FIG. 4

FIG. 5

FIG. 6
Fig. 9
TEXTILE MAT FOR INDUSTRIAL USE IN THE FIELD OF CIVIL ENGINEERING

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ABSTRACT OF THE DISCLOSURE

A fabric mat for soil stabilization has continuous bands of single ply fabric alternating with intervening continuous bands of two-ply fabric forming between the two plies continuous hollow tubelike containers which are filled with sand, gravel or the like. One end of the tubelike containers is closed before filling and the other after filling. The mats may have selvages along opposite side edges which are secured to selvages of like mats to connect a plurality of mats together.

The present invention relates to a textile mat for industrial use in the field of civil engineering, more particularly to a woven mat provided with a plurality of hollowed portions for containing sand or gravel and which can be used as a material for reclamation in the field of civil engineering.

Generally, concrete blocks, asphalt-mats, wood blocks, stones, etc., have been used as materials for reclamation of bank-revetment or coast protection works. However, these materials are not economical because of the cost of their transportation. The quality of these is also unsatisfactory from the point of view of working efficiency and mechanical properties. It is already known that sand bags or some textile mat comprising a plurality of sand bags connected to each other by sewing them with threads are used now and then. Similar drawbacks as described above are also present in case of sand bags and even in case of using textile mat comprising a plurality of sand bags, it is difficult to carry out the work with high efficiency, and further there is a tendency of the connected portion of the sand bags breaking.

The principal object of the present invention is to provide a practical woven mat having a plurality of hollowed portions for containing sand or gravel which can be used as a material for reclamation in the field of civil engineering.

Further object of the present invention is to make possible economical reclamation by using a textile mat of the invention in the same field.

Another object of the present invention is to make possible economical reclamation by using a textile mat of the invention in the same field.

Generally, the textile mat of the present invention comprises a plurality of hollowed portions consisting of hollowed cloth, and a plurality of connecting portions between the hollowed portions without using any connecting sewing threads.

The hollowed portions are arranged in a parallel condition to each other, further, it is preferable to close one end of the hollowed portions of the textile mat of the invention before using as a material for reclamation.

The textile mat of the present invention can be easily manufactured by power looms but it is necessary to have some particular design of the woven cloth for the present purpose and also consideration must be given regarding selection of the textile yarns for manufacturing the textile mat of the invention.

The textile mat of the invention (hereinafter called "the woven mat") is filled with sand or gravel by pouring a slurry composed of water and insoluble matters such as sand, gravel, etc., into its hollowed portions, while water passes through the numerous fine intervened spaces between the textile yarns of the woven mat (hereinafter called "mesh").

Consequently, it is very easy to make a compact material of sand or gravel for reclamation in the field of civil engineering. The above-mentioned operative characteristic of the woven mat of the invention is one of its remarkable features.

Other objects and advantages of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings, in which,

FIG. 1 is a perspective view of an embodiment of the woven mat according to the invention.

FIG. 2 is an enlarged view of the cross section of the hollowed portion of the woven mat shown in FIG. 1.

FIG. 3 is an enlarged plan view of the hollowed portion of the woven mat shown in FIG. 1.

FIG. 4 is an explanatory diagram for showing the relation between the accumulated frequency in percent and particle size in mm., of sand contained in an experimental slurry poured into the woven mat according to the invention.

FIGS. 5 and 6 are diagrams of results obtained by experiments for showing the relation between the size of fine spaces existing in the woven mat and the maximum particle size of sand which passes through the spaces when slurry containing water and sand is poured into a hollow portion of the woven mat of the invention.

FIG. 7 is a perspective view of another embodiment of the woven mat provided with a plurality of hollow portions having particular yarn density, according to the invention.

FIG. 8 is an enlarged plan view of the woven mat shown in FIG. 7.

FIG. 9 is a plan view of another embodiment of the woven mat of the invention.

FIG. 10 is an explanatory section view, taken along line X-X in FIG. 9.

FIG. 11 is an explanatory drawing for showing the variable yarn density of the hollow portion of another embodiment of the woven mat, according to the invention.

FIG. 12 is also an explanatory perspective view of the woven mat provided with reinforced edge portion, according to the invention.

