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(54) A cement tile reinforced with fibers and a method for the production of the same.

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EP-A- 0 114 518 **EP-A- 0 173 553**
DE-A- 2 743 934 **FR-A- 1 010 876**
FR-A- 1 371 646 **FR-A- 2 217 937**
FR-A- 2 286 254 **FR-A- 2 370 010**
US-A- 2 672 670 **US-A- 3 224 205**
US-A- 4 414 030

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Description

This invention relates to a tile that is made of cement and reinforced with fibers, for which the reinforcing material is made of synthetic fibers.

Tiles generally have as their main ingredients clay and cement, and are installed one after another along the slope of a roof from the eaves to the ridge. At that time, the edge toward the ridge of a tile that is placed at the edge of the eaves has placed on the edge toward the eaves of the next tile. Each tile is supported by the attachment of the edge of the tile toward the ridge to the underlying building material such as flat boards, roofing, or the like, and by the placement of the edge of the tile toward the eaves on the top of the edge toward the ridge of the next tile. Thus, the edge of each tile toward the eaves is placed in a higher position with respect to the building material under the tiles than the edge of that tile toward the ridge, resulting in a space between the underneath surface of the tile and said building materials under the tiles. For that reason, when a load is placed on the central part of tiles installed in such a way on a roof, bending stress affects this central part, and gives rise to the danger of breakage of the tiles.

In order to prevent this kind of bending stress, the entire body of the tile can be made thick. However, if the entire body of the tile is made thick, the weight of the tile itself increases, which makes the tile costly. Moreover, the work load at the time of the installation of the tiles on the roof is increased, and there is an additional disadvantage that the durability of the building itself is decreased.

For these reasons, in order to increase the strength of the tiles, and also to increase the ease of the operation of the formation of the tiles, asbestos fibers have been mixed in as a reinforcing material. For example, in wave-shaped tiles with alternating hills and valleys, a mixture made of cement, asbestos, pulp, and the like in water is used to make a form in a cement mold like the process of making hand-made paper, and this is formed with pressure in a liquid roller, etc., in a so-called paper-making process, by which the hills and valleys are formed with approximately the same thickness.

However, in recent years, it has been found that asbestos fibers are a carcinogenic material, and so there are problems with the use of asbestos fibers. For that reason, in place of asbestos fibers, inorganic fibers such as glass fibers, inorganic fibers such as potassium titanate fibers, etc., organic fibers such as vinylon, acrylonitrile, polypropylene, polyamide, etc., or metallic fibers such as steel fibers, etc., have been developed for the use in tiles made of cement as reinforcing materials. For example, tiles made of a cement in which short fibers of polyester, glass, etc., as reinforcing materials are disclosed in Japanese Patent Publication No. 57-9009.

In this kind of tile made from cement reinforced with fibres, the tiles are light-weight, so their production is made easier, and another advantage is the high strength conferred. However, with this kind of tile, the hardness is slightly decreased, and as mentioned above, when the tiles are installed on a roof and there is a load placed on the central part of the tiles, the tiles are largely deformed, and stress accumulates in the centre part of the tiles, bringing about the possibility that the tiles will break.

Also, in a wave-shaped tile formed with alternating hills and valleys, when the tile is installed with its hills and valleys running along the slope of a roof, and when a load is placed on the upper surface of the tile, it is known that more force is exerted on the valleys than on the hills. Tiles with this kind of shape are generally made with the hills and valleys of approximately the same thickness, so that when a large load is placed on the valleys, there is the disadvantage of the valleys being easily broken.

FR-A-1010876 discloses a wave-shaped tile having parallelepiped shaped stops on respectively the upper surface and undersurface of the tile.

FR-A-2 286 254 discloses a wave-shaped tile made of fibre-reinforced cement in which the valleys of the tile are thicker than the alternating hills.

Japanese Laid-Open Patent Application 58-213666 discloses a molding method that gives tiles made of cement and reinforced with fibres, wherein an inorganic filler and synthetic fibres are mixed with cement and 15-30 parts by weight of water per 100 parts by weight of the cement are added and kneaded by a kneader in which the surfaces of the fibres are scratched, after which the amount of water needed for the formation of the particular shape is added, and molding is accomplished by, for example, the use of a press. Kneaders that have sharp protuberances in the kneading chamber, pressure kneaders, pulpers, or the like can be used.

However, with this kind of method, the synthetic fibers may come to be twisted around each other, and there is the chance of their forming a fiber ball. In general, the chance of synthetic fibers becoming twisted around each other is greater than for asbestos fibers. Once a fiber ball has been formed, it is not easy to undo said ball, so there is a tendency for the synthetic fibers to be distributed unevenly in the cement matrix. Scratches are made in synthetic fibers in the kneader, so the strength of the said synthetic fibers themselves may be decreased. The result is that the molded products may not have the desired strength.

Also, when a mixture that contains 30 parts by weight or more of water is molded under pressure, there may be separation out of the water portion in the mold before molding is complete. The result is that this mixture is not completely molded, and there is the possibility that the strength of the molded product will not be uniform.

The tile made of cement reinforced with fibers of this invention which overcomes the above-discussed and numerous other disadvantages and deficiencies of the prior art, has, per 100 parts by weight of cement, 0.3-7 parts by weight of synthetic fibres as reinforcing materials, and 200 parts by weight or less of an inorganic filler, wherein said tile has a wave-shape with alternating hills and valleys, which run in the direction of the slope of the roof when it is installed on the building material of the roof that is under the tiles of a sloping roof, the valley of the tile being provided on its undersurface, except for the edges of the hills and valleys, with at least one supporting member having a length y along the direction of the slope of the said building material under the tile, a length x at right angles to the said direction of the slope, and a maximum height h such that $y \geqq 3$ mm, $x \geqq 3$ mm, and $h \leqq 60$ mm.

The method for the manufacture of tiles made of cement reinforced with fibres of this invention comprises mixing 200 parts by weight of an inorganic filler with an aqueous solution that has been or is being prepared by dissolving 1 part by weight or less of a water-soluble high polymer, if needed, into 30 parts by weight or more of water; mixing by agitation the mixture with 0.3-7 parts by weight of synthetic fibres; mixing by agitation the mixture with 100 parts by weight of cement; putting the mixture into a mold that can be opened and closed; and then molding the mixture at a rate of pressure of 0.3 mm/sec or more, resulting in the desired tile reinforced with fibres.

Thus, the invention described herein makes possible the objectives of (1) providing light-weight tiles with improved strength by which the tiles are not readily broken even when a weight is put thereon; and a method for the manufacture of tiles made of cement reinforced with fibres by which synthetic fibres that function as a reinforcing material are not damaged and cut, and accordingly are uniformly dispersed into the cement matrix.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:

FIGURE 1 is a perspective view of the undersurface of a tile of this invention.

FIGURE 2 is a sectional view showing the installation of tiles of Figure 1 on a roof.

FIGURE 3 is a perspective view of the undersurface of another tile of this invention.

FIGURE 4 is a perspective view of the undersurface of a further tile of this invention.

As cements that can be used for the tiles of this invention, Portland cement, alumina cement, blast furnace cement, and other hydraulic cements can be used.

