[0006] While load spreading will allow higher wind uplift values to be achieved with equivalent fasteners, load spreading will also allow an equivalent uplift to be achieved utilizing fewer fasteners. Reducing the number of fasteners in a roof system while maintaining wind uplift performance is highly advantageous because it requires less labor to install a roof system with fewer fasteners, fewer fasteners reduces the material cost of the roof system, and fewer fasteners results in fewer penetrations of the polyurethane or polyisocyanurate foam board, minimizing heat sinks, thereby leading to improved insulating performance of the insulation board.

Summary of the Invention:

[0006a] According to an aspect of the present invention, there is provided an insulation board assembly, including: a foam insulation board having first and second opposing surfaces; a top single layer facer attached onto a top side of the foam insulation board, wherein the top single layer facer is in direct contact with the first surface of the foam insulation board, the top facer being made of woven material having a warp density from 4 to 30 ends per inch or a weft density from 4 to 30 picks per inch and a tensile strength greater than 80 lbf/3 inch in both a machine direction and a cross direction and a tear strength of over 15 lbf in both a machine direction and a cross direction, the top single layer facer defining an outermost top surface of the insulation board assembly; and a bottom single layer facer attached onto a bottom side of the foam insulation board, wherein the bottom single layer facer is in direct contact with the second surface of the foam insulation board, the bottom facer being made of woven material having a warp density from 4 to 30 ends per inch or a weft density from 4 to 30 picks per inch and a tensile strength greater than 80 lbf/3 inch in both a machine direction and a cross direction and a tear strength of over 15 lbf in both a machine direction and a cross direction, the bottom single layer facer defining an outermost bottom surface of the insulation board assembly, wherein the insulation board assembly when adhered or mechanically fastened onto a roof assembly permits the roof assembly to meet the Very Severe Hail rating of FM 4470 (Class 1), and wherein the woven material comprises woven polypropylene and/or propylene alpha-olefin copolymers or ethylene alpha-olefin copolymers.

[0007] In an embodiment, the present invention comprises an insulation board assembly, having: a foam insulation board (which may optionally be polyurethane or polyisocyanurate, or a phenolic material or an expanded polystyrene material (EPS)); a woven mat as the top facer attached onto a top side of the foam insulation board; and a woven mat as the bottom facer attached onto a bottom side of the foam insulation board. Optionally, the woven facers may be made of natural and/or

synthetic yarns and/or tapes. Suitable synthetic yarns or tapes can be made from polymers such as polyethylene, ethylene and alpha-olefin copolymers, polypropylene, propylene and alpha-olefin copolymers, nylon, polyester, acrylic polyester, polyamide, aramid etc. Suitable natural yarns can be made from nature fibers, such as cotton, cellulose, wool, rayon, silk, hemp, sisal, etc.

[0008] The woven mats can have different weave density. Fabric Mesh is a measure of the density of the fabric weave as the number of yarns or tapes per inch in both the Warp (machine) and Weft (cross) directions. Ends per inch (EPI) is the number of warp yarns or tapes per inch of woven fabric and picks per inch (PPI) is the number of weft yarns and tapes per inch of woven fabric. For example, the weave density can be 2 tapes per inch x 2 tapes per inch (EPIxPPI) to 100 tapes per inch x100 tapes per inch. Preferably, the weave density would be 4x4 to 60x60 mesh. Most preferably, the weave density would be 4x4 to 30x30 mesh. Optionally, the woven mats have different weave density along warp and weft direction, for example, the weave density can optionally be 4x8 mesh in one embodiment.

[0009] The present woven mats can have different weights, typically measured by the fabric weight in ounces per square yard or grams per square meters. For example, the woven mat weight can optionally be from 10 gsm to 400 gsm. Preferably, the woven mat weight could be from 20 gsm to 200 gsm. Most preferably, the woven mat weight could be from 40 gsm to 100 gsm. Alternatively, the woven mats can have different thicknesses. For example, the woven mat thickness can be from 1 mil to 200 mil. Preferably, the woven mat thickness could be from 2 mil to 100 mil. Most preferably, the woven mat thickness could be from 2 mil to 50 mil.

[00010] Optionally, the woven mat can have a coating on one or both sides of the surface. The coating can be of different polymer compositions, such as polyethylene, ethylene and alpha-olefin copolymers, polypropylene, propylene and alpha-olefin copolymers, silicones, acrylates, natural rubber, styrene-butadiene rubber, etc. Advantageously, such coating will provide bleed through resistance during the polyurethane or polyisocyanurate board manufacturing process, water resistance during foam board transportation, and slip and water resistance during field installation. The coating may additionally provide improved adhesion to the polyurethane or polyisocyanurate foam during manufacturing and provide improved compatibility and adhesion to bonding adhesives during field installation. The bonding adhesives can consist of different polymer compositions, such as polyurethane, nitrile, neoprene, chloroprene, silane-terminated polyether, styrene butadiene rubber, acrylic, ethylene propylene diene monomer (EPDM), etc.

[00011] Optionally, each of the top and bottom woven mats can have an additional layer of non-woven material laminated to one or both sides. The lamination could optionally be done with adhesives or with a tie layer. When the non-woven layer is in contact with the polyurethane or polyisocyanurate insulating foam during the manufacturing process, the non-woven layer may increase the surface roughness and surface area of the woven mat to allow the woven mat to have better adhesion or bonding with the polyurethane or polyisocyanurate foam. When the non-woven layer is positioned on the outside (i.e.: top or bottom) of the foam insulation board, it may enhance the slip resistance and improve adhesion performance with bonding adhesives during the field installation. The non-woven fiber can optionally be made of different polymer composition, such as polyester, polyethylene, ethylene and alpha-olefin copolymers, polypropylene, propylene and alpha-olefin copolymers, nylon, glass, Kevlar, basalt, carbon fiber, etc.

