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A water-impermeable sealing mat

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Fig. 1

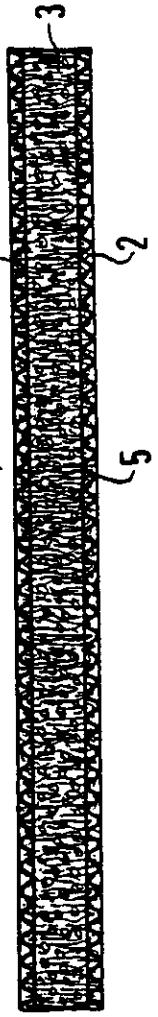
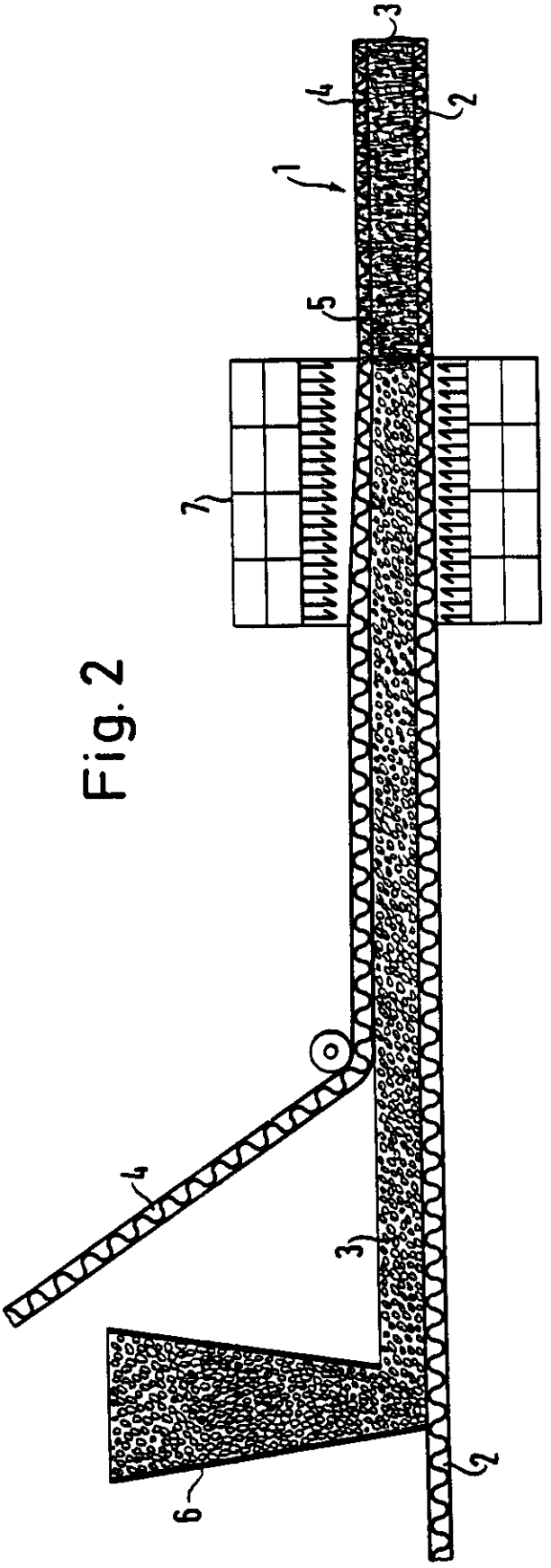


Fig. 2



2202185

A WATER-IMPERMEABLE SEALING MAT

The present invention relates to a water-impermeable sealing mat suited for use preferably in hydraulic engineering and waste disposal engineering which substantially consists of a substrate layer, an interlayer of swellable clay, and a cover layer, and a method for producing same.

Such sealing mats are known from European Patent No. O 059 625 where a flexible substrate layer supports a bentonite interlayer on which a cover layer may be provided. All three layers, i.e. the substrate layer, which may be a non-woven textile material, the bentonite interlayer, and the cover layer which may be a mat not defined in more detail, are bonded together by an adhesive. The production of such a product is disadvantageous not only due to the use of an adhesive but especially also on account of the circumstance that both the substrate layer and the cover layer are interconnected only by way of the bentonite interlayer. Moreover, such sealing mats lose their flexibility owing to the use of adhesive solidifying the individual layers, which becomes a nuisance especially in case of underground deformation of earth constructions. Moreover, said prior art sealing mats have the disadvantage that the bentonite interlayer sandwiched therebetween can freely expand in all three dimensions when moistened, which frequently results in cracks in the bentonite interlayer which, in turn, renders the mats water-permeable.

