(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 658 231 B2

(12) NEW EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the opposition decision:
03.09.2003 Bulletin 2003/36

(45) Mention of the grant of the patent:
12.01.2000 Bulletin 2000/02

(21) Application number: **94908846.2**

(22) Date of filing: **24.08.1993**

(51) Int Cl.[7]: **E02D 31/00**

(86) International application number:
PCT/GB93/01807

(87) International publication number:
WO 94/005863 (17.03.1994 Gazette 1994/07)

(54) WATER PROOFING LINER

WASSERABDICHTUNGSBAHN

REVETEMENT D'ETANCHEITE

(84) Designated Contracting States:
BE DE DK FR GB IE NL

(30) Priority: **26.08.1992 GB 9218178**
10.05.1993 GB 9309586

(43) Date of publication of application:
21.06.1995 Bulletin 1995/25

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Description

[0001] This invention relates to a waterproofing material suitable for waterproofing ponds, lakes, lagoons or comparable sites whereby water is retained, or wherein waste is deposited and the ground beneath has to be protected against leakage of aqueous or other liquid. The material can also be used in relation to water proofing structures, covering contaminated land to prevent flow of water into such contaminated land and lining trenches which separate contaminated areas from clear areas. The material can also be used as roofing material on flat or sloping roofs. Several materials have been proposed in the past which include a layer of swellable smectite such as montmorillonite and/or saponite incorporated'within the material to act as the sealing agent. The montmorillonite has been carried by a support layer or base which has been provided in various ways. A support layer acts as protection but also gives additional strength within the material.

[0002] European patent number 59625 (CLEM) describes a waterproofing material which is a laminate comprising a fabric base, particles of montmorillonite adhered to the base and a scrim adhered over the montmorillonite particles to retain them on the base.

[0003] In European patent application 246 311 (McGROARTY) a lower sheet comprises a base and montmorillonite and an overlaid sheet comprises a base and montmorillonite. The bases are of solid plastics non-venting and impermeable material so one of the bases forms a non-water transmissive layer between the two layers of montmorillonite, thus giving a very good seal.

[0004] However, the McGROARTY construction does have several practical difficulties. Firstly, the bases are made from a thick, impervious and essentially solid plastics material, described in the specification as HDPE.

[0005] Secondly, the granules of montmorillonite are adhered not only to the base but also to each other.

[0006] Waterproofing materials of this kind are usually supplied in rolls and have to be unrolled and placed to lie in the pond, lagoon or storage space. With the bases made from high density polyethylene the MCGROARTY material is less flexible than when using a fabric (non-woven or woven) for the base. This means that the product is much more difficult to handle and the montmorillonite is likely to crack during folding and unfolding. Further, because of the nature of an HDPE plastic sheet the adhering of the montmorillonite to its surface is not easy. Quite large quantities of very strong glue have to be used.

[0007] A further waterproofing barrier material is disclosed in British patent number 2 202 185 (NAUE) in which a layer of montmorillonite is sandwiched between a pair of layers of non-woven textile. material and the two layers are united by needling, the needles passing through the layer of montmorillonite and uniting all three layers. Again, because the montmorillonite is not adhered to the layers, as the material is unfolded, folded and manhandled during installation, the montmorillonite can move relative to the two layers leaving voids and/or more permeable thinner areas in the montmorillonite layer.

[0008] There is a further disadvantage in that all these earlier materials tend to use particulate montmorillonite which may be from 2 - 5, usually about 3mm in size. Although finer material can be poured to fill gaps between the larger granules, such granules tend to make up the bulk of the montmorillonite layer in the waterproofing material. As the water proofing material is only relatively thin, for example containing only perhaps one or two layers of montmorillonite granules, problems can arise in connection with foreign bodies in the montmorillonite used. In its natural state montmorillonite is found alongside shale and other impurities. Whilst the montmorillonite can be quite highly purified, it is not unusual for a low percentage of shale particles to remain in the final sized and graded montmorillonite. An unfortunate result of the use of relatively large granules of montmorillonite in the layer is that granules of impurities can also become incorporated in the material. The chemical nature of shale and some other impurities have the effect that not only are they not montmorillonite (and therefore do not swell upon contact with water), but, when wetted, act as to inhibit swelling in adjacent montmorillonite granules. Thus, a single granule of shale in a layer of waterproofing material can form a small area (perhaps 10mm in diameter) which does not swell upon being contacted with water. Small such areas are generally water impermeable, but medium and larger such areas allow water to pass through the sheet. When water pressure is high this flow can cause significant wash out of adjacent montmorillonite leading to failure of the sealing system. Although the percentage of impurities is small, and although the failure rate is small, when a large area is sealed using sheet material incorporating such impurities it needs only a single leak for the whole system to have failed. A pond or lagoon which has a single leak is no pond or lagoon at all!