As the synthetic fibers, there are vinylon, polyamide, polyester, polypropylene, and other fibers, the thickness of which can be 2-40 deniers, and the length of which can be 2-30 mm.

The amount of synthetic fibers to be added is 0.3-7 parts by weight. If the amount of synthetic fibers added is too small, the effect of reinforcement will not appear, and if the amount of synthetic fibers added is too large, the distribution of the said fibers will become poor, which decreases the flow during the time of molding, so that the effect of reinforcement by the said fibers will not appear. As the synthetic fibers, vinylon fibers are especially suitable because their flow characteristics are good, giving good formability.

As inorganic filler, silica, river sand, fly ash, silica flour, bentonite, sepiolite, wollastonite, calcium carbonate, mica, and so on can be listed.

For satisfactory distribution of the inorganic filler and synthetic fibers in the cement, a water-soluble polymer is used, if necessary. When the inorganic filler and synthetic fibers can be distributed in the cement satisfactorily by themselves, the addition of the said water-soluble polymer is not necessarily required.

As the water-soluble polymer, methyl cellulose, carboxymethylcellulose, polyvinyl alcohol, hydroxyethylcellulose, polyacrylic acid, etc., are suitable. The said water-soluble polymers act to disperse aggregates and synthetic fibers such as vinylon fibers and the like uniformly throughout the cement, and can be added to prevent the formation of fiber balls made by the precipitation of aggregates or by the mutual twisting together of the said fibers, for which purpose 1 part by weight or less can be added.

Also, for the preparation of the composition from which cement tiles are obtained, the method of mixture by agitation can be used. In this method, agitation blades are not used, but instead, agitation involves the use of an apparatus to which is attached a vessel made of rubber that is pliable and is in the form of a disc-shaped agitating platform; the direction of the inclination of the agitating platform and the angle of the inclination can be continuously changed, so that the rubber vessel in which the materials to be mixed are placed is deformed and agitated, mixing them.

As the apparatus for mixture by agitation, for example, the Omuni mixer of the Chiyoda Giken Kogyo

Co. can be used.

The tile of this invention is made from, for example, 100 parts by weight of cement, 30 parts by weight of fly ash, 2 parts by weight of vinylon fibers as the synthetic fibers, and 40 parts by weight of water, which are mixed to produce a cement composition that is reinforced with fiber, and the desired shape is formed by the use of a water-removing press on the said fibre-reinforced cement composition, after which the resulting molded product is heated at 60 °C and at the relative humidity of 95% in a steam room for 24 hours for steam curing.

Figure 1 shows a tile of this invention. This tile 10 is formed in a wave shape so that when it is installed on a roof, there are alternate hills 14 and valleys 15 that follow the direction of the slope of the roof; in cross-section, the shape of each hill 14 and each valley 15 is a rectangle. When each tile 10 is installed on a roof, then, as shown in Figure 2, the eaves-side edge 12 of the tile 10 is placed on the ridge-side edge of the next tile 10.

The said tile 10 has at its edge that is placed on the eaves side at the time of installation on the roof a downward-projecting part 13 that projects downward (in Figure 1, it is shown projecting upward), which is provided continuously along each hill 14 and each valley 15. On the underside of this edge toward the eaves, there is a parallel groove 16 with a fixed distance from the said downward projecting part 13. The groove 16 is provided continuously along each hill 14 and each valley 15.

At the edge of the tile 10 that is placed toward the ridge at the time of roof, there is an upward-projecting part 17 that projects upward. The upward-projecting part 17 is provided continuously along each hill 14 and each valley 15, and is fitted with the groove 16 mentioned above along the edge of the tile toward the eaves. On the upper side of the edge of the tile toward the ridge, there is a groove 18 that is parallel at a fixed distance from the said projection 16. The groove 18 is provided continuously along each hill 14 and each valley 15, and the projection 13 that is established along the eaves side, as mentioned above, fits into the said groove 18.

On the underside of each valley 15, there is a pair of supporting members 20 and 21 that project downward. The supporting members 20 and 21 are both in the shape of a right-angled parallelepiped, and one of the supporting members, 20, is placed near the edge of the tile toward the eaves, and the other supporting member, 21, is placed near the edge of the tile toward the ridge. The position of the supporting members 20 and 21, at the time of roofing, corresponds to the main roof crosspiece that is under the building materials 19 of the roof that are under the tiles. The height of each of the supporting members 20 and 21 is set so that the supporting members 20 and 21 can touch or can have a space from the building materials 19 when the tiles 10 are installed on the top of the building materials 19 under the tiles on a roof, whereby the ridge-side edge of the tile 10 comes into contact with the building material 19; the projection 13 on the eaves-side edge of the tile fits into the groove 18 on the ridge-side edge of the next tile that is placed toward the eaves; and moreover, the projection 17 on the ridge-side edge of the tile is fit into the groove 16 on the eaves-side edge of the next tile. The lower surfaces of the supporting members 20 and 21 have the same slope as the building materials 19 placed under the tile 10. Therefore, the height of the supporting member 20 on the eaves side of the tile is greater than the height of the supporting member 21 on the ridge side. The bottom surfaces of said supporting members 20 and 21, even when they are not directly connected with the building materials 19 under the tiles, come into direct contact with the building materials 19 under the tiles if a load is placed on the upper surface of the tile 10 and the tile 10 is deformed by the load.

The tile of this kind of shape is manufactured from a cement reinforced by fibres in which there are, per 100 parts of cement by weight, 0.2-7 parts by weight of synthetic fibres as reinforcing material, and 200 parts by weight or less of an inorganic filler. The supporting members 20 and 21 are formed of the same material as the valleys and are made in one piece with the said valleys.

The supporting members 20 and 21 for the tiles 10 undergo the same compressive stress as the ridge-side edge of a tile 10 when the ridge-side edge of the tile 10 installed at the ridge side is placed on the eaves-side edge of the next tile 10. In general, cement that is reinforced with fibres has excellent strength against compression, but because the deformation of the tile 10 itself when a load is put on the said tile 10 must be minimized, the measurement y of the direction of the slope of the roof of the supporting members 20 and 21 should be 3 mm or more, and the measurement x at right angles to that direction should be 3 mm or more, with the maximum height h being preferably 60 mm or less. If both the measurement y of the supporting members 20 and 21 in the direction of the roof slope and the measurement x in the direction at right angles to that direction are smaller than 3 mm, then when the tile 10 is produced from a cement composition reinforced with fibres by use of press moulding, not every part of the mold for the molding of the supporting members 20 and 21 is filled satisfactorily with the composition, and gaps in the supporting members 20 and 21 to be molded may occur. Sufficient resistance to loading cannot be obtained with the supporting members that have these kinds of gaps. If the maximum height h of the supporting members 20 and 21 exceeds 60 mm, in the same way, not every part of the mold for the molding of the supporting stands is filled satisfactorily with the composition, and sufficient resistance to loading may not be obtained.

