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(54) **New and improved glass fiber mats particularly useful for built-up roofing membranes and systems.**

(57) A glass fiber mat having an advantageous combination of high tensile strength and tear resistance properties for use in built-up roofing (BUR) membranes and systems. The mat includes two fibrous components, namely, individual fiber filaments and extended fiber elements, which are present in substantially equal amounts by weight of the mat. The total number of fibrous components in the enmeshed glass fibers is predetermined to provide the desired combination of high strength characteristics. The glass mats are made in a wet-laid process in which bundles of sized glass fibers having a predetermined fiber diameter, particularly 13-14 microns, and a fiber length between 19 and 44 mm., are well-dispersed in a chemical dispersant material whose concentration is predetermined in accordance with the length of fibers used.

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NEW AND IMPROVED GLASS FIBER MATS PARTICULARLY USEFUL FOR BUILT-UP ROOFING MEMBRANES AND SYSTEMS

This invention relates to new and improved glass fiber mats which are particularly useful for built-up roofing membranes and systems.

Built-up roofing ("BUR") membranes and systems are used primarily on commercial buildings, and, to the substantial exclusion of other roofing types, on large industrial buildings of low profile. Its popularity arises from its relatively low cost combined with its effectiveness as a weather repellant surface and its durability. The major drawback in its use is that a unique combination of both high tensile and tear strength properties is required. These rigid requirements arise because built-up roofing systems, unlike residential roofing are subject to severe stresses induced internally or externally by the surrounding atmosphere, including expansion caused by the presence of moisture internal to the system, and both expansion and contraction forces caused by variation in ambient temperature conditions. For these and other reasons, it is essential that built-up roofing systems possess an excellent balance of both high tensile strength and tear resistance.
In the past, most roofing products were made of organic-felt impregnated with asphalt. However, organic felt is not fire-resistant and it is expensive to manufacture.

Accordingly, the industry has looked to glass fiber mats to replace organic felts in this application. Several roofing products using glass fiber mats are described in U.S. patents 4,129,674 4,135,022 and 4,135,029. These mats rely upon either continuous glass fiber strands or elongated, rod-like bundles of fibers as reinforcing agents to achieve the desired combination of tensile and tear strength properties. Unfortunately, such mats are expensive and difficult to make.

In U.S. patents 4,200,487 and 4,233,353 there is described a wet-laid process of making glass fiber mats which exhibit exceedingly high tear strengths. Such mats are made from very long fibers which generate a predominate amount of extended fiber elements during the process. Extended fiber elements are characterized structurally by being comprised of a plurality of longitudinally connected fibers formed from extension of bundles of fibers which slide apart during the process of dispersion of the fiber bundles. Thus the extended fiber elements have an exaggerated length and a non-uniform diameter, being greater in the mid-section, where connection of fibers is greatest, and tapered towards its ends. However, in practice it is rather difficult to disperse elongated fibers efficiently. In addition, the tensile strength of such products are rather modest.

What is provided herein is a new and improved glass fiber mat which can be used in place of organic felts to make BUR products characterized particularly by their unusual combination of both high tensile and tear strengths, and efficiency of manufacture, as compared to other commercially available products of similar construction. The tensile strengths range from 270 to 550 N/50 mm. width (MD), and the corresponding Elmendorf tear strengths range from 5.0 to 6.6 N (MD). The ratio of tensile to tear strengths ranges from 40:1 to 70:1.

The BUR products of the invention are characterized particularly by their unusual combination of both high tensile and tear strengths, and efficiency of manufacture, as compared to other commercially available products of similar construction. The tensile strengths range from 490 to 600 N/50 mm. width (MD), and the corresponding Elmendorf tear strengths range from 6.0 to 8.1 N/50 mm. width (MD). The ratio of tensile to tear strength is about 60:1 to 100:1.

The enmeshed glass fibers in the mat includes two fibrous components, namely, individual filament fibers and extended fiber elements, which are present in substantially equal amounts by weight. The number of fibers in a given extended element is about 2 to 200, generally about 20 fibers per element. Accordingly, there are usually about 20 times as many individual filament fibers as extended element fibers in the mat. The number of both fibrous components resides between 2.9 and 6.6 x 10^6 fibers per m^2 of the glass mat, at a glass weight of about 30 g/m^2 and a mat thickness of about 0.7 mm. The enmeshed glass fibers are made by a wet-laid process using sized glass fiber bundles having a critical fiber diameter of 13-14 microns and a fiber length between 19 and 44 mm.