[00012] Optionally, the woven mats may be laminated with a glass scrim, glass mat, carbon fibers scrim, or coated PET scrim. When laminated to the woven mat, these materials could potentially improve dimensional stability of the facer and the insulation board.

[00013] Optionally, the woven mats can be made of low shrinkage polymer yarns or tapes. The shrinkage rate of polymer tape can be assessed by the percentage of length change when the polymer tape is heated from room temperature to 100 ^{o}C. Preferably, the polymer tape used in the woven mat has < 10% in shrinkage rate. Most preferable, the polymer tape has < 5% shrinkage rate.

[00014] Optionally, flame retardants can be added to polymer yarns or tapes to enhance the fire resistance of the woven facer.

[00015] Disclosed herein is a rolled woven facer material having a sufficiently desirable strength in both its machine direction and its cross direction. This rolled woven material can then be used as a top and/or bottom facer to a polyurethane or polyisocyanurate foam insulation board. Preferably, this rolled woven facer material is quite thin and has low weight.

[00016] In preferred embodiments, the present woven polypropylene facer has a tensile strength greater than 80 lbf/3 inch in both a machine direction and a cross direction, and also has a tongue tear strength of over 15 lbf in both a machine direction and a cross direction.

[00017] Advantages of the present woven facer material include the fact that it provides added surface strength, load-spreading and durability as compared to existing GRF and CGF facers. Such added surface strength and load-spreading allows for foot traffic and

kneeling on the insulation boards during roof installation. It also provides superior hail resistance and equivalent mold/moisture resistance to that of CGF. Specifically, the present roofing system comprising the present facer has been shown to meet the "Very Severe Hail" test rating announced by Factory Mutual as described in FM 4470 (Class 1 – VSH).

[00018] The present woven facer is preferably a light but strong and heavy duty material. An advantage of the present woven facer material is that it has higher fastener pull through force, and thus provides excellent wind uplift resistance after the insulation board has been secured to the roof. In addition, the present woven facer system is also very durable and lengthens the effective lifespan of the foam roofing insulation board. In optional embodiments, the woven facers are made of a polymer, such as polyethylene, ethylene and alpha-olefin copolymers, polypropylene, propylene and alpha-olefin copolymers, nylon, polyester, polyamide, etc. However, it is to be understood that other woven materials including both natural and synthetic yarns or tapes, such as cotton, cellulose, rayon, silk, hemp, sisal, etc. can be used as well.

[00019] As such, the present woven facer system also offers the advantages of a higher flex modulus and a higher fastener-plate pull-through resistance as compared to traditional GRF and CGF facers.

[00020] In the case of a woven polypropylene material, the present facer can optionally be made from a plastic film that has been drawn into filaments or tapes, and then woven to create a fabric sheet or mat. In these preferred embodiments, the woven mat optionally comprises a nonwoven layer on one side that will promote adhesion to the polyurethane or polyisocyanurate foam and polymer coating on the other side that will enhance water, moisture and bleed through resistance. The polymer coating can optionally provide improved compatibility and adhesion to bonding adhesives during field installation.

[00021] Another advantage of the present woven facer material is its low cost. In addition, the present woven facer materials can optionally be made from recycled plastics, providing environmental benefits.

Brief Description of the Drawings:

[00022] Fig. 1 is a sectional side elevation view of a foam insulation board with top and bottom woven facers.

CLAIMS

1. An insulation board assembly, comprising:

a foam insulation board having first and second opposing surfaces;

a top single layer facer attached onto a top side of the foam insulation board, wherein the top single layer facer is in direct contact with the first surface of the foam insulation board, the top facer being made of woven material having a warp density from 4 to 30 ends per inch or a weft density from 4 to 30 picks per inch and a tensile strength greater than 80 lbf/3 inch in both a machine direction and a cross direction and a tear strength of over 15 lbf in both a machine direction and a cross direction, the top single layer facer defining an outermost top surface of the insulation board assembly; and

a bottom single layer facer attached onto a bottom side of the foam insulation board, wherein the bottom single layer facer is in direct contact with the second surface of the foam insulation board, the bottom facer being made of woven material having a warp density from 4 to 30 ends per inch or a weft density from 4 to 30 picks per inch and a tensile strength greater than 80 lbf/3 inch in both a machine direction and a cross direction and a tear strength of over 15 lbf in both a machine direction and a cross direction, the bottom single layer facer defining an outermost bottom surface of the insulation board assembly,

wherein the insulation board assembly when adhered or mechanically fastened onto a roof assembly permits the roof assembly to meet the Very Severe Hail rating of FM 4470 (Class 1), and

wherein the woven material comprises woven polypropylene and/or propylene alpha-olefin copolymers or ethylene alpha-olefin copolymers.

2. The insulation board assembly of claim 1, wherein the foam board is a polyisocyanurate or polyurethane foam board.

3. The insulation board assembly of claim 1, wherein the top facer and the bottom facer comprise no glass fibers.

4. The insulation board assembly of claim 1, wherein the foam insulation board has a density of 0.5 to 6.0 pcf.

5. The insulation board assembly of claim 1, wherein the insulation board assembly exhibits a fastener Pull-Through value that is higher than 300 lbf.

6. The assembly of claim 1, wherein the woven material comprises yarns or tapes.

7. The assembly of claim 1, wherein the woven material has a weight from 40 to 200 grams per square meter.

8. The assembly of claim 1, wherein the woven material has a thickness of 2 mil to 50 mil.