If the measurement x of the supporting members 20 and 21 in the direction at right angles to the direction of the slope of the roof is the same as the maximum height h or more ($x \geqq h$), then the cement composition reinforced with fibres can fill every part of the mold for the molding of the supporting stands, and the deformation of the supporting members 20 and 21 in response to the loading of the tile 10 can be minimized. Moreover, if the measurement of the maximum height h of the supporting members 20 and 21 is 2 mm or less, the deformation in response to a load on the tile 10 is large, which is not desirable.

The shapes of the supporting members 20 and 21 are not limited to right-angled parallelepipeds; as shown in Figure 3, they can be elliptical columns. In this case as well, it is preferable that the supporting members 20 and 21 fulfil the conditions for measurements described above.

In this way, when a pair of supporting members 20 and 21 are provided, one being near the eaves-side edge of the tile and the other being near the ridge-side edge thereof, if a load is placed on the tile 10, the hills 14 and the valleys 15 between the supporting members 20 and 21 undergo bending stress, but because the distance between the supporting stands is relatively short, there is no danger of breakage of the tile 10. To support this kind of bending stress, there can be one supporting member 22 that is in the shape of, for example, a right-angled parallelepiped, as shown in Figure 4, which stretches from near the eaves-side to near the ridge-side edge.

Because the space between the undersurface of the valleys 15 and the building materials under the tile is smaller than the space between the undersurface of the hills 14 and the building materials under the tile, by the provision of a supporting member on the undersurface of the said valley 15, it is possible to make the measurements of the supporting stand small, so that the increase in the weight of the entire tile becomes small and economical.

When such a tile is installed on a roof, even if the upper surface of the tile is stepped on, there is no danger of the breaking of the said tile, which increases the ease of the roofing operation.

Moreover, together with the provision of a supporting member on the undersurface of the valleys 15, if the thickness of the valleys is made 5-30% thicker than the thickness of the hills, the strength of the tile is yet more increased, and if the upper surface of the tile is stepped on by a person, there is no danger of breakage.

Next, examples and comparative examples will be explained, in order to compare the strength of the tile of this invention that have supporting members with the strength of conventional tiles.

Example 1

(1) Preparation of a composition for tiles made of cement reinforced with fibres:

Per 100 parts by weight of ordinary Portland cement, 45 parts by weight of water, 1.5 parts by weight of vinylon fibres (diameter, 18 μm; length, 4 mm) as synthetic fibres, and 50 parts by weight of fly ash as aggregate were mixed in an Omuni mixer by agitation, which gave a composition for use in the making of tiles made of cement reinforced with fibres.

(2) Formation of tiles made of cement reinforced with fibres:

The composition described in Section 1 above was molded by a water-removing press, and as shown in Figure 3, each valley was provided on its underside with a pair of supporting members 20 and 21 of elliptical shape, giving a tile 10 made of cement reinforced with fibres.

The supporting member 20 that was provided on the eaves-side edge of the tile had a measurement y in the direction of the slope of the roof of 15 mm, a measurement x in the direction at right angles to that direction of 10 mm, and a measurement h for the maximum height of 15 mm; for the supporting member 21 on the ridge-side edge, these measurements were 10 mm, 8 mm, and 7 mm, respectively.

(3) Condition of filing with material for tiles made of cement reinforced with fibres:

Some of the tiles made of cement reinforced with fibres that were formed in Section 2 above were cut cross-sectionally, and the conditions of filling with the material for the supporting members 20 and 21 were observed in cross-section. It was found that filling was satisfactory in every place.

(4) Quality of tiles made of cement reinforced with fibers:

Some of the tiles **10** made of cement reinforced with fibers that were formed in Section 2 above were cured by being placed in water for 14 days. Then they were installed on a roof, and a person bearing a weight walked on the tiles. The weight required for the tiles to break when stepped on by a person bearing a weight was measured; it was 160 kg.

Example 2

(1) Preparation of a composition for use in the making of tiles made of cement reinforced with fibers:

Per 100 parts by weight of ordinary Portland cement, 45 parts by weight of water, 2.0 parts by weight of vinylon fibers (diameter, 18 µm;, length, 6 mm), 40 parts by weight of silica powder as aggregate, and 0.1 part by weight of methyl cellulose as a water-soluble polymer were mixed in the same way as in Example 1 by agitation in an Omuni mixer, which gave a composition for use in the making of tiles made of cement reinforced with fibers.

(2) Molding of tiles made of cement reinforced with fibers:

The composition described in Section 1 above was molded by a water-removing press to form tiles made of cement reinforced with fibers in the same shape as in Example 1.

(3) Condition of filling with material for tiles made of cement reinforced with fibers:

In the same way as in Example 1, the condition of filling with material was observed, and it was found that filling of all places was satisfactory.

(4) Quality of tiles made of cement reinforced with fibers:

Some of the tiles **10** made of cement reinforced with fibers that were formed in Section 2 above were cured by being placed in water for 14 days. Then, in the same way as in Example 1, the weight required for the tiles to break when stepped on by a person bearing a weight was measured. It was 180 kg.

Example 3

(1) Preparation of a composition for use in the making of tiles made of cement reinforced with fibers:

Per 100 parts by weight of quick-hardening cement, 50 parts by weight of water, 2.5 parts by weight of vinylon fibers (diameter, 18 µm; length, 12 mm), 20 parts by weight of fly ash and 30 parts by weight of silica powder as aggregates, and 0.4 part by weight of methyl cellulose as a water-soluble polymer were mixed in the same way as in Example 1 by agitation in an Omuni mixer, which gave a composition for use in the making of tiles made of cement reinforced with fibers.

(2) Molding of tiles made of cement reinforced with fibers:

The composition described in Section 1 above was molded by a water-removing press to form tiles made of cement reinforced with fibers in the same shape as in Example 1.

(3) Condition of filling with material for tiles made of cement reinforced with fibers:

In the same way as in Example 1, the condition of filling with material was observed, and it was found that filling of all places was satisfactory.

(4) Quality of tiles made of cement reinforced with fibers:

Some of the tiles **10** made of cement reinforced with fibers that were formed in Section 2 above were cured by being placed in water for 14 days. Then, in the same way as in Example 1, the weight required for the tiles to break when stepped on by a person bearing a weight was measured. It was 230 kg.

Example 4

(1) Preparation of a composition for use in the making of tiles made of cement reinforced with fibers:

Per 100 parts by weight of ordinary Portland cement, 45 part by weight of water, 1.5 parts by weight of vinylon fibres (diameter, 18 µm, length, 4 mm), and 50 parts by weight of fly ash as aggregate were agitated in an Omuni mixer, which gave a composition for use in the making of tiles made of cement reinforced with vinylon fibres.

(2) Molding of tiles made of cement reinforced with fibres:

The composition described in Section 1 above was molded by a water-removing press to form the tiles 10 made of cement reinforced with fibres shown in Figure 4, with single supporting member 22 in the shape of right-angled parallelepipeds on the undersurfaces of valleys 15.

The measurements of the supporting member 22 were: y, the measurement in the direction of the slope of the roof, 300 mm; x, the measurement in the direction at right angles to this direction, 15 mm, and the maximum height h, 7 mm.