[0009] Particulate montmorillonite has also been mixed with various organic components to form a thick putty (see US Patent Number 4 534 925). Typical components are polypropene and polybutene. This material has been extruded in the form of rods and sheets, usually being stored between layers of release paper. Such material has been used for sealing ground foundations and similar structures. It is extruded so as to become united with a carrier sheet and be capable of use in large rolls for covering large areas. indeed, the polypropene and polybutene used is intended deliberately to give the extruded material a rubbery or formable consistency enabling it to be moulded by hand around small areas such as chimneys, at joints in concrete panels or where drains penetrate foundations. These materials are also quite expensive and prohibitively so for use in relation to large area sheets.

[0010] It is an object of the present invention to provide a waterproofing material whereby the above described disadvantages are reduced or minimised.

[0011] Calcium montmorillonite is often used as a substitute for sodium montmorillonite. In use calcium bentonite has a property that when initially wetted it will swell and expand in the same way as sodium nontmorillonite. However, if the material should dry out, for example due to low rain fall or a falling water table calcium montmorillonite cannot shrink back to its original size upon loss of water without cracking. After cracking and upon re-wetting the clay can not re-wet so as to reform the water proof barrier. Thus, a calcium bentonite water proofing material should only be used in cases where permanent wetness is to be encountered.

[0012] All sodium containing montmorillonites do have a problem when the water which comes into contact with them is contaminated by salts, particularly sea water or other salts which render the ground water ionised And highly active. In ground water calcium is invariably present in quantity from soil and minerals. When such ionic calcium comes into contact with montmorillonite it invariably tends to convert the montmorillonite from the sodium to the calcium form with the disadvantage which has been outlined above.

[0013] This particular process makes it generally unwise to use even sodium montmorillonite in a situation where the ground water can become rapidly ionised or contaminated by leachates or the like. In particular, fertilisers are a particularly notorious cause of ground water ionisation and can cause sodium montmorillonite break down.

[0014] It is a further object of the present invention to provide an improved waterproofing material whereby the above described disadvantages are reduced or minimised.

[0015] In a paper entitled "Preparation of Montmorillonite - Polyacrylate Intercalation Compounds and the Water Absorbing Property" by Ogawa et al published in Clay Science Number 7, 243 251 (1989), the authors have described the introduction of a acrylamide into montmorillonite and the polymerisation of the acrylamide to form a polyacrylamide intercalation compound. The enhanced water-absorbing properties of the compound are noted.

[0016] It is to be appreciated, of course, that the processes carried out in the Ogawa paper were essentially laboratory processes involving small amounts of material. No techniques were described for making any useful product and there was not discussion of the advantages of high density such compounds as waterproofing agents.

[0017] Document US-A-5,021,094 discloses a waterproofing grout composition which can be formed by mixing smectite clay with a liquid, primarily consisting of water, until the clay particles are fully dispersed, yielding a thick, paste-like consistency.

[0018] The present invention provides a method of making a waterproofing material as specified in claim 1.

[0019] Desirably the smectite containing layer is sandwiched between said support sheet and a cover sheet.

[0020] Reinforcement can be provided in the middle of the smectite containing layer.

[0021] The reinforcement can be secured to the cover sheet and/or the support sheet.

[0022] The laminate of the smectite layer and the support sheet can be treated after union to cause the layer to loose a degree of plasticity to enable it to be handled and stored without undergoing further deformation.

[0023] Desirably the smectite clay is mixed primarily with water to form a paste or a putty like plastic mass which can be extruded, rolled or otherwise formed into a continuous layer.

[0024] After forming the layer is subjected to a drying step to remove excess water to convert the smectite layer into a more dimensionally stable configuration unlikely to deform further during transportation and storage and further to increase the swellability of the smectite upon contact with water in use.

[0025] Additives which modify the behiaviour of the smectite under certain specified conditions such as salt water, or presence of strong leachates, radiation hydrocarbons or organic chemicals can be added at the mixing stage to be operative when the smectite is in use.

[0026] Union of the smectite containing layer with the support sheet can be by adhesive, but desirably no adhesive is used, the mixture of smectite land other substance(s)) being such as to allow pressure to force the plastic mass into the interstices of the cover sheet (which is desirably of a textile nature) physically to unite the two. Similar connection can be effected between the layer and the cover sheet.

[0027] In addition to water, organic materials such as methanol, ethanol and other alcohols, glycerine, diesel and other oils and fats can be used. These materials do have the advantage that it is not necessary to drive off so much water so as to increase the swellability of the smectite layer, but they also have the disadvantages that they do need a drying step so that the material is not subject to further deformation under its own weight during storage and transportation and many organic materials are usually far more expensive then water.