Therefore, it is the object of the present invention to provide an absolutely water-tight mat in a manner that obviates the use of an adhesive.

This object is realized according to the present invention in that (a) the substrate layer and/or the cover layer consist(s) of a non-woven textile material, and the layer optionally not consisting of non-woven textile material consists of a woven or knitted fabric, and (b) all three layers are bonded together by needling.

Preferably both the substrate layer and the cover layer consist of non-woven textile material. However, also a structure may be desirable in which the substrate layer consists of non-woven textile fabric and the cover layer consists of woven or knitted textile fabric, or the cover layer consists of non-woven textile fabric and the substrate layer consists of woven or knitted fabric.

The preferably continuously operating method claimed as invention is carried out such that first the interlayer of dry, swellable clay is applied onto the substrate layer and thereon the cover layer is placed, whereafter all three layers are needled in a needle loom.

The non-woven textile fabrics employed preferably consists of high grade synthetic resin fibers, especially of polyehtylene, polypropylene, polyester and polyacrylic and/or polyamide fibers. For use in waste disposal engineering non-woven textile materials made from high density polyethylene (HDPE) are especially preferred.

Such non-woven fabrics are absolutely resistant to rotting (resistant to all substances occuring in bodies of water and in soil) and thus warrant evidently an

extremely long service life. Their extraordinarily high tear strength provides substantial resistance to mechanical wear. They are highly stable toward ultraviolet radiation and have a high specific gravity (significant advantage in case of underwater installation).

The non-woven textile materials employed according to the invention preferably have the mechanically consolidated structure of staple fiber batts. The crimped fibers are assembled to form a sheet structure with a maze of interstices. This ideally imitates the structure of the soil. The structure of the non-woven textile materials can be made coarser or finer, depending on the nature of the soil, so that optimum adaption to the type of soil at the site of use is warranted. The mechanical consolidation ensures a high friction coefficient between the soil and the non-woven textile material and the covering material. Instead of the non-woven textile fabrics consolidated mechanically by needling also non-woven textile fabrics can be employed which were consolidated mechanically by stitchbonding or by swirling, or which were chemically bonded.

The non-woven textile materials include, for example, materials listed in the following Tables 1 and 2.

Table 1

Type	D 455 R	D 615 R	D 815 R
Fiber Raw Material	100 % HDPE	100 % HDPE	100 % HDPE
Sheet Weight (g/m^2)	450	600	800
Thickness (mm) at 2 kN/m^2	4,3	4,4	4,7
Maximum Tensile Strength DIN 53 857 (Strip Drawing Test) (Length/Width) (daN/10 cm)	54/66	80/102	84/120
Elongation at Break DIN 53 857 (Length/Width) (%)	230/193	247/198	300/200
Deformation at Indenter Piercing Force DIN 54 307 (%)	123	116	110
Interstitial Width (mm)	0,13	0,09	0,08
Water Permeability (m/s) at 2 kN/m^2 without Soil Contact	$7,7 \cdot 10^{-3}$	$4,6 \cdot 10^{-3}$	$4,5 \cdot 10^{-3}$
Cone Dropping Test (Piercing Test) Hole Diameter (mm)	15	9	8
Standard Width (m) / Length (m)	4,40/100	4,40 / 50	4,40 / 50

Table 2

Double Layer Composite Batt

		Filter Layer		Drain Layer
		mechanically consolidated non-woven sheet material consisting of PES staple fibers		mechanically consolidated and chemically bonded non-woven sheet material of coarse PP fibers
Sheet Weight	g/m^2	250	Total 1000	750
Thickness (DIN 53855) Load Bearing Limit	mm	3,0	14	11,0
Maximum Tensile Strength DIN 53 857	kN/m	7		
Elongation at Break	%	45		
Effective Interstitial Width	mm	0,09 corresponds to pore width of medium sand ($d_{50} \sim 0{,}4$ mm)		1,34 corresponds to pore width of medium gravel ($d_{50} \sim 6$ mm)
Water Permeability (k-value) vertical	kN/m	$1{,}8 \cdot 10^{-2}$ at 2 kN/m^2 to $1{,}8 \cdot 10^{-3}$ at 200 kN/m^2 weight bearing capacity (k values determine flow to drain layer; correspond approximately to the values for coarse sand)		
Water Permeability, planar (Drain Effect)		Information about dimensioning available upon request		

The interlayer of swellable clay preferably consists of bentonites. Bentonites are clays having an appreciably to high content of smectite (montmorillonite) which decisively determines the properties (high swellability , good water absorption capacity, high plasticity). In order to obtain from an alkaline earth metal bentonite having low swellability in water a highly swellable active bentonite the alkaline earth metal ions of the bentonites are replaced by alkali metal ions, preferably sodium ions. Therefore, sodium bentonite exhibiting highly increased plasticity, viscosity, thixotropy and water absorption is preferred for use according to the present invention.