(3) Condition of filling with material for tiles made of cement reinforced with fibres:

Some of the tiles made of cement reinforced with fibres that were formed in Section 2 above were out cross-sectionally, and the conditions of filling with material for the supporting member 22 were observed in cross-section. It was found that filling was satisfactory in every place.

(4) Quality of tiles made of cement reinforced with fibres:

Some of the tiles 10 formed in Section 2 above were cured by being placed in water for 14 days. Then, in the same way as in Example 1, the weight required for the tiles to break when stepped on by a person bearing a weight was measured. It was 170 kg.

Example 5

(1) Preparation of a composition for use in the making of tiles made of cement reinforced with fibres:

Per 100 parts by weight of ordinary Portland cement, 45 parts by weight of water, 2.0 parts by weight of vinylon fibres (diameter, 18 µm; length, 6 mm), 40 parts by weight of silica powder as aggregate, and 0.1 part by weight of methyl cellulose as a water-soluble polymer were mixed by being agitated in an Omuni mixer, which gave a composition for use in the making of tiles made of cement reinforced with vinylon fibres.

(2) Molding of tiles made of cement reinforced with fibres:

The composition described in Section 1 above was molded by a water-removing press as in Example 4 to give tiles 10 made of cement reinforced with vinylon fibres, which tiles had a supporting member 22 in the shape of a right-angled parallelepiped.

(3) Condition of filling a with material for tiles made of cement reinforced with fibers:

Some of the tiles made in Section 2 above were cut cross-sectionally, and the conditions of filling with material for the supporting member 22 in the shape of a right-angled parallelepiped were observed. It was found that filling was satisfactory in every place.

(4) Quality of tiles made of cement reinforced with fibres:

Some of the tiles 10 formed in Section 2 above were cured by being placed in water for 14 days. Then, in the same way as in Example 4, the weight required for the tiles to break when stepped on by a person bearing a weight was measured. It was 200 kg.

Example 6

(1) Preparation of a composition for use in the making of tiles made of cement reinforced with fibres:

Per 100 parts by weight of quick-hardening cement, 50 parts by weight of water, 2.5 parts by weight of vinylon fibres (diameter, 18 µm, length, 12 mm), 20 parts by weight of fly ash and 30 parts by weight of silica powder as aggregates, and 0.4 part by weight of methyl cellulose as a water-soluble polymer were mixed by being agitated in an Omuni mixer, which gave a composition for use in the making of tiles made of cement reinforced with fibres.

(2) Molding of tiles made of cement reinforced with fibres:

The composition described in Section 1 above was molded by a water-removing press to form tiles made of cement reinforced with fibres in the same shape as in Example 4, with one supporting member 22 in the shape of a right-angled parallelepiped, giving tiles 10 made of cement reinforced with vinylon fibres.

(3) Condition of filling with material for tiles made of cement reinforced with fibres:

Some of the tiles 10 formed in Section 2 above were cut cross-sectionally, and the conditions of filling with material for the supporting member 22 were observed in cross-section. It was found that filling was satisfactory in every place.

(4) Quality of tiles made of cement reinforced with fibres:

Some of the tiles 10 formed in Section 2 above were cured by being placed in water for 14 days. Then, in the same way as in Example 4, the weight required for the tiles to break when stepped on by a person bearing a weight was measured. It was 220 kg.

Comparative Example 1

(1) Preparation of a composition for use in the making of tiles made of cement reinforced with fibres:

Per 100 parts by weight of ordinary Portland cement, 45 parts by weight of water, 1.5 parts by weight of vinylon fibers (diameter, 18 µm: length, 4 mm), and 50 parts by weight of fly ash as aggregate were mixed by being agitated in an Omuni mixer, which gave a composition for use in the making of tiles made of cement reinforced with fibers.

(2) Molding of tiles made of cement reinforced with fibers:

The composition obtained in Section 1 above was molded by a water-removing press, and tiles made of cement reinforced with fibers were formed into a wave shape in which there were absolutely no supports formed on the undersurface.

(3) Condition of filling with material for tiles made of cement reinforced with fibers:

Some of the tiles formed of cement in Section 2 above were cut cross-sectionally, and the conditions of filling with material were observed in cross-section. It was found that filling was satisfactory in every place.

(4) Quality of tiles made of cement reinforced with fibers:

Some of the tiles **10** formed in Section 2 above were cured by being placed in water for 14 days. Then, in the same way as in Example 1, the weight required for the tiles to break when stepped on by a person bearing a weight was measured. It was 60 kg.

Comparative Example 2

(1) Preparation of a composition for use in the making of tiles made of cement reinforced with fibers:

Per 100 parts by weight of ordinary Portland cement, 45 parts by weight of water, 2.0 parts by weight of vinylon fibers (diameter, 18 µm; length, 4 mm), 40 parts by weight of silica powder as aggregate, and 0.1 part by weight of methyl cellulose as a water-soluble polymer were mixed by being agitated in an Omuni mixer, which gave a composition for use in the making of tiles made of cement reinforced with fibers.

(2) Molding of tiles made of cement reinforced with fibers:

The composition described in Section 1 above was molded by a water-removing press to form tiles made of cement reinforced with fibers in the same shape as in Comparative Example 1.

(3) Condition of filling with material for tiles made of cement reinforced with fibers:

Some of the tiles formed in Section 2 above were cut cross-sectionally, and the conditions of filling with material were observed in cross-section. It was found that filling was satisfactory in every place.

(4) Quality of tiles made of cement reinforced with fibers:

Some of the tiles 10 formed in Section 2 above were cured by being placed in water for 14 days. Then, in the same way as in Example 1, the weight required for the tiles to break when stepped on by a person bearing a weight was measured. It was 90 kg.

Comparative Example 3

(1) Preparation of a composition for use in the making of tiles made of cement reinforced with fibers:

Per 100 parts by weight of ordinary Portland cement, 50 parts of water by weight, 2.5 parts by weight of vinylon fibers (diameter, 18 µm, length, 12 mm), 20 parts by weight of fly ash and 30 parts by weight of silica powder as aggregates, and 0.4 part by weight of methyl cellulose as a water-soluble polymer were mixed by being agitated in an Omuni mixer, which gave a composition for use in the making of tiles made of cement reinforced with fibers:

(2) Molding of tiles made of cement reinforced with fibers:

The composition described in Section 1 above was molded by a water-removing press to form tiles made of cement reinforced with fibers in the same shape as in Comparative Example 1.

(3) Condition of filling with material for tiles made of cement reinforced with fibers:

Some of the tiles formed in Section 2 above were cut cross-sectionally, and the conditions of filling with material were observed in cross-section. It was found that filling was satisfactory in every place.

(4) Quality of tiles made of cement reinforced with fibers:

Some of the tiles formed in Section 2 above were cured by being placed in water for 14 days. Then, in the same way as in Example 1, the weight required for the tiles to break when stepped on by a person bearing a weight was measured. It was 100 kg.

In all of the examples including the comparative examples, the shapes and the measurements of the tiles were exactly alike, except that the tiles of this invention were provided with supporting members while the tiles of the comparative examples were not provided with supporting members.