[0028] Alcohols, particularly methyl alcohol do, however, have particular advantages. Whilst alcohols are generally expensive, they are also usually far more volatile than water. Thus, a plastic mass made using methyl alcohol can, after having been formed into a cohesive continuous layer be dried using far less heat than would be necessary to drive out the water from a similar mass. In addition to this however, the alcohol driven off can be condensed and reused thus offsetting the cost thereof.

[0029] The montmorillonite mesh size can be anything from 50 mesh or smaller, desirably, however the size is a maximum of 100. In practice a mesh size of 200 has been found useful although variations downwards from about 100 mesh do work although with less desirable qualities. Finer meshes are perfectly acceptable, but tend to be unnecessary. The smectite used is desirably sodium montmorillonite although calcium montmorillonite (modified by treatment with sodium hydroxide) can be used. As the montmorillonite is usually broken down significantly during mixing to micro sizes, initial grain size is not critical.

[0030] The fabrics used as support and/or cover layer can be conventional woven or non-woven textiles such as nylon or polypropylene or polyester. They should be non-venting (that is to say they do not allow gas or liquid to pass along the structure in use to any significant degree). The fabrics are desirably woven and this degree of non-venting can be achieved by ensuring that the fabric is of relatively open mesh and fairly thin, a significant portion thereof being embedded in and physically uniting with the outer layer of the montmorillonite layer

[0031] Apparatus for making such a waterproofing material includes a conveyor, means for feeding a support to the conveyor, means for applying a plastic smectite-containing mass onto the support, and means for forming said plastic mass into a uniform continuous layer.

[0032] Means can be provided for sizing the laminate in thickness and/or in width.

[0033] Desirably the apparatus includes means for conditioning the laminate after formation to render it stable in use and storage. Said means can include an oven for evaporating substances, from the laminate.

[0034] Means for supplying the plastic mass to the conveyor can include one or more nozzles, and/or an extrusion head.

[0035] Means can also be provided for supplying a cover sheet to a surface of the layer remote from the support sheet.

[0036] Means can also be provided for feeding a reinforcement to be embedded within the smectite containing layer.

[0037] Means can be provided for uniting said reinforcement with one or both of the cover and support sheets; for example by heat sealing.

[0038] Waterprobfing material in accordance with the invention can be used, for example, as roofing material or to provide a seal for a pipe or other plumbing fittings.

[0039] The smectite mixture can be in the form of a sealing ring or annulus or can be provided as a continuous length for wrapping around joints. The sealing material can be made by the aforesaid methods of forming a plastic mass and extruding, cutting or moulding therefrom.

[0040] Acrylate or polyacrylate compounds may desirably be added to the liquid for mixing with the clay.

[0041] The acrylate can have the formula shown in figure 9. Although the sodium salt of polyacrylate is shown other cation forms can be used. In the sodium cation form the acrylate can replace the sodium cations which normally coat the outer layers of the smectite plates.

[0042] The acrylate polymer can be doped with various desirable material to alter various properties of the clay.

[0043] One particular doping agent is glycerol. The introduction of glycerol can increase the flexibility of the clay so that a length of the clay can be bent easily without breaking.

[0044] Methanol can also be introduced, as previously mentioned. It is a useful material for increasing the flexibility and reducing the stiffness of the mixture thus assisting in its processing.

[0045] A further problem of smectite clay when used as a waterproofing material, is that its function is very dependent on the amount of montmorillonite used. For example when a body of a montmorillonite is constrained between two surfaces, such as the concrete of a structure and the ground, when contacted by water it swells and forms the aforesaid high pressure layer which prevents ingress of water to the structure and therefore effectively waterproofs it. To increase the waterproofing efficiency of the clay body, larger quantities of montmorillonite can be used. However, higher quantities of montmorillonite mean thicker sheets of material which are more difficult to handle and which are heavier have more transportation costs and are bulky. In sheets which consist principally of particulate montmorillonite there can be significant difficulty in getting a large quantity into a small area. Sheet material used for waterproofing in ground situation or for roofs, walls and the like tend to have relatively low densities. This is because they are generally made from particulate montmorillonite adhered to a supporting sheet as of plastics material or textile material and secured thereto by a variety of means ranging from adhesive to needling to sewing or by embedment in a mesh of fibres.

[0046] The invention provides a smectite clay waterproofing material having a density greater than 1000 kg. m^{-3}.

[0047] The waterproofing material can be a sheet at least a metre wide and desirably up to four metres wide or more.

[0048] Desirably the material is subsequently subjected to pressure. Such a pressure step can reduce the number of voids in the product as well as urging the molecules of the product closer together to produce a denser product.

[0049] The pressure can be applied by extrusion or by passing the forming material through rollers, or by any other convenient means.

[0050] Where the product is subjected to pressure as aforesaid it is desirable that the pressure is applied when the temperature is within the range 15° to 30°C.