In the intermediate layer the bentonites can be present in powder and/or granulated form. If they are granular, the particles can have a particle size in excess of 2.5 mm. Of course, they may also be smaller.

Moreover, the water permeability of the sealing mats according to the invention can also be reduced by first applying, in the manufacture thereof, a powdery bentonite on the substrate layer and distributing it by vibration, and only thereafter applying the granular bentonite. Instead of the distribution of the powdery bentonite by vibration into the substrate layer the substrate layer can also be first impregnated with an aqueous bentonite suspension, or an aqueous bentonite paste can be rolled onto the substrate layer, whereafter - optionally after previous drying - the granular bentonite is applied. If desired, the cover layer can be treated like the substrate layer in the manner described above before being placed on the interlayer.

For some applications the substrate or cover layer pretreated in the described way may even be used per se as sealing mat.

Depending on the particular application, the thickness of the bentonite or other swellable clay interlayer preferably ranges from 0.5 to 10.0 mm. However, it may also be smaller or greater, which depends, inter alia, also on the circumstance whether or not the substrate and/or cover layer was pretreated with ultrafinely divided bentonites, as described above.

Preferably, the substrate and cover layers have a thickness of from 1 to 10 mm.

Needling of the three layers on the needle loom provides the desired strong mechanical coherence of the three layers of the sealing mat according to the invention, and at the same time obviates the adhesive used in the prior art. In addition thereto, further essential advantages are thereby attained. Even without the previous pretreatment of substrate and/or cover layer described above, needling at the inner surface facing the bentonite interlayer and the zones of the non-woven textile materials disposed therebeneath effects intensive mixing of fibers and bentonite. Moreover, as the bentonite swells when moistened, the strong needling bond provides a pressure counteracting the swelling pressure which, in combination with the above described intensive mixing of fibers and bentonite, warrants water impermeability of the sealing mats of the invention. Furthermore, needling ensures flexibility of the sealing mats to a degree that comes close to the good pliability properties of mechanically consolidated non-woven textile materials.

The water impermeable sealing mats of the invention are used especially in hydraulic engineering and waste disposal engineering.

The present invention will now be explained with reference to Figs. 1 and 2 and the following examples, without being restricted thereto.

Fig. 1 shows in cross section a part of the sealing mat 1 according to the invention;

Fig. 2 shows schematically a longitudinal section along the continuous production line resulting in the water impermeable sealing mat 1 according to the invention.

From a supply bin 6 the bentonite is applied as bentonite interlayer 3 onto the substrate layer 2 (non-woven textile material) wound off a supply reel, not shown. Thereafter the cover layer 4 (also a non-woven textile material) likewise wound off a supply reel, not shown, is placed on the bentonite interlayer 3. The thus obtained sheet structure composed of three layers is passed through a needle loom 7 in which all three layers are needled in a manner known per se. Depending on the thickness of the bentonite interlayer 3 the needled sheet structure representing the water impermeable sealing mat 1 is wound on reels or is cut into the particular lengths desired for the contemplated use.

After having been laid out on large areas at the site of use the thus manufactured sealing mats can be fused together or sewn together along the abutting rims to allow also along the abutting edges the bentonite interlayer

to merge and form a coherent water-impermeable interlayer upon swelling. Water-tight overlapping is also achieved by inserting between the overlapping regions a bentonite bead and then compressing said regions.

Example 1

To make a sealing mat for hydraulic engineering a non-woven textile material 1004 R is used as supporting layer 2, and a non-woven textile material 201-3 is used as cover layer 4 with the characteristics listed hereafter:

Type	1004 R	201-3
Fiber Raw Material	PES/PP	PES
Sheet Weight (g/m^2)	814	225
Thickness (mm) at 2 kN/m^2	6,6	2,8
Maximum Tensile Strength DIN 53 857 (Strip Drawing Test) (Length/Width) (daN/10 cm)	149/341	95/14o
Elongation at Break DIN 53 857 (Length/Width) (%)	111/49	65/60
Deformation at Indenter Piercing force DIN 54 307 (%)	--	--
Interstitial Width (mm)	0,08	0,09
Water Permeability (m/s) without Soil Contact at 2 kN/m^2	$4,9\text{-}10^{-3}$	$6,0\text{-}10^{-5}$
Cone Dropping Test (Piercing Test) Hole Diameter (mm)	--	16
Standard Width (m)/ Length (m)	4,80 x 100	4,75 x 100

The non-woven material, Type 1004 R, is a hydraulic engineering mat that has been in use for years and proved to be serviceable. The production width is usually 4.80 m. It constitutes a composite material composed of two layers of non-woven textile fabric, namely a filter layer of polyester (PES; about 70 % of the total weight) and a coarse fiber layer of polypropylene fibers (about 30 % of the total weight). The fibers are consolidated purely mechanically by needling. This two-layer composite non-woven material serving as substrate layer 2 has a sheet thickness greater than 6.0 mm.