The compositions of the examples and the comparative examples given above are shown in Table 1, as are the shapes, measurements, numbers, and filling condition by the compositions of the supporting members, together with the results of the weight-bearing test.

Table 1

		Composition (parts by weight)						
		Ordinary cement	Quick-hardening cement	Water	Vinylon fibers	Fly ash	Silica powder	Methyl cellulose
Examples	1	100	-	45	1.5	50	-	-
	2	100	-	45	2.0	-	40	0.1
	3	-	100	50	2.5	20	30	0.4
	4	100	-	45	1.5	50	-	-
	5	100	-	45	2.0	-	40	0.1
	6	-	100	50	2.5	20	30	0.4
Comparative examples	1	100	-	45	1.5	50	-	-
	2	100	-	45	2.0	-	40	0.1
	3	-	100	50	2.5	20	30	0.4

Table 2

	Shape, numbers, and measurements of supporting members								Condition of filling	Weight-bearing test(kg)
	Shape	Numbers	Measurements 1 (mm)			Measurements 2 (mm)				
			x	y	h	x	y	h		
Example 1	Elliptical	6	10	15	15	8	10	7	Good	160
Example 2	Elliptical	6	10	15	15	8	10	7	Good	180
Example 3	Elliptical	6	10	15	15	8	10	7	Good	230
Example 4	Rectangular	3	15	300	7	—	—	—	Good	170
Example 5	Rectangular	3	15	300	7	—	—	—	Good	200
Example 6	Rectangular	3	15	300	7	—	—	—	Good	220
Comparative Example 1	—	—	—	—	—	—	—	—	Good	60
Comparative Example 2	—	—	—	—	—	—	—	—	Good	90
Comparative Example 3	—	—	—	—	—	—	—	—	Good	100

Note) Numbers: Numbers of supporting members per tile made of cement.
Measurements: In the case of a valley with two supporting members Measurements 1 are the measurements of the supporting member toward the ridge, and Measurements 2 are the measurements of the supporting member toward the eaves.

In this way, when the measurement y of the supporting members in the direction of the slope of the roof is ≧ 3 mm, the measurement x thereof in the direction at right angles to this direction is ≧ 3 mm, and the maximum height h thereof is ≦ 60 mm, the resistance to loading on the tile greatly increases.

Next, the method for production of the tiles made of cement reinforced with fibers of this invention will be explained. First, 1 part by weight or less of a water-soluble polymer is dissolved into 30 parts of water by weight or more, if needed, resulting in an aqueous solution containing the water-soluble polymer. To this aqueous solution (or an aqueous solution that is made while dissolving the said compound into the said water), 200 parts by weight or less of an inorganic filler is added and mixed, to which 0.3-7 parts by weight of synthetic fibers is added and mixed in by agitation. In this way, the synthetic fibers are not damaged or broken, and they can therefore be uniformly dispersed in the mixture. In these circumstances, if the mean diameter of the inorganic filler particles is more than 100 μm, it is difficult for the particles to enter in the fiber spaces between the synthetic fibers, and there is thus a tendency for the particles to aggregate, so it is preferable for the mean diameter of particles of the inorganic filler to be 100 μm or less. If the amount of synthetic fibers added is less than 0.3 part by weight, sufficient strength is not obtained at the time of molding of the tiles. If the amount of synthetic fibers added is more than 7 parts by weight, the dispersion of the fibers becomes poor, and flowability is also poor at the time of molding of the tiles.

Then, to the mixture obtained above, 100 parts by weight of cement is added and mixed in by agitation, thereby attaining the dispersion of the fine particles of cement in the spaces between the inorganic filler and the synthetic fibers.

Then, the mixture obtained above is put into a mold that can be opened and closed, and the desired shape is formed by the application of pressure. At this time, the mixture with 30 parts by weight of water or more readily undergoes the separation out of water. For this reason, it is necessary that the molding of the tile be completed before the separation out of water occurs. If the rate of pressure of the mixture in the mold is 0.3 mm/sec or more, there is no separation out of the water, and the desired shape can be made perfectly, as the entire mold is rapidly filled with the mixture.

A certain amount of water is removed from the molded product within the mold so that the molded product can keep its shape, after which it is removed from the mold, and cured and hardened by the well-known method. In this way, a tile of the desired shape is obtained.

With this kind of method for the manufacture of tiles, even if part of the cement is added during the first step, the synthetic fibers are not damaged or broken in the first step, and can be mixed in uniformly. Then, even if the remaining cement to be added is added in the second step, the dispersion of the fine particles of cement in the spaces between the inorganic filler and the synthetic fibers is readily attained. Also, even if part of the cement and part of the aggregate are added during the first step, the synthetic fibers are not damaged or broken in the first step, and uniform mixing can be attained. And, if the remaining part of the cement and the remaining part of the aggregate are added in the second step, it is still easy for the fine particles of cement to be dispersed in the spaces between the inorganic filler and the synthetic fibers.

In addition, if some of the synthetic fibers are added in the first step, and if the remaining synthetic fibers are added in the second step, the synthetic fibers are not damaged or broken, and uniform mixing can be attained. In this case, the fine particles of cement can easily be dispersed in the spaces between the inorganic filler and the synthetic fibers.

Next, the method of this invention will be explained by other examples of the manufacture of the above-mentioned tiles made of cement reinforced with fibers.

Example 7

To 30 parts by weight of water, 0.1 part by weight of methyl cellulose and 0.3 part by weight of vinylon fibers (fiber length, 6 mm; thickness, 5 deniers) as synthetic fibers were added, and these were mixed by being agitated in an Omuni mixer with a 5-ℓ capacity manufactured by Chiyoda Giken Kogyo Co. To this mixture, 100 parts by weight of cement was added, and mixing by agitation was done again. This mixture was molded by a water-removing press at the surface pressure of 65 kg/cm^2 and the rate of pressure of 3 mm/sec resulting in a tile. The tile was cured at 60°C and a relative humidity of 90% for one week. The condition of dispersal of the fibers before molding, the surface of the cured tile, and the strength against being bent were observed. These results are shown in Table 3, wherein the evaluation of the dispersion of the vinylon fibers was graded as follows: O means that the fibers were completely dispersed, with absolutely no agglutination of fibers, Δ means that dispersion was fairly complete but that some slight agglutination was observed, and X means that agglutination was marked.

Also, with the surface of the tiles, O means that the surface was glossy, with fibers being uniformly dispersed, Δ means that there was uneveness of the surface, with some fibers not being uniformly dispersed, and X means that the surface was uneven, and the fibers were dispersed without uniformity. The strength against being bent was measured according to the methods of JIS 1048U.

Example 8

To 40 parts by weight of water, 0.2 part by weight of methyl cellulose, 30 parts by weight of fly ash (mean particle diameter, 100 µm), and 2.0 parts by weight of vinylon fibers were added, and these were mixed by agitation, after which 100 parts by weight of cement was added to this mixture, and mixed by agitation, with other steps being carried out as in Example 1. The results are shown in Table 3.

Example 9

A test was done of the same way as in Example 8 except that instead of the fly ash, silica (mean diameter, 100 µm) was used. The results are shown in Table 3.