[0051] A further disadvantage of existing smectite-based waterproofing materials is that upon exposure to water they tend to swell (this is the very factor which gives them their waterproofing properties in that they produce an area of such high pressure that additional water cannot penetrate). However, the pressures can tend to be very high and, therefore a very significant overlay of either a heavy earth layer (for example one to two metres) or up to 3" or more of concrete are necessary in order that the expansion pressure of the smectite cannot cause movement or displacement of any structure.

[0052] The invention provides a waterproofing material having a significantly reduced expansion pressure compared with known smectite based waterproofing material.

[0053] The expansion pressure can be as low as 10mm of concrete as carried out in the test later defined herein.

[0054] Preferred embodiments of the material of the invention provide a barrier against aggressive ionic fluid, the barrier being in the form of a constrained layer of said material wherein interlayers of the smectite have been treated with acrylate or polyacrylate or comparable substances.

[0055] The interlayers are then capable of absorbing water to swell the material to a barrier pressure while the acrylate or polyacrylate inhibit ion exchange between said fluid and the smectite.

[0056] The fluid will normally be aqueous and can be highly ionised fluid such as leachate or fluid containing fertilizer and the like. However, the barrier can be equally effective against organic fluids or fluids containing organic material, as the smectite interlayers remain proof against ion exchange with such fluid.

[0057] The smectite layer needs to be constrained in order that the barrier pressure can be achieved. The constraint can be a back-fill or overlay of earth or other material or in solid structure an adjacent or surrounding area of concrete or the like can be used.

[0058] A further problem with known smectite based waterproofing materials is that it has been very difficult to secure them to surfaces to be waterproofed. Whilst a flat or gradually sloping surface can be easily waterproofed simply by laying a sheet of the smectite material thereon, when vertical surfaces (such as adjacent edges of concrete panels) are to be waterproofed it has been necessary somehow to attach a smectite based strip thereto. Existing methods used have included the provision of rebates into which strips of seal material can be pushed and the use of clips or nails. Although nails can be used they tend to be frowned upon as they pierce a waterproof layer and they can introduce metal ions into the surrounding water which may have a detrimental effect. Because of the generally incohesive nature of clays and their friability, adhesives have not been very effective. Some heavy soaking adhesives have been used, particularly the type of adhesive used in the adherence of smectite particles to sheets. However these adhesives have a great tendency to inhibit the swelling properties of the clay and to react adversely.

[0059] Preferred embodiments of the material of the invention are readily securable to a surface by use of an adhesive compatible to the acrylate or polyacrylate component, such as a cyanoacrylate adhesive.

[0060] The invention will be described further, by way of example, with reference to the accompanying drawings wherein;

Figure 1 is a cross sectional view illustrating a preferred waterproofing material of the invention;

Figure 2 is an enlarged cross sectional view illustrating a surface of a preferred material of the invention;

Figure 3 is a schematic view illustrating the apparatus of the invention suitable for carrying out a preferred method of the invention;

Figure 4 is a plan view of part of the apparatus of figure 5 and illustrating two possible variations;

Figure 5 is a view similar to figure 1 but illustrating a modified material of the invention;

Figure 6 is a view similar to figure 5 but illustrating a still further modified material;

Figure 7 illustrates an overlap join made using the material of the present invention;

Figure 8 is an enlarged view of the portion ringed at numeral 10 in figure 9; and acrylate useable in the invention.

[0061] Referring to figure 1, the preferred waterproofing material (10) of the invention is a laminate consisting of a core layer (11) containing montmorillonite. The core layer (11) is united with a support sheet (12) and is desirably but not essentially overlaid by a cover sheet (13).

[0062] The essentials of the material (10) of the invention will probably be best apparent from a detailed description of the way it is made and the apparatus which is used to make it.

[0063] Referring, therefore, to figure 3 it will be seen that a preferred apparatus of the invention comprises a conveyor (15) having an upper run (16) and a lower run (17) entrained about end rollers (18) and (19). The upper run (16) travels from left to right in figure 5.

[0064] At the upstream end of run (16) a support sheet (20) is fed from a supply roll (21) by a guide roll (22) so as to run on and in synchronism with the conveyor (16).

[0065] The support sheet (20) is a sheet of woven or non-woven textile material (preferably woven) which is relatively loose weave, being quite porous in a direction transverse to its plane.

[0066] The web forming the support sheet can be made of any geotextile material which is suitable for disposal within the ground for long periods. Typical materials for weaving or forming the fabric of the sheet (20) can be polypropylene, polyesters including nylon, and many other plastics materials alone or in blends. The material should be sufficiently strong to support the composite laminate to be formed and can be similar to many of the facing sheets used in relation to the prior known materials discussed in the introduction hereto. Polypropylene and cotton mixers can also be used. A typical support and/or cover sheet can be of a print weave and of a weight 700g per sq.metre.

