manner, such as with fasteners, adhesives, positive locking mechanisms, other manners, or combinations thereof. In the illustrated example, the panels 50, 52 are secured to the flanges 44, 46 with fasteners 54, 55, 56 and 57, which can comprise nails, screws, bolts, other fasteners, or combinations thereof. For example, the fasteners can comprise Type W drywall screws or 5d cooler nails. The length of the fasteners can be selected based on the values of T5, T6, and/or W2. In the illustrated example in FIGS. 3 and 4, each fastener extends through one gypsum panel and into a flange.
in order to secure the panels to the flange. In one example, the fasteners used to secure 0.5" thick gypsum panels to the flanges can have a length of about 1.625".

[0034] As shown in FIG. 3, the fasteners 54, 55, 56, and 57 (only fasteners 54 and 56 are shown) can be applied at intervals along the length of the member 40. FIG. 3 shows that, for example, fasteners 54A, 56A can be spaced an interval 1.2 from the fasteners 54B, 56B, and fasteners 54C, 56C can be spaced a similar or different interval from the fasteners 54B, 56B. The interval 1.2 between fasteners can be at any size, such as about 12" o.c. to about 24" o.c.

[0035] The fasteners can be positioned at various vertical locations along the heights H7, H8 of the flanges 44, 46. For example, in the example of FIGS. 3 and 4, the fasteners 54, 55 can position a distance H9 below the top of the upper flange 44, and the fasteners 56, 57 can be positioned a distance H10 above the bottom of the lower flange 46. H9 and H10 can be any size, such as about have the values of H7 and H8, respectively, such as about 0.75".

[0036] As shown in FIG. 3, the member 40 can include one or more web holes 58 that pass through the web 42 and both panels 50, 52. The web holes 58 can allow traverse access through the member 40, such as for plumbing and wiring. A web hole 58 can have a diameter up to the height H6 of the web. The member 40 can have any number of such web holes along its length, and the web holes can be located between the fasteners when present. The impact of a web holes 58 on the fire-resistance of the member 40 can be minimal. Although a web hole provides access to the cavities between the panels 50, 52 and the web 42, flames and hot gasses tend not to enter those cavities due to the lack of oxygen and ventilation. The web material near the perimeter of the web hole 58 can char due to flames entering the through the holes in the panel, but the flames and charring tend not to migrate further into the adjacent cavities. Furthermore, in some embodiments, the cavities between the panels 50, 52 and the web 42 can include baffles and/or fill material that further reduces damage due to flames and/or heat entering through the web holes 58.

[0037] Table 5 below provides exemplary ratios relating how much raw material (gypsum board) is required on a per square foot basis of floor area using the web and flange protected members 40 versus installing the membrane protection currently required in the International Residential Code. A ratio greater than one indicates that it takes more gypsum board material to protect the web and flanges than to install a ceiling membrane.

<table>
<thead>
<tr>
<th>I-Joint O.C.</th>
<th>9½&quot;</th>
<th>11¾&quot;</th>
<th>14&quot;</th>
<th>16&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot; o.c.</td>
<td>1.58</td>
<td>1.98</td>
<td>2.33</td>
<td>2.67</td>
</tr>
<tr>
<td>16&quot; o.c.</td>
<td>1.19</td>
<td>1.48</td>
<td>1.75</td>
<td>2.00</td>
</tr>
<tr>
<td>19.2&quot; o.c.</td>
<td>0.99</td>
<td>1.24</td>
<td>1.46</td>
<td>1.67</td>
</tr>
<tr>
<td>24&quot; o.c.</td>
<td>0.79</td>
<td>0.99</td>
<td>1.17</td>
<td>1.33</td>
</tr>
</tbody>
</table>

[0038] Regarding the described gypsum protected members 10 and 40, the gypsum panels can contribute in various ways that limit the growth of fire damage on the web and/or flange material. Some examples can include: 1) preventing surface burning of wood material, 2) reflecting/absorbing significant amounts of thermal and radiant energy, and 3) reducing the availability of oxygen and ventilation.

[0039] In some embodiments, a member can comprise an increased web thickness, such as from about 0.5" to about 0.0875", in combination with gypsum panels over the web and/or flanges, to provide increased fire resistance.

[0040] In view of the many possible embodiments to which the principles of the disclosure may be applied, it should be recognized that the illustrated embodiments are only preferred examples and should not be taken as limiting the scope of the disclosure. Rather, the scope of the disclosure is defined by the following claims. We therefore claim all that comes within the scope of these claims.

We claim:

1. A fire resistant construction member comprising an internal portion comprising a wood-based material and an external portion comprising one or more gypsum panels.

2. The member of claim 1, wherein the internal portion comprises an I-joint.

3. The member of claim 2, wherein the external portion comprises one or more gypsum panels secured to a web of the I-joint.

4. The member of claim 2, wherein the external portion comprises one or more gypsum panels secured to flanges of the I-joint.

5. The member of claim 1, wherein the internal portion comprises a web portion comprised of oriented strand board or structural plywood.

6. The member of claim 2, wherein the external portion comprises a first gypsum panel secured to a first side of the I-joint and a second gypsum panel secured to a second, opposite side of the I-joint.

7. The member of claim 6, wherein the first gypsum panel is secured to a first side of a web of the I-joint, and the second gypsum panel is secured to a second, opposite side of the web.

8. The member of claim 6, wherein the first gypsum panel is secured to a first side of an upper flange of the I-joint and to a first side of a lower flange of the I-joint, and the second gypsum panel is secured to a second, opposite side of the upper flange and to a second, opposite side of the lower flange.

9. The member of claim 2, further comprising a web hole passing through the external portion and through a web of the I-joint.

10. The member of claim 7, wherein the gypsum panels have a height about equal to a height of the web.

11. The member of claim 8, wherein the gypsum members have a height about equal to a height of the I-joint.

12. The member of claim 1, wherein the external portion is secured to the internal portion with mechanical fasteners.

13. A construction member comprising an engineered wood product I-joint and at least one panel comprising gypsum secured to the I-joint.

14. The member of claim 13, wherein the construction member comprises a first gypsum panel secured to a side of the member and a second gypsum panel secured to a second, opposite side of the member.

15. The member of claim 13, wherein the at least one panel is secured to one side of a web of the I-joint.

16. The member of claim 13, wherein the at least one panel is secured to a lower flange of the I-joint and to an upper flange of the I-joint.

17. The member of claim 13, wherein the at least one panel has a thickness of at least about 0.25".
18. A method of making a construction member, comprising:
   providing an I-joist comprising an engineered wood product, and
   securing at least one gypsum panel to a side of the I-joist.
19. The method of claim 18, wherein securing at least one gypsum panel to a side of the I-joist comprises:
   securing a first gypsum panel to a first side of a web of the I-joist; and
   securing a second gypsum panel to a second, opposite side of the web.
20. The method of claim 18, wherein securing at least one gypsum panel to a side of the I-joist comprises:
   securing a first gypsum panel to a first side of an upper flange of the I-joist and to a first side of a lower flange of the I-joist; and
   securing a second gypsum panel to a second, opposite side of the upper flange and to a second, opposite side of the lower flange.

* * * * *