Example 10

A test was done of the same way as in Example 8 except that instead of the fly ash, slag (mean diameter, 100 µm) was used. The results are shown in Table 3.

Example 11

A test was done of the same way as in Example 8 except that instead of the fly ash, silica flour (mean diameter, 100 µm) was used. The results are shown in Table 3.

Example 12

A test was done of the same way as in Example 8 except that instead of the fly ash, bentonite (mean diameter, 100 µm) was used. The results are shown in Table 3.

Example 13

A test was done of the same way as in Example 8 except that instead of the methyl cellulose, polyvinyl alcohol was used. The results are shown in Table 3.

Example 14

A test was done of the same way as in Example 8 except that instead of the methyl cellulose, hydroxyethylcellulose was used. The results are shown in Table 3.

Example 15

A test was done of the same way as in Example 8 except that instead of there being 0.2 part by weight of methyl cellulose, there were 2.0 parts by weight. The results are shown in Table 3.

Example 16

A test was done in the same way as in Example 7 except that per 150 parts by weight of water, 1.0 part by weight of methyl cellulose, 200 parts by weight of fly ash (mean particle diameter, 100 µm), and 7.0 parts by weight of vinylon fiber were added, and the whole was mixed by agitation. The results are shown in Table 3.

Example 17

A test was done in the same way as in Example 8 except that the rate of pressure was 5 mm/second. The results are shown in Table 3.

Example 18

A test was done in the same way as in Example 8 except that the rate of pressure was 7.5 mm/second. The results are shown in Table 3.

Example 19

A test was done in the same way as in Example 7 except that per 30 parts of water, methyl cellulose was not added, but 30 parts by weight of fly ash, 10 parts by weight of cement, and 0.5 part by weight of vinylon fibers were added and mixed by agitation; to this mixture, 90 parts by weight of the cement was added, and mixing by agitation was done once more. The results are shown in Table 3.

Example 20

A test was done in the same way as in Example 7 except that per 40 parts of water, methyl cellulose was not added, but 20 parts by weight of fly ash (mean particle diameter, 100 µm), 10 parts by weight of cement, and 2.2 parts by weight of vinylon fibers were added and mixed by agitation; to this mixture, 20 parts by weight of fly ash (mean particle diameter, 100 µm) and 90 parts by weight of cement were added, and mixing by agitation was done once more. The results are shown in Table 3.

Example 21

A test was done in the same way as in Example 7 except that per 40 parts of water, methyl cellulose was not added, but 30 parts by weight of silica (mean particle diameter, 100 µm), 10 parts by weight of cement, and I.2 parts by weight of vinylon fibers were added and mixed by agitation; to this mixture, 1.0 part by weight of vinylon fibers and 100 parts by weight of cement were added, and mixing by agitation was done once more. The results are shown in Table 3.

Comparative Example 4

A test was done in the same way as in Example 7 except that the amount of vinylon fibers used was 0.2 part by weight. The results are shown in Table 3.

Comparative Example 5

A test was done in the same way as in Example 7 except that per 150 parts of water by weight, 0.2 part by weight of methyl cellulose and 200 parts by weight of fly ash (mean particle diameter, 100 µm) were added and mixing was done by agitation. The results are shown in Table 3.

Comparative Example 6

A test was done in the same way as in Example 7 except that per 150 parts by weight of water, 0.2 part by weight of methyl cellulose, 220 parts by weight of fly ash (mean particle diameter, 100 µm), and 2.0 parts by weight of vinylon fibers were added and mixed by agitation; to this mixture, 100 parts by weight of cement was added and mixing by agitation was done once more. The results are shown in Table 3.

Comparative Example 7

A test was done in the same way as in Example 8 except that instead of mixing being done by agitation, a mixer with blades was used. The results are shown in Table 3.

It is seen from Table 3 that according to the method of this invention, tiles with superior strength against being bent are obtained, and that the said tiles are not readily broken when a weight is put on their upper surfaces, so the said tiles ease the operation of roofing when the tiles are being installed on a roof.

Table 3-1

		Example 7	Example 8	Example 9	Example 10	Example 11	Example 12	Example 13	Example 14	Example 15	Example 16
	Cement	100	100	100	100	100	100	100	100	100	100
	Vinylon (6 mm long, 5 denier thick)	0.3	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	7.0
Inorganic filler	Fly ash (mean particle diameter 100 µm)		30					30	30	30	200
	Silica (mean particle diameter 100 µm)			30							
	Slag (mean particle diameter 100µm)				30						
	Silica flour (mean particle diameter 100 µm)					30					
	Bentonite (mean particle diameter 100 µm)						30				
Water-soluble polymer	Methyl cellulose	0.1	0.2	0.2	0.2	0.2	0.2			2.0	1.0
	Polyvinyl alcohol							0.2			
	Hydroxy ethyl cellulose								0.2		
Water		30	40	40	40	40	40	40	40	40	150
Mixer		Omuni mixer	Omuni mixer	Omuni mixer	Omuni mixer	Omuni mixer	Omuni mixer	Omuni mixer	Omuni mixer	Omuni mixer	Omuni mixer
Dispersion of vinylon fibers		○	○	○	○	○	○	○	○	○	○
Surface of molded tile		○	○	○	○	○	○	○	○	○	○
Rate of water-removing press (mm/sec.)		3	3	3	3	3	3	3	3	3	3
Strength against bending		162	275	310	301	295	290	265	270	300	195

Table 3-2

		Example 17	Example 18	Example 19	Example 20	Example 21	Comparative 4 Exam.	Comparative 5 Exam.	Comparative 6 Exam.	Comparative 7 Exam.
	Cement	100	100	100	100	100	100	100	100	100
	Vinylon (6 mm long, 5 denier thick)	2.0	2.0	0.5	2.2	2.2	0.2	7.5	2.0	2.0
Inorganic filler	Fly ash (mean particle diameter 100 µm)	30	30	30	30			200	220	30
	Silica (mean particle diameter 100 µm)					30				
	Slag (mean particle diameter 100 µm)									
	Silica flour (mean particle diameter 100 µm)									
	Bentonite (mean particle diameter 100 µm)									
Water-soluble polymer	Methyl cellulose	0.2	0.2				0.1	0.2	0.2	0.2
	Polyvinyl alcohol									
	Hydroxy ethyl cellulose									
Water		40	40	30	40	40	30	150	150	40
Mixer		Omuni mixer	Omuni mixer	Omuni mixer	Omuni mixer	Omuni mixer	Omuni mixer	Omuni mixer	Omuni mixer	Mixer with blades
Dispersion of vinylon fibers		○	○	○	○	○	○	×	○	×
Surface of molded tile		○	○	○	○	○	○	×	○	×
Rate of water-removing press (mm/sec.)		5	7.5	3	3	3	3	3	3	3
Strength against bending		285	286	151	255	260	120	125	140	135

Claims

1. A tile (10) for use as roofing material on an essentially planar, sloping roof, comprising fibre reinforced cement having from 0.3 to 7 parts by weight of synthetic fibres and up to 200 parts by weight of an inorganic filler per 100 parts by weight of cement, the tile being shaped in a wave-like pattern having on its undersurface elevations (14) and depressions (15) in one direction; and

at least one supporting member (20, 21) having a height h, positioned on the undersurface of each depression (15), said supporting member being adapted to bear weight, wherein the surface of the or each said supporting member has a slope which is the same as the slope of said roof and the height of the portion of said supporting member towards a lower portion of the roof is greater than the height of the portion of said supporting member towards an upper portion of the roof, the or each said supporting member having a length y parallel to the slope of said roof, a length x along the roof at right angles to the slope, and a maximum height h, such that y ≧ 3 mm x ≧ 3 mm and h ≦ 60 mm.