[0067] Downstream of the supply roll is a hopper mixer (23) in which particulate montmorillonite can be supplied as indicated by the arrow (24). The particulate montmorillonite can be supplied from a mill or like supply and in the preferred embodiment is of 200 mesh. Finer mesh can be used although great advantages are not obtained. Meshes up to 50 mesh can be used, but at sizes greater then 100 mesh, union between the montmorillonite particles is less effective.

[0068] The process which takes place in the hopper mixer (23) can be either a continuous or a batch process. Within the hopper mixer (23) a measured quantity of montmorillonite is mixed with a measured quantity of liquid to produce a fluent mass. The liquid can be supplied from a tank or comparable supply (25) and when mixed with the montmorillonite will form a shapable mass. The liquid used can include an organic liquid such as glycerine, diesel oil or comparable oils or mixes thereof. For economy and for ease of handling and simplicity the liquid is primarily water. In the preferred embodiment of method of the invention water is mixed with the montmorillonite there being approximately from 10 to 30% water, desirably about 15 to 20%.

[0069] The liquid may also include a proportion of alcohol. Methyl, ethyl or propyl alcohol can be used. Methyl is preferred. An alcohol water mixture needs less drying power than water alone. Some alcohol can be reclaimed and reused.

[0070] In making a typical product in accordance with the invention 5 killogrammes of montmorillonite were mixed with 0.446 killogrammes of sodium carboxymethyl cellulose (CMC), 2.5 litres of methanol and 1.8 litres of water. Both the CMC and the methanol make the mixed and kneaded product more flexible and extrudable. The more water that is used the more heat is required to drive it out. This means added expense.

[0071] Although the above particular mixtures have proved suitable many variations can be made.

[0072] The material desirably contains a bulking agent, an anti fungicidal preserving agent, to prevent growth of mould in or on the material and desirably a lubricant to assist in the extrusion process and convey also a degree of flexibility to the plastic mass. CMC is a very desirable substance in that it provides all these properties. It has anti fungicidal properties, it is a lubricant and it makes the product more flexible. It also has the great advantage that upon contact by water, in use, it dissolves. Those areas of the outer surface of the material when first contacted by water have the CMC dissolved out of them leaving micro pores into which more water can penetrate, wash out more CMC and cause rapid expansion of the adjacent montmorillonite. This greatly increases the rate of water transfer into the material. A bulking agent which dissolves in water and aids water ingress to the montmorillonite is very desirable.

[0073] The montmorillonite used is desirably sodium montmorillonite but calcium montmorillonite or treated calcium montmorillonite and other smectites can also be used. As shown the materials are first mixed by means of a mixer (27) and then extruded by screws (28) to an extrusion nozzle (29). Where the fluid mass is spread out as a thin layer covering the entire width of the conveyor run (16).

[0074] If reinforcement is required within the montmorillonite layer in order that it can be laid on steep slopes without loss of function it can be desirable to incorporate within the plastic mass a reinforcing layer. This can be done by embedding the reinforcing layer into the mass as it is being extruded or as it is being spread out into a layer. The reinforcing layer can be made in the form of a core having bristles or comparable formations extending outwards which, with the core disposed centrally in the body of montmorillonite extend to the surface thereof and contact and possibly project through the surface layers. The material of the reinforcement and the surface layers can be made such that the exposed bristles can be heat sealed to contact and be secured to the outer layers. It is envisaged that it would be possible for the montmorillonite mass to be extruded or formed into a pair of sheets and the reinforcement fed between them and to have its bristles projecting through each of the two part layers of the montmorillonite core and project to the other surfaces thereof and be united with the support/cover sheets.

[0075] Although the extrusion of a thin layer of the plastic mass containing montmorillonite is desirable, as it can be 3 or more metres wide, it could well be that a three metre wide extrusion nozzle is either expensive, slow, or requires inordinate amounts of power to be successful. Such a extrusion nozzle (29) is shown in figure 5 which also shows an alternative which will be described later.

[0076] It is expected that the mass will be extruded as a rod and rolled flat.

[0077] Downstream of the nozzle (29) the layer (30) of montmorillonite - containing plastic mass is levelled and formed into a uniform uninterrupted layer. This can be achieved by means of an initial doctor blade (31) or more likely, a roller, and subsequent sizing rollers (32) to (34). The pairs of sizing rolls (32) (33) (34) can effect kneading and levelling of the fluid material and subsequent size thickness reductions.

[0078] Figure 6 shows one of the rollers and shows the plastics material extruded outwards beyond the edge of the conveyor and being removed by trimming knives (36).

[0079] At one of the sets of rollers (32) (33) (34) there is fed a web of cover sheet (37), from a supply roll (38). Of course, if roll (32) or (33) and (34) are needed to effect creation of a uniform flat layer of the montmorillonite containing mass, application of the cover sheet (37) can be left until roll (34). However, this is not desirable as rollers (32) and (33) are best protected from the plastic montmorillonite layer by the cover sheet (37).