FIG. 13 is an explanatory skeleton sketch showing a method for carrying the woven mat of the invention which is filled with sand or gravel.

FIGS. 14 and 15 are explanatory diagrams showing examples of end uses of the woven mat according to the invention.
Referring to FIGS. 1 and 2, an embodiment of the woven mat of the invention is composed of a plurality of portions 1 having so-called hollow-cloth structure and a plurality of intervened portions 2 between the adjacent portions 1. The intervened portions 2 form a single sheet, and these portions 1 and 2 are arranged in a parallel condition to each other. In the above-mentioned embodiment, the portions 1 and 2 may extend along the warp yarn or weft yarn of the woven mat of the invention, for instance, if the intervened portions 2 extend along the warp yarn 4, the direction of the intervened portions 1 is perpendicular to the direction of the warp yarn 3, as shown in FIGS. 1 and 2.

To obtain sufficient strength of the woven mat for practical use, it is necessary to utilize synthetic fiber materials in the form of multifilament yarn with or without twist, or spun yarn, or a tape yarn composed of film, and/or a monofilament yarn. However, it is also possible to use union yarn or blended spun yarn mainly composed of synthetic fiber materials together with other textile fiber material such as cotton, jute, etc., as the other component. The synthetic fiber material of the woven mat prevents decomposition of the woven mat in water or earth. To reinforce the resistance of the synthetic fiber materials of the woven mat, some chemical agent for improving the resistance of the synthetic fiber material to ultraviolet rays or abrasion, may be used for coating the woven mat in such a way that the porosity of the woven mat is maintained. For example, synthetic resin such as acrylic, vinyl chloride or polyamide resin or bituminous agent can be used for the above-mentioned purpose.

In the conventional synthetic fiber materials such as polyester, polyamide, polyacrylic, polyvinyl and polyolefine fiber materials can be used for manufacturing the woven mat of the present invention. However, synthetic fiber materials having high tenacity and high resistance against alkali and containing some stabilizer against ultraviolet rays is preferably used for the present purpose.

As already illustrated, a slurry composed of water and sand or gravel is poured into the hollowed portions of the woven mat of the invention when the material for reclamation is made by using a suitable mechanical means such as a pump. The efficiency of the above-mentioned filling operation mainly depends on the porosity of the woven mat, in other words, if the size of the unit mesh of the woven mat is so large that a large quantity of sand passes through the woven mat together with water or if the size of the unit mesh of the woven mat is so small that it becomes difficult for water to pass without pollution of a higher pressure, the working efficiency is lowered. Experiments were performed in order to find the most preferable unit size of the mesh. Referring to FIG. 3, experimental fabrics made of synthetic multifilament yarn having equal density of warp 3 and weft 4 yarn were prepared. The size of the unit mesh 5 is presented by an intervening space between the adjacent warp yarn 3 and is designated by "a" in FIG. 3. An experimental slurry composed of water and sand is poured on the cloth.

The particle size of the sand contained in the experimental slurry varies and the amount of the sand having different grain sizes also varies as shown in FIG. 4, wherein the ordinate represents the accumulated frequency in percent and the abscissa represents the particle size of the sand contained in the slurry, where the particle size of the sand is represented by the minimum thickness of the respective particles of sand.

Table 1 shows the structure of experimental test pieces having different meshes. The text was performed under the following condition: Composition of slurry used—water 70%, sand 30%. Vacuum—corresponds to 50 cm. water column.

<table>
<thead>
<tr>
<th>Number of test piece</th>
<th>Structure of test piece</th>
<th>Size of unit mesh (a) in mm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>890 denier/1 x 840 denier/1</td>
<td>0.40 x 0.40 (0.40)</td>
</tr>
<tr>
<td>2</td>
<td>1,000 x 1,000</td>
<td>0.38 x 0.38 (0.38)</td>
</tr>
<tr>
<td>3</td>
<td>840 denier/1 x 840 denier/1</td>
<td>0.20 x 0.20 (0.20)</td>
</tr>
<tr>
<td>4</td>
<td>1,290 denier/1 x 1,290 denier/1</td>
<td>0.17 x 0.17 (0.17)</td>
</tr>
<tr>
<td>5</td>
<td>840 denier/1 x 840 denier/1</td>
<td>0.10 x 0.10 (0.10)</td>
</tr>
<tr>
<td>6</td>
<td>840 denier/1 x 840 denier/1</td>
<td>0.05 x 0.05 (0.05)</td>
</tr>
<tr>
<td>7</td>
<td>70 denier/1 x 70 denier</td>
<td>0.02 x 0.02 (0.02)</td>
</tr>
</tbody>
</table>