The bundles are maintained at a given fiber consistency, and are dispersed under vigorous agitation in the presence of a predetermined concentration of a chemical dispersant. A higher concentration of dispersant is used with fibers of greater length; most preferably it ranges from 60 to 160 ppm.

In the best mode embodiment of the invention, the glass mat has a tensile strength of 300 N/50 mm. width (MD) and tensile to tear strength ratio of 53:1. This mat is made from glass fibers having a length of 32 mm. and a diameter of 13-14 microns, dispersed in 90 ppm. of dispersant. The total number of fibrous components in this glass mat is 3.9 x 10^6 fibers per m^2. The BUR

membrane has a tensile strength of 550 N/50 mm. width (MD) and tensile to tear strength ratio of 79:1. This membrane is made from glass fibers having a length of 32 mm. and a diameter of 13-14 microns, dispersed in 90 ppm. of dispersant.

To provide glass mats, and BUR products, having the desired unusual combination of both high tensile and tear strengths, it is necessary to use glass fibers having a diameter of 13-14 microns and a length between 19 and 44 inches. Mats made with glass fibers having a diameter greater than 13-14 microns have too few fibers present in the mat to provide these properties, since the number of fibers present in a mat of given mass varies inversely with the square of the diameter of the fiber. On the other hand, mats made with fibers having a diameter lower than 13-14 microns will produce mats having too many fibers, which will decrease the porosity of the mat below a level required for impregnation of a sufficient amount of asphalt therein necessary for making a commercial BUR product.

A single source of raw material is used in the wet-laid process of making the glass fiber mats, namely, bundles of fiber glass, preferably sized. Each bundle contains about 20 to 2000 fibers.

The glass fiber bundles are maintained in an aqueous medium in which a chemical dispersant is present at a predetermined concentration. Any suitable dispersant material may be used as long as it can effectively disperse the bundles. Several such materials are known in the art and are available for this purpose. However, a particularly useful dispersant is a tertiary amine oxide, such as Aromox DMHT, which is dimethyl hydrogenated tallow amine oxide, sold by Armak Chemical Co. The use of this dispersant is described in U.S. patent 4,179,331. The description hereinafter will be directed to this compound.

The fiber bundles are agitated vigorously in the aqueous dispersement medium to form a dilute fiber

slurry of selected consistency. During this agitation, some of the bundles become unbundled or filamentized, i.e. form individual filaments. These filaments can become connected longitudinally to form an extended glass fiber element. Other bundles can slide apart to provide extended elements directly.

The dispersant in the fiber slurry is maintained at a predetermined concentration of about 60 to 160 ppm. The lower concentration is more suitable for shorter fibers, while the higher concentration is used with longer fibers. In the best mode embodiment, a concentration of 90 ppm. is employed with fibers having a length of 32 mm. Under these conditions, vigorous agitation of the fiber slurry for about 10 minutes will form mats having the desired equal amounts of individual filaments and extended fiber elements and the prescribed total number of fibrous components.

The fiber slurry suitably is maintained at a consistency of about 0.30 to 0.50% by weight of the fibers in the slurry. Preferably it is decreased in increments of about 0.05% for each 6 mm. increase in fiber length. As in the usual wet-laid processes, the concentrated dispersion slurry is diluted with water before being applied to the mat-forming screen. Preferably the dispersion slurry is diluted about 5 to 25 times at the screen, and, optimally, about 10 times.

The enmeshed glass fibers thus-formed are provided with a suitable binder to hold the fibrous components together. Any commercially available binder may be used, such as urea-formaldehyde or phenol-formaldehyde resins. The binder usually is applied in an amount of about 5 to 50% by weight of the finished mat, preferably about 10 to 30%, and, optimally, about 20%. Accordingly, the weight of fibers in the mat is about 50 to 95%, preferably 70 to 90%, and, optimally, about 80%, by weight of the mat.