[0080] The liquid which converts the powdered montmorillonite into a plastic fluent mass will need some degree of subsequent treatment, for example by evaporation, drying or partial chemical change so as to ensure that the final material can not deform further in use or in storage. This can be effected by means of a treatment facility indicated by the reference numeral (39).

[0081] In the illustrated apparatus the treatment facility (39) is in the form of an oven which will reduce the solvent water content of the montmorillonite containing layer from 20% down to 5% or less. Hot air is supplied at an inlet (41) and leaves via outlet (42).

[0082] After leaving the treatment facility (39) the laminate can be allowed to cool and then be fed to a store roll (44). A knife or the like can be provided for cutting the laminate as it leaves the oven when roll (44) is full.

[0083] The initial consistency of the plastic/fluent mass containing montmorillonite can vary widely from almost a liquid condition to a stiff paste. The stiffer the paste the better as water has to be expelled by passage through the oven.

[0084] As has previously been mentioned the use of a very wide extrusion nozzle (29) may not be practical in view of the power required for such a device. Instead, as illustrated in figure 6 a smaller extrusion or fluid delivery nozzle (45) can be used which can be mounted so as to perform a generally sinuous path transversely of the direction of travel of the run (17) of the belt (15). Thus, the nozzle (45) can follow a path indicated by the line (46). By altering the speed of travel of the nozzle and/or the rate of delivery of the fluent material it can be assured that sufficient material is applied to the belt to allow a layer of desired thickness to be formed throughout the area of the belt without voids, cracks or the like which would be most undesirable. To this end it is advantageous if the material can be applied to some significant excess and after having been formed into a uniform coherent layer excess material extruded sideways is removed by means of the trimming knives or the like (36). of course, such material can be reclaimed and re-used.

[0085] It has been mentioned that the support sheet and/or the cover sheet can be of woven or non-woven material. Woven material is preferred but it gives significant strength with lesser weight of materials. A non-woven material might have advantage, however in that it can form a physical union with the montmorillonite containing core (11). The term core (11) is used even though the cover sheet (13) may not be provided.

[0086] As best seen in figures 2 and 8 the action of the rollers (32) (33) and (34) is to cause the support/cover sheets (12) (13) to be partially embedded in surface zones of the plastic mass of material forming the core (11) whilst the core is in a plastic state. There is no need for any adhesive, which is an expensive and unreliable component.

[0087] As the core is treated in the facility (39) either by evaporation or chemically so as to cause the core to harden there is a physical locking of the surface portions of the core (11) with portions of the fabrics (12) (13) physically, uniting them to the surface without the need for adhesive.

[0088] This has two important consequences.

[0089] Firstly, because a good portion of the sheets (12) and (13) are embedded within the material of the core, only a small portion of the body of the fabric is exposed above the surface.In use that fabric surface will be in contact either with anchoring overburden (at least 150mm of overlying material is recommended to protect such layers) or the underlying earth. The overburden or the earth penetrates the fabric quite easily (it is a very open fabric and there is intimate contact with both the overburden and the underlying earth). This again has two important consequences. Firstly, once the support layer (12) (which will normally be in contact with underlying earth) is intimately contacted by the earth, ground water enters, contacts the montmorillonite and causes swelling which creates a seal.

[0090] It is a further advantage that because of the intimate contact of the underlying soil or the overburden with the montmorillonite through the support and cover sheets (12), (13) there is no possibility that either the cover sheet (13) or the support sheet (12) can allow any venting of gas laterally though the fabric.

[0091] The second advantage of this is illustrated in figures 7 and 8. In figure 7 a first piece (47) of the material of the invention is shown overlapping a lower piece (48), both lying on the ground. The overlap cover sheet (50) of the second sheet (48) is in contact with the support sheet (51) on the piece (47). As illustrated in figure 8 the sheets (50) and (51) are in intimate contact and they are significantly penetrated by montmorillonite from the respective cores of the two panels. Upon entry of water in the direction of arrow (52) or (53) the montmorillonite in one or each of the cores can swell and expand into the unfilled portions of the fabrics (50) (51) and form effectively a continuous layer of expanded montmorillonite uniting the two cores and providing a completely water tight seal.

[0092] The invention is not limited to the precise details of the foregoing and variations can be made thereto.

[0093] In a further specific example of the invention a quantity of untreated sodium montmorillonite and approximately 10% by weight of a polyacrylate of the formula shown in figure 12, from 2% to 7% of a sodium carboxymethyl cellulose (CMC), 14% of methanol and 5% of glycerol were intimately mixed together. Kneading and mixing were continued until the mixture reached a suitable consistency for extrusion. This can take longer than would normally be necessary for simple mixing as the chemical reaction between the acrylate and the structural plates of the clay takes some time to occur. The heat emitted by such reaction is an important factor in bringing the plastic mass to a suitable consistency and structure.