Referring to FIG. 4 wherein the abscissa represents the size (a) of the unit mesh of the woven mat and the ordinate represents the maximum particle size of the sand which passes through the unit mesh, respectively, it was noticed that the size (a) of the unit mesh is limited to three times the particle size of the sand which is desired for accumulation on the woven mat.

Generally, the filling of sand or gravel in the hollowed portions of the woven mat of the invention is carried out under a reduced pressure using a vacuum pump in the range of 50 cm. to 200 cm. water column, therefore the maximum particle size of the sand which can pass through the mesh of the woven mat varies in accordance with the vacuum condition of the pump. The result obtained by our further experimental test carried out under the vacuum of 200 cm. water column is shown in Table 2, where R represents the accumulated amount of sand in percent calculated by the following definition, that is, R represents the amount of sand accumulated on the test piece/amount of sand supplied in percent. T represents the time for completion of the filtration of the slurry poured on the test piece, and M represents the maximum particle size of the sand which passes through the woven mat in mm.

<table>
<thead>
<tr>
<th>Number of test piece</th>
<th>Size of unit mesh (a) in mm.</th>
<th>R in percent</th>
<th>T in second</th>
<th>M in mm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.49</td>
<td>2.2</td>
<td>0.5 x 0.185</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.31</td>
<td>3.4</td>
<td>1.0 x 0.175</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.29</td>
<td>2.9</td>
<td>1.5 x 0.145</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.17</td>
<td>20.6</td>
<td>41 x 0.100</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.15</td>
<td>40.1</td>
<td>36 x 0.090</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.05</td>
<td>81.8</td>
<td>156 x 0.095</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.02</td>
<td>90.0</td>
<td>210 x 0.092</td>
<td></td>
</tr>
</tbody>
</table>

It was found from the result obtained as shown in Table 2, that the size (a) of the unit mesh is limited to 1.5 times the particle size of the sand which is desired to be accumulated on the woven mat.

Further experimental test was performed under a working condition similar to the actual filling operation of sand into the hollowed portion of the woven mat. That is, several pieces of bags made of woven cloth composed of polyamide multifilament yarn of 1,260 denier were used. The structure of the test pieces was plain weave, the size of the unit mesh of the test pieces was designed as shown in Table 3, and the size of the bag was 30 cm. in diameter and 10 m. in length. A slurry composed of water (70%) and sand (30%) was poured into the respective bags for 40 minutes at a pouring speed of 1.00 liter per second, and the amount of sand accumulated in the bags was measured. The particle size of the sand contained in the
slurry varies as shown in FIG. 4. Table 3 shows the
results obtained by the above-mentioned test, where X repre-
sents size of unit mesh or particle size of sand which is
desired to be accumulated in the bag, Rₜ represents
amount of sand accumulated in the bag/amount of sand
supplied to the bag in percent, when a slurry composed of
water and sand with a theoretical mixing ratio of 72 and
28 percent.

<table>
<thead>
<tr>
<th>X (in mm.)</th>
<th>Size of unit mesh accumulated in the bag (e) (in mm.)</th>
<th>Amount of sand accumulated in the bag (m³)</th>
<th>Apparent condition of filling operation of sand into the bag</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>0.015</td>
<td>0.29</td>
<td>Overflows from the mouth of the bag.</td>
</tr>
<tr>
<td>0.5</td>
<td>0.090</td>
<td>0.35</td>
<td>Do.</td>
</tr>
<tr>
<td>1.0</td>
<td>0.060</td>
<td>0.45</td>
<td>Do.</td>
</tr>
<tr>
<td>1.5</td>
<td>0.120</td>
<td>0.63</td>
<td>Do.</td>
</tr>
<tr>
<td>2.0</td>
<td>0.120</td>
<td>0.63</td>
<td>Do.</td>
</tr>
<tr>
<td>2.5</td>
<td>0.180</td>
<td>0.83</td>
<td>Do.</td>
</tr>
<tr>
<td>3.0</td>
<td>0.210</td>
<td>0.83</td>
<td>Water containing sand passes through the bag.</td>
</tr>
<tr>
<td>3.5</td>
<td>0.240</td>
<td>0.90</td>
<td>Do.</td>
</tr>
<tr>
<td>4.0</td>
<td>0.150</td>
<td>0.15</td>
<td>Do.</td>
</tr>
</tbody>
</table>