2. A method for the manufacture of a tile in accordance with Claim 1, comprising mixing 200 parts by weight of an inorganic filler and up to 100 parts by weight of cement with an aqueous solution that has been or is being prepared by dissolving 1 part by weight or less of a water-soluble high polymer, if needed, into 30 parts by weight or more of water; mixing by agitation the resulting mixture with 0.3-7 parts by weight of synthetic fibres; mixing by agitation the resulting mixture with 100 parts by weight of cement or the remaining cement; putting the mixture into a mold that can be opened and closed; and then molding the mixture at a rate of pressure of 0.3 mm/sec or more, resulting in the desired tile reinforced with fibres.

Revendications

1. Une tuile (10) à utiliser comme matériau de toiture sur un toit en pente, essentiellement plan, comprenant un ciment armé de fibres comportant de 0,3 à 7 parties en poids de fibres synthétiques et jusqu'à 200 parties en poids d'une charge inorganique pour 100 parties en poids de ciment, la tuile étant formée selon une configuration en forme d'onde comportant sur sa surface inférieure des élévations (14) et des dépressions (15) dans une direction; et

au moins un élément de support (20, 21), d'une hauteur h, positionné sur la surface inférieure de chaque dépression (15), ledit élément de support étant apte à porter un poids, dans lequel la surface de l'élément de support ou de chacun d'entre eux présente une pente qui est la même que la pente dudit toit et la hauteur de la partie dudit élément de support vers une partie inférieure du toit est supérieure à la hauteur de la partie dudit élément de support vers une partie supérieure du toit, l'élément de support ou chacun d'entre eux étant d'une longueur y parallèle à la pente dudit toit, d'une longueur x le long du toit selon un angle droit avec la pente, et d'une hauteur maximale h telles que y ≧ 3 mm x ≧ 3 mm et h ≦ 60 mm.

2. Un procédé de fabrication d'une tuile selon la revendication 1, comprenant les étapes consistant à: mélanger 200 parties en poids d'une charge inorganique et jusqu'à 100 parties en poids de ciment avec une solution aqueuse qui a été préparée ou est en cours de préparation en dissolvant 1 partie en poids ou moins d'un polymère élevé soluble dans l'eau, si nécessaire, dans 30 parties en poids ou davantage d'eau; mélanger par agitation le mélange résultant avec 0,3 à 7 parties en poids de fibres synthétiques; mélanger par agitation le mélange résultant avec 100 parties en poids de ciment ou le ciment restant; mettre le mélange dans un moule qui peut être ouvert et fermé; et mouler ensuite le mélange à une allure d'application de pression de 0,3 mm/sec ou davantage, en produisant la tuile souhaitée armée de fibres.

Patentansprüche

1. Ziegel (10) zur Verwendung als Dachmaterial auf einem im wesentlichen ebenen Schrägdach, der faserverstärkten Zement mit 0,3 bis 7 Gewichtsteilen synthetischer Fasern und bis zu 200 Gewichtsteilen eines anorganischen Füllstoffs pro 100 Gewichtsteile Zement umfaßt, wobei der Ziegel in einem wellenartigen Muster geformt ist und an seiner Unterseite in einer Richtung verlaufende Erhebungen (14) und Vertiefungen (15) aufweist, und

mindestens ein auf der Unterseite jeder Vertiefung (15) angeordnetes, zur Aufnahme von Last ausgebildetes Stützelement (20, 21) mit einer Höhe h besitzt, wobei die Oberfläche des oder jedes der Stützelemente eine Schräge aufweist, welche die gleiche wie die Schräge des Dachs ist, die Höhe des Teils des Stützelements, der in Richtung eines niedrigeren Teils des Dachs weist, größer ist als die Höhe des Teils des Stützelements, der in Richtung eines höheren Teils des Dachs weist, und das oder jedes der Stützelemente eine solche parallel zur Schräge des Daches verlaufende Länge y, im rechten Winkel zur Schräge am Dach entlang verlaufende Länge x und maximale Höhe h aufweist, daß y ≧ 3 mm, x ≧ 3 mm und h ≦ 60 mm sind.

2. Verfahren zur Herstellung eines Ziegels gemäß Anspruch 1, bei dem 200 Gewichtsteile eines anorganischen Füllstoffs und bis zu 100 Gewichtsteile Zement mit einer wäßrigen Lösung gemischt werden, die hergestellt worden ist oder wird, indem 1 Gewichtsteil oder weniger eines wasserlöslichen Hochpolymeren, falls nötig, in 30 Gewichtsteilen oder mehr Wasser gelöst werden, die erhaltene Mischung mit 0,3 bis 7 Gewichtsteilen synthetischer Fasern unter Rühren gemischt wird, die erhaltene Mischung mit 100 Gewichtsteilen Zement oder dem restlichen Zement unter Rühren gemischt wird, die Mischung in eine Form gegeben wird, die geöffnet und geschlossen werden kann, und dann mit einer Drückgeschwindigkeit von 0,3 mm/s oder mehr geformt wird, wobei sich der gewünschte mit Fasern verstärkte Ziegel ergibt.

Fig. 1

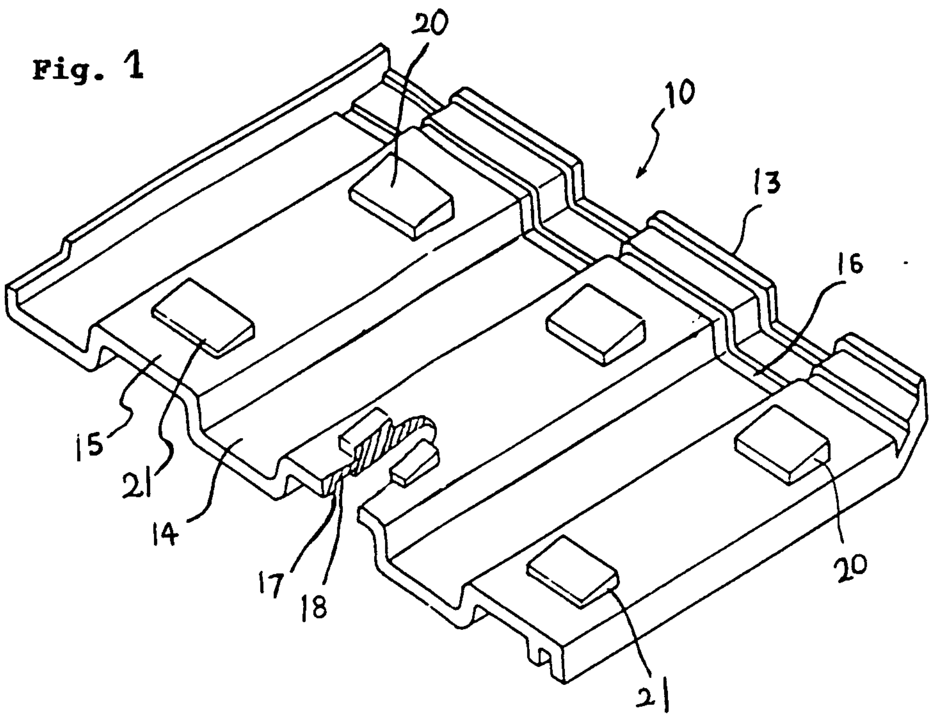
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Fig. 2