The basis weight of the finished glass fiber mat (enmeshed fibers with binder) usually is about 90 to

110 g/m^2. The mat generally is about 0.7 mm. thick. The glass fiber mat exhibits a porosity which is suitable for impregnation of asphalt to form BUR membranes. Such mats exhibit a porosity of at least 100 m^3/m^2/min., and usually 140 or more, as measured by the conventional Frazier ASTM-D737 test method.

BUR membranes are fabricated by impregnation of the glass fiber mat with a suitable quantity of saturant asphalt, usually about 330% of asphalt based on the original weight of glass fiber mat. Then BUR roofing systems, e.g., 3-ply BUR systems, are made from multiple layers of BUR membranes which are held together with coatings of asphaltic adhesive.

A summary of the preferred embodiments of the invention are given in the Table below:

TABLE

Fiber Diameter (microns)	Fiber Length	Fiber Consistency (% by wt.)	Dispersant Conc. (ppm)	Number of Fibrous Components in Mat (per/m^2 x 10^6)	GLASS MAT Porosity (m^3/m^2/min)	GLASS MAT Tensile Strength N/50 mm. (MD)	GLASS MAT Tear Strength (N) Elmendorf (MD)	GLASS MAT Tensile/Tear Ratio	BUR Membrane Tensile (MD)	BUR Membrane Tear (MD)	BUR Membrane Tensile/Tear Ratio
13-14	19	0.50	60	6.6	140	350	5.0	70.0	600	6.0	100
13-14	25	0.45	80	5.0	140	325	5.2	62.5	570	6.5	88
13-14	32	0.40	90	3.9	140	300	5.6	53.5	550	7.0	79
13-14	38	0.35	120	3.3	140	290	5.8	50.0	520	7.2	72
13-14	44	0.30	160	2.9	140	270	6.6	40.0	490	8.1	60

CLAIMS:

1. A new and improved glass fiber mat particularly useful for making built-up roofing membranes comprising:

(i) enmeshed glass fibrous components formed by dispersion of bundles of glass fibers in a wet-laid process, said fibers having a diameter of about 13-14 microns and a length between 19 and 44 mm., said fibrous components including individual filament fibers and extended fiber elements which are present in about equal amounts by weight, and

(ii) a binder substance to hold said fibrous components together.

2. A glass fiber mat according to claim 1 wherein the porosity of the mat is at least 100 $m^3/m^2/min$.

3. A glass fiber mat according to Claim 1 wherein said mat has a porosity of 140 $m^3/m^2/min$.

4. A glass fiber mat according to Claim 1 wherein said fibers are sized.

5. A glass fiber mat according to Claim 1 wherein the extended fiber elements have about 2 to 200 fibers per element therein.

6. A glass fiber mat according to Claim 1 wherein the total number of said fibrous components in a unit area of the enmeshed glass fibrous components is between 2.9 and 5.6 x 10^6 fibers per m^2, at a glass weight of about 80 g/m^2 and a mat thickness of about 0.7 mm.

7. A glass fiber mat according to Claim 6 wherein said fibers have a length of about 32 mm., and the total number of said fibrous components is about 3.9 x 10^6 fibers per m^2.

6. A glass fiber mat according to Claim 6 having a tensile strength of 300 N/50 mm. width (MD) and an Elmendorf tear strength of 5.6 N (MD), at a glass mat basis weight of about 100 g/m^2 and a binder level of 20% by weight of said mat.

9. A new and improved built-up roofing membrane according to Claim 1 further characterized by including saturant asphalt impregnated in said mat.

10. A built-up roofing membrane according to Claim 9 having a tensile strength of 550 N/50 mm. width (MD) and an Elmendorf tear strength of 7 N (MD), at a glass mat basis weight of about 100 g/m^2 and a binder level of 20% by weight of said mat.

11. A built-up roofing system according to Claim 9 comprising multiple plies of said high-strength built-up roofing membranes and adhesive asphaltic coatings between said membranes.

12. A 3-ply built-up roofing system according to Claim 11 having three plies of said membranes therein.

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EUROPEAN SEARCH REPORT

Application number
EP 81 10 9892

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
D,X	US - A - 4 233 353 (A.A. BONDOC et al.) * the entire document * & EP - A - 0 019 465	1-12

CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

D 21 H 5/18
E 04 D 5/02

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

D 21 H

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same category
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: earlier patent document, but published on, or after the filing date
D: document cited in the application
L. document cited for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	09-03-1982	NESTBY