Consequently, when it is desired to accumulate sand
caracterized by the lower limit of particle size of up to
at least 0.06 mm, it was found that the size of the unit
mesh of the woven mat from 0.09 mm. to 0.18 mm., that
is, 1.5 to 3.0 times the particle size of the sand, must
be chosen, from the experimental test shown in Table 3.

After the slurry has been poured into the hollowed por-
tions of the woven mat of the invention, the opened end
portions of the woven mat are closed by a suitable method
such as stitching with threads, etc., and then carried to
the work site by some mechanical means. The sand or
gravel contained in the woven mat of the invention some-
times contain water, therefore, it is necessary to use woven
yarns having sufficient strength to prevent breakage of
the woven mat while carrying it.

The thickness of the yarn for manufacturing the woven
mat of the invention must be chosen so as to conform with
requirements which can be decided from the required
mechanical properties such as tensile strength and abra-
sion resistance, filtration, etc. For example, it is prefer-
able for the tensile strength of the woven mat to be more
than 100 kg./cm.

In our practical test of the woven mat of the present
invention, it was observed that relative slip between the
warp and weft yarns occurred when the slurry was being
poured into the hollowed portions 2, thereby the size of
the mesh of the woven mat is varied. The above-men-
tioned slip between the warp and weft yarns must be
avoided in order to maintain the uniform working con-
dition during the filling operation of sand or gravel into
the woven mat of the invention.

The above-mentioned slip between the warp yarns and
the weft yarns of the woven mat can be prevented by
fixing the crossing of the warp yarns with the weft
yarn.

The fixing of the crossing of the warp yarns with the
weft yarns can be carried out by the so-called heat-set
treatment of the woven-mat, or fixing the crossed por-
tions of the warp yarn with the weft yarns of the woven
mat by a certain synthetic bonding agent. Further, the
above-mentioned slip between the warp yarn and the
weft yarn can also be prevented by using a particular
structure of the woven mat.

In FIGS. 7 and 8, embodiments of the woven mat provided
with particular woven structure are shown. In the draw-
ing of FIG. 7, the woven mat comprises hol-
lowed portions 1 composed of hollowed cloth and con-
necting portions 2 between the adjacent hollowed por-
tions 1. The warp density of the connecting portions 2
and of the side portions Y of the hollowed portions 1
are more dense than the main portion X of the hollowed
portions 1. It was observed that when the warp density of
the connecting portions 2 and of the side portions Y
is 1.2 times larger than the main portion X of the hollowed
portions 1, slip between the warp yarns 3 and weft
yarns 4 can be effectively prevented, and a width of the
connecting portions 2 of 2 cm. was effective for the
present purpose.

From the practical point of view, it is desirable to
have the length of the hollowed portion of the woven mat
of the invention more than 5 meters. In this case, it is
better to use a woven structure of woven mat compris-
ing a plurality of hollowed mat wherein the hollowed
portion extend in the direction of the warp yarn and a
plurality of connecting portions between the adjacent
hollowed portions. Consequently, it is clear that there
is certain limitation to the number of hollowed portions
of the woven mat manufactured by a power loom (hereinafter
called the "unit woven mat"), in other
words, if it is required to supply woven mat having a
certain number of hollowed portions which is larger than
the number of hollowed portion of unit woven mat
manufactured with a power loom, the woven mat is man-
ufactured by connecting a plurality of the unit woven
mats by sewing them together.
The woven mat formed by combing a plurality of unit woven mats is hereinafter
called a "combined woven mat".