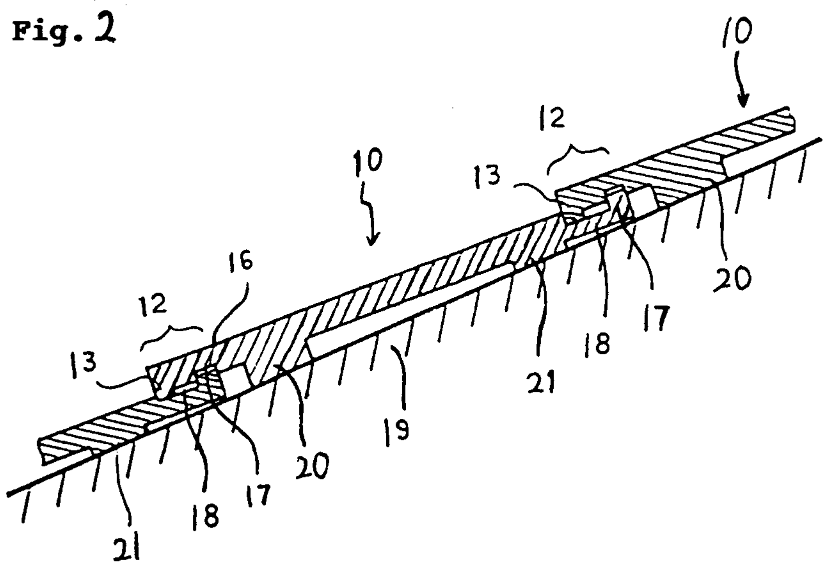
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Fig. 3

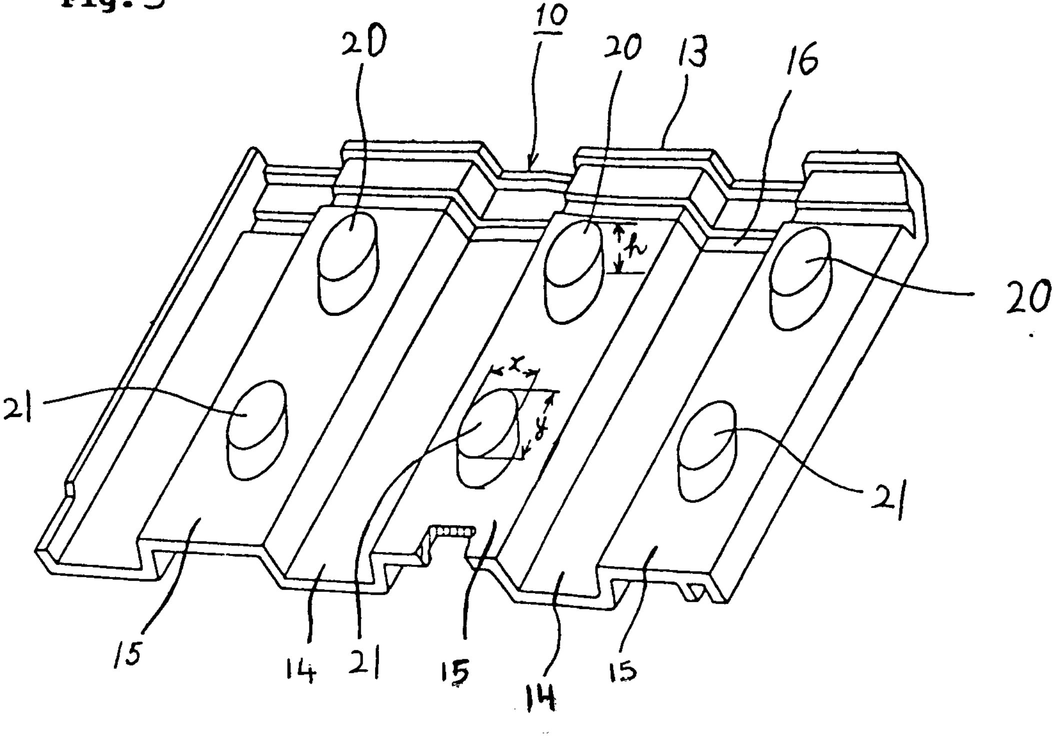
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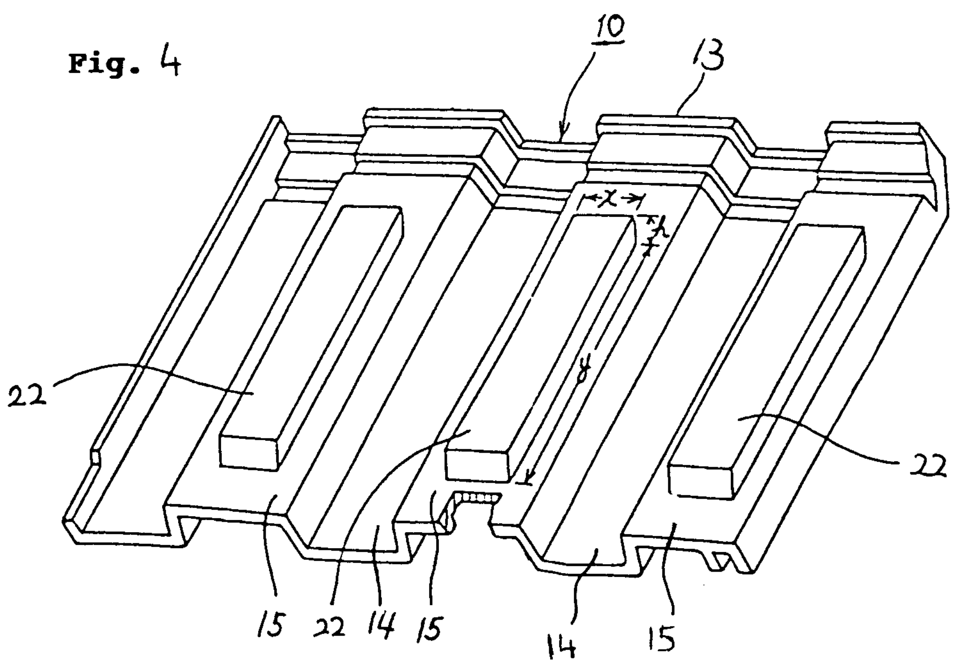
Fig. 4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