The non-woven textile fabric 201-3 is a single-layer material made up of 100 % polyester fibers. As will be seen from the preceding table, the sheet weigth is about 225 g/m^2 and the sheet thickness is about 2.8 mm. The production width normally is also 4.80 m.

The bentonite interlayer 4 consists of an activated sodium bentonite applied in an amount of about 2500 g/m^2, which corresponds to a layer thickness of about 1 to 2 mm.

The mat is manufactured in the following way:

A roll of non-woven textile material 1004 R is wound off a reel and is guided to a needling loom 7 as substrate layer 2. While the web is unwound a weighed quantity of dry bentonite having a particle size of a few millimeters is applied onto the substrate layer 2. At the same time a roll of non-woven textile material 201-3 is fed via a further reel to the bentonite interlayer 3 as cover layer 4. These three layers then pass

through the needle loom 7 where they are mechanically firmly bonded together.

The needle loom 7 has one or more needle boards. Each needle board is provided with thousands of needles. The needle boards are moved rapidly up and down (up to about 1000 strokes per minute). The needles provided with barbs pierce the layers of non-woven fabric material 2, 4 and the bentonite interlayer 3, and the barbs take care that the individual fibers are interlaced to form a firm structure. Since the needling operation is not free of vibrations, a portion of the applied bentonite enters into the fiber batts, especially into the pores of the coarse fiber batt of the substrate layer 2 facing the bentonite interlayer 3.

The sealing mat obtained downstream of the needling loom 7 is wound on a reel and is transported to the site of use where it performs the function of a water impermeable sealing mat after having been laid out and moistened.

Example 2

For the manufacture of a water impermeable sealing mat for use in waste disposal engineering the non-woven textile materials specified in Table 1 consisting of high density polyethylene fibers are used for the substrate 2 and for the cover layer 4.
Substrate layer 2 and cover layer 4 may be the same or different.

CLAIMS

1. A water-impermeable sealing mat comprising a substrate layer, an interlayer of swellable clay, and a cover layer, in which:

at least one of the substrate layer and the cover layer consists of non-woven textile material; the other one, if any, of the substrate layer and the cover layer consisting of woven or knitted fabric; and in which all three layers are bonded together by needling.

2. A sealing mat according to claim 1, in which the non-woven textile materials are mechanically consolidated non-woven staple fiber mats.

3. A sealing mat according to claim 1 or 2, in which the non-woven textile materials consist of non-rotting synthetic resin fibers.

4. A sealing mat according to any preceding claim in which the non-woven textile material is of polyolefin fibres.

5. A sealing mat according to any preceding claim in which the non-woven textile material is of high density polyethyle(ne) (HDPE).

6. A sealing mat according to any preceding claim, in which the interlayer consists of a bentonite.

7. A sealing mat according to any preceding claim in which the interlayer consists of an alkali metal activated bentonite.

8. A sealing mat according to any preceding claim in which the interlayer consists of sodium activated bentonite.

9. A sealing mat according to any preceding claim, in which the bentonite employed is powdered or granular.

10. A sealing mat according to any preceding claim, in which a granulated bentonite having a particle size of at least 2.5 mm is employed.

11. A sealing mat according to any preceding claim, in which the substrate layer has a thickness of 1 to 10 mm, the swellable clay interlayer has a thickness of 0.5 to 10 mm, and the cover layer has a thickness of 1 to 10 mm.

12. A method for continuously producing sealing mats according to any of claims 1 to 11, comprising applying on the substrate layer the dry, powdered to granular, swellable clay, placing the cover layer thereon, and passing the resulting triple layer material through a needle loom in order to needle the substrate layer and cover layer together.

13. A method according to claim 12, wherein a dry, activated sodium bentonite having an average particle size of at least 2.5 mm is applied onto the substrate layer.

14. A method according to claim 12 or 13, wherein the substrate layer and/or the cover layer is impregnated with a bentonite suspension, or very finely divided bentonite is applied onto and said bentonite is optionally vibrated into said layers, prior to joining said layers to said interlayer.

15. A water-impermeable sealing mat substantially as hereinbefore described with reference to the accompanying drawings.

16. A method substantially as herein before described with reference to the accompanying drawings.

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