[0094] Once this has occurred the mixture is passed to an extruder where it is driven towards an extrusion screw and subjected to a suction stage to remove significantly all entrained gas from it before being extruded in the form of a rope, profile or sheet as desired.

[0095] The montmorillonite used in the process is finely ground andthe cations in the interlayer are essentially sodium cations.

[0096] During the reaction the clay becomes acrylated and the long organic chains of polyacrylate penetrate into the interlayers and displace water. At the particle surfaces, polyacrylate bonds with strong hydrogen bonds to the free unsatisfied OH groups. This effectively shields the sodium cations, thus greatly resisting their replacement by calcium cations in contaminated ground water.

[0097] This has the important effect that any cations which enter within the interlayer can not replace sodium cations and thus do not reduce the capacity of the clay to expand, shrink and re-expand after drying out.

[0098] Instead of carrying out the invention using acrylate other materials can be used. For example sugars such as fructose, glucose,dextrose can be used. All act in very similar way to the acrylic molecule and have comparable and similar effects. The use of sugar may, however, be undesirable in some circumstances in view of its encouragement of microbial growth.

[0099] A further alternative material is alkylammonium trimethyl alkyl ammonium which can be used in the manner very similar to the polyacrylic compound to-give a similar complex with similar properties.

[0100] In another example of making a smectite clay water proofing material in accordance with the invention sodium montmorillonite powder was mixed with polyacrylate, glycerol and methanol. The mass was mixed together for some fifteen minutes and then extruded through a 25mm square orifice at a rate of about 0.5 metres per second to produce a rope like concrete sealing strip having a density of about 1350 kg m m^{-3}.

[0101] The actual density can be varied by varying the proportion of materials in the complex.

[0102] The waterproofing material can be made without using polyacrylate. In addition it is possible to use CMC either in addition to the acrylate or as a substitute therefore. The CMC can be useful in varying the reaction rate of the clay but it also has a property of forming, on the surface of the extruded material a layer which improves the life of the sealing material by resisting degradation and swelling by rain over a first few hours or days.

[0103] In testing the aforesaid material of the present invention a layer of conventional particulate smectite clay waterproofing sheet was laid on the ground and contacted with typical water high in ionic leaching chemicals. After six hours the bentonite layer had absorbed the liquid and had swelled to form a uniform water retaining layer.

[0104] A material according to the invention was similarly treated and had, within six hours reached precisely the same condition.

[0105] The two sheets were then allowed to dry. In the complex clay sheet according to the invention the sheet reduced in thickness to its original thickness with no significant cracking. In the untreated prior art clay particulate layer sheet there was significant cracking and large gaps appeared in the material. Both sheets where then rewetted (whether pure water or contaminated leachate water was used made no difference). The prior art material, wherein clearly sodium montmorillonite had been converted to calcium montmorillonite there was no significant re-swelling. The cracks remained and water was able to penetrate through those cracks even after prolonged soaking with water as would happen in an underground situation. The prior art material was no longer waterproof and did not itself form a waterproof layer by expansion.

[0106] On the contrary, however, the material of the present invention formed a uniform waterproofing layer.

[0107] As well as montmorillonite, saponite and other smectites can be used. In carrying out further preferred processes the percentages of the various materials used can be varied as follows: -

ITEM	PERCENTAGE RANGE
Water	15 - 25
Sodium Polyacrylate	8 - 16
(Methyl) Alcohol	0 - 5
Wyoming Bentonite	50 - 75
Carboxy Methyl Cellulose	0 - 3
Sodium Hexameta Phosphate	0 - 0.5

Claims

1. A method of making a waterproofing material comprising mixing particulate smectite clay with a liquid, at least a proportion of which is water, kneading the mixture to form a substantially homogeneous plastic mass, forming the mass into a continuous layer (11;30) by extrusion, rolling or other means, uniting same with a carrier sheet (12; 20;51), and subjecting same to a drying step by passing through an oven (39) to remove liquid from the layer by evaporation.

2. A method as claimed in claim 1 wherein a proportion of said liquid is an alcohol having from 1 to 12 carbon atoms.

3. A method as claimed in claim 2 wherein said alcohol is methanol, ethanol or propanol.

4. A method as claimed in any preceding claim wherein said liquid contains acrylate or polyacrylate.

5. A method as claimed in any preceding claim wherein said liquid contains glycerol or glycerine.

6. A method as claimed in any preceding claim wherein said liquid contains a carboxymethyl cellulose (CMC) compound.

7. A method as claimed in any preceding claim wherein the smectite containing layer (11;30) is sandwiched between said carrier sheet (12;20;51) and a cover sheet (13;37;50).