It was also disclosed that, when the combined woven
mat is used for filling sand or gravel, warp yarns, parci-

ally the warp yarns of the connecting portions between
the adjacent unit woven mats frequently slide on the
weft yarns by lateral force causing by filling of sand or
gravel into the hollowed portions of the woven mat.

In other words, the mesh of the hollowed portions
of the woven mat become enlarged, thereby the filling ef-

ciency of sand contained in the woven mat is reduced.
To prevent the above-men-
tioned drawback of the combined woven mat, a
certain woven structure of the woven mat was disclosed.
Referring to FIGS. 9 and 10, the unit woven mat of an
embodiment of the invention comprises a pair of hol-
lowed portions 1 and connecting portion 2 between the
hollowed portions 1 and a pair of selvage 8. The woven
structure of the selvage 8 is different from the other
portions of the unit woven mat for example in FIG. 10,
woven yarns 12, 15, 16, 19, 20 are interlaced with
the warp yarns 9 of the selvage 8 while weft yarns 13, 14,
and 18 are not interlaced with the warp yarns 9 of the
selvage 8, on the other hand weft yarns 12, 13, 16 and
17 are interlaced with warp yarns 10 of the selvage 8
while weft yarns 14, 15, 18 and 19 are not interlaced
with the warp yarns 10 of the selvage 8. As mentioned
above, there are two kinds of weft yarns, one interlaces
with the warp yarns of the selvage and the side portion of the hollowed
portion of the woven mat on the weft yarns can be prevented from filling sand or gravel into the hollowed portions of
the woven mat. It is preferable to apply the particular
structure shown in FIG. 8 wherein the density of warp yarns in the connected portion 2 and the side portion of the
hollowed portion of the woven mat is larger than the
other portions, to obtain further prevention of slip between warp yarns and weft yarns.

Referring to FIG. 11, a modified embodiment of the woven mat of the invention is shown. The woven mat of this embodiment comprises a woven structure similar to the woven mat shown in FIG. 1 except for the variation of the density of the warp yarn in the hollowed portion 1. The density of the weft yarn in the hollowed portion 1 varies with three groups, that is, supposing one end of the hollowed portions 1 are closed by a suitable means, and the portions including the closed end of the holes 2, the portions including the second and third portions 5, 6, and the portions including the opened end of the hollowed portions 1 are called the first portions 5, and the portions between the first and the third portions are called the second portions 6, the density of the weft yarn is increased from the first portion to the third portion, in other words, the density of the weft yarn in the first portion is the lowest, while that of the third portion is the highest. It was also disclosed that the efficiency for filling sand, gravel into the hollowed portions of the woven mat was remarkably improved by using the above-mentioned modified embodiment of the woven mat, as shown in the following example.

EXAMPLE 1

A standard bag was made with a plain weave cloth of warp yarn 840 denier, weft yarn 840 denier, warp density 15/cm. weft density 15/cm. The size of the bag was 30 cm. diameter x 10 m. length. A test bag according to the invention was made with a woven hollow cloth of warp yarn 840 denier and weft yarn 840 denier. The size of the test bag was the same as the standard bag. The yarn density of the woven hollow cloth was designed as follows; in the first portion of 3.3 m. in length warp 15/cm. x weft 12/cm.; in the second portion 3.3 m. in length warp 15/cm. x weft 15/cm.; in the third portion of 3.4 m. in length, warp 15/cm. x weft 18/cm. Both bags were disposed at an inclination of 30°. The opened mouth was on the top. A slurry composed of water (50%) and sand (50%) was poured into the opened mouth of the bags at a supplying rate of 0.2 m² per minute by a sand pump, and the time required for filling the bag was measured. The time required for filling the standard bag was 8 minutes, while the time for the modified bag of the invention was 5 minutes. As shown in the above-mentioned experimental test, the efficiency for filling sand into the bag was remarkably improved by using the above-mentioned bag according to the invention.