8. A method as claimed in any preceding claim wherein reinforcement is provided in the smectite containing layer

9. A method as claimed in claim 8 wherein the reinforcement is secured to the cover sheet (13;37;50) and/or the carrier sheet (12;20;51).

10. A method as claimed in any preceding claim wherein the smectite layer (11;30) and the carrier sheet (12;20;51) are treated after union to cause the layer to lose a degree of plasticity to enable it to be handled and stored without undergoing significant deformation.

Patentansprüche

1. Verfahren zum Herstellen eines wasserabhaltenden Materials, beinhaltend Vermischen von teilchenförmigem Smektit-Ton mit einer Flüssigkeit, von welcher wenigstens ein Teil Wasser ist, Kneten der Mischung, um eine im wesentlichen homogene plastische Masse zu bilden, Formen der Masse zu einer durchgehenden Schicht (11; 30) durch Extrusion, Walzen oder eine andere Maßnahme, Vereinigen derselben mit einer Trägerbahn (12; 20; 51) und Bearbeiten derselben durch einen Trocknungsschritt durch Hindurchleiten durch einen Ofen (39), um Flüssigkeit durch Verdampfung aus der Schicht zu entfernen.

2. Verfahren nach Anspruch 1, wobei ein Teil der Flüssigkeit ein Alkohol ist, der 1 bis 12 Kohlenstoffatome hat.

3. Verfahren nach Anspruch 2, wobei der Alkohol Methanol, Ethanol oder Propanol ist.

4. Verfahren nach einem der vorhergehenden Ansprüche, wobei die Flüssigkeit Acrylat oder Polyacrylat enthält.

5. Verfahren nach einem der vorhergehenden Ansprüche, wobei die Flüssigkeit Glycerol oder Glycerin enthält.

6. Verfahren nach einem der vorhergehenden Ansprüche, wobei die Flüssigkeit eine Carboxymethylcellulose (CMC) -Verbindung enthält.

7. Verfahren nach einem der vorhergehenden Ansprüche, wobei die Smektit enthaltende Schicht (11; 30) zwischen der Trägerbahn (12; 20; 51) und einer Deckbahn (13; 37; 50) angeordnet wird.

8. Verfahren nach einem der vorhergehenden Ansprüche, wobei eine Verstärkung in der Smektit enthaltenden Schicht vorgesehen wird.

9. Verfahren nach Anspruch 8, wobei die Verstärkung an der Deckbahn (13; 37; 50) und/oder an der Trägerbahn (12; 20; 51) befestigt wird.

10. Verfahren nach einem der vorhergehenden Ansprüche, wobei die Smektit-Schicht (11; 30) und die Trägerbahn (12; 20; 51) nach der Vereinigung behandelt werden, um zu bewirken, dass die Schicht einen Grad an Plastizität verliert, damit sie gehandhabt und gelagert werden kann, ohne nennenswert deformiert zu werden.

Revendications

1. Procédé de préparation d'un matériau d'étanchéification à l'eau, comportant les étapes de mélanger de l'argile de smectite en particules avec un liquide dont au moins une partie est de l'eau, de pétrir le mélange de manière à former une masse plastique essentiellement homogène, de former la masse en une couche continue (11 ; 30) par extrusion, roulage ou d'autres moyens, de relier cette couche à une feuille de support (12 ; 20 ; 51), et de soumettre ladite couche continue à une étape de séchage par passage dans un four (39), pour éliminer le liquide de la couche, par évaporation.

2. Procédé selon la revendication 1, dans lequel une partie dudit liquide est un alcool comptant de 1 à 12 atomes de carbone.

3. Procédé selon la revendication 2, dans lequel ledit alcool est le méthanol, l'éthanol ou le propanol.

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit liquide contient un acrylate ou un polyacrylate.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit liquide contient du glycérol ou de la glycérine.

6. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit liquide contient un composé de carboxyméthylcellulose (CMC).

7. Procédé selon l'une quelconque des revendications précédentes, dans lequel la couche (11 ; 30) contenant de la smectite est intercalée entre ladite feuille de support (12 ; 20 ; 51) et une feuille de couverture (13 ; 37 ; 50).

8. Procédé selon l'une quelconque des revendications précédentes, dans lequel un renforcement est prévu dans la couche contenant de la smectite.

9. Procédé selon la revendication 8, dans lequel le renforcement est fixé à la couche de couverture (13 ; 37 ; 50) et/ou à la couche de support (12 ; 20 ; 51).

10. Procédé selon l'une quelconque des revendications précédentes, dans lequel la couche de smectite (11 ; 30) et la feuille de support (12, 20 ; 51) sont traitées après avoir été réunies, pour amener la couche à perdre un certain degré de plasticité, pour qu'elle puisse être manipulée et entreposée sans subir de déformation significative.