After completion of filling sand or gravel into the hollowed portions of the woven mat of the invention, the open end portion 11 of the hollowed portions 1 is firmly closed by a certain way such as sewing by threads or by strands, and then carried to the work site. However, the woven mat filled with sand or gravel was frequently broken at the connected portions 2 while carrying because both sides of the connected portions 2 receive an unexpected lateral load caused by shock or excess weight of sand or gravel containing water. Consequently, when the sides of the connected portions 2 are broken, the woven structure of the hollowed portions is broken and the sand or gravel filled in the hollowed portions flows out. To prevent the above-mentioned trouble, it is desirable to reinforce the side of the connecting portions 2. One method for reinforcing the side of the connecting portions 2 is shown in FIG. 12, wherein the side portion 21 of the connecting portion 2 is cut and the cut portions are folded and sewn by thread 22. A piece of cloth 23 is attached to an inside end of the cut portion 21 by sewing to the connecting portion 1 as shown in the drawing. By this method of reinforcing the side of the connecting portions 2, the above-mentioned possibility of breaking the side of the connecting portions 2 can be completely prevented. Instead of attaching a piece of cloth 22 for reinforcing, a certain synthetic resin may be used for reinforcing the side end portion or the connecting portions 2 of the woven mat by the coating method.

In FIGS. 13, 14 and 15, examples of using and carrying the woven mat of the invention are shown. The woven mat 23 filled with sand or gravel is attached with a plurality of hanging ropes 25 and lifted by a hanger 26 of a conventional crane 27 installed on a base 28, and transported to the site in the water 29. Therefore, it is very easy to perform the reclamation work by using the woven mat according to the invention with high working efficiency and at low cost. The woven mat 23 filled with sand or gravel according to the invention has a flexible construction, consequently the woven mat 23 filled with sand or gravel conforms very well to the irregular surface of the ground 30 or 31 and a construction block 32 can be stably set on the woven mat 23, as shown in FIGS. 14 and 15.

What is claimed is:

1. A fabric mat for soil stabilization comprising alternating continuous bands of single ply fabric and intervening continuous bands of two-ply fabric forming between said two plies continuous hollow tubelike containers for sand, gravel or like material, said two-ply bands being of mesh fabric with a mesh size to permit passage of water while retaining said sand, gravel or like material, interlacing portions of said strands of said mesh fabric being fixed to each other to maintain the mesh size of said fabric substantially constant, said bands of single ply fabric being used for reinforcing the side end portion or the connecting portions 2 of the woven mat.

2. A fabric mat according to claim 1, in which the density of said strands extending in a lengthwise direction in said bands of single ply fabric and in adjacent portions of said bands of two-ply fabric is at least 1.2 times greater than in the remaining portions of said bands of two-ply fabric.

3. A fabric mat according to claim 1, in which said fabric is woven and said bands extend in a warp direction, said mat further having a part of opposite selvages extending in a warp direction.

4. A fabric mat according to claim 1, in which said fabric is woven and said bands extend in a warp direction, said mat further having a part of opposite selvages extending in a warp direction.

5. A plurality of fabric mats according to claim 4, in which said bands extend in a warp direction, said mat further having a part of opposite selvages extending in a warp direction.

6. A plurality of fabric mats according to claim 4, in which said bands extend in a warp direction, said mat further having a part of opposite selvages extending in a warp direction.
tainers, being greatest at the closed ends of said containers and least at the open ends of said containers.

8. A fabric mat according to claim 7, in which said bands of single ply fabric have reinforced portions in the vicinity of the open ends of said tubelike containers.

9. A fabric mat for soil stabilization comprising a unitary continuous fabric having spaced parallel bands of constant width in which said fabric is of two-ply construction and intervening narrower bands of constant width in which said fabric is of single ply construction, said bands of two-ply construction extending the full width of the fabric and forming continuous hollow tubelike containers of uniform width for sand, gravel or the like joined with one another by said bands of single ply construction, and means joining the opposite plies of said bands of two-ply construction to close one end of said tubelike containers along one boundary of said mat, said fabric being formed of strands of at least mainly synthetic material, the fabric in said bands of two-ply construction being open mesh fabric with a mesh size to permit passage of water while retaining sand, gravel or like material, crossing portions of said strands of said mesh fabric being fixed to each other to maintain the mesh size of said fabric substantially constant and the fabric in said bands of single ply construction being stronger and denser than the fabric in said bands of two-ply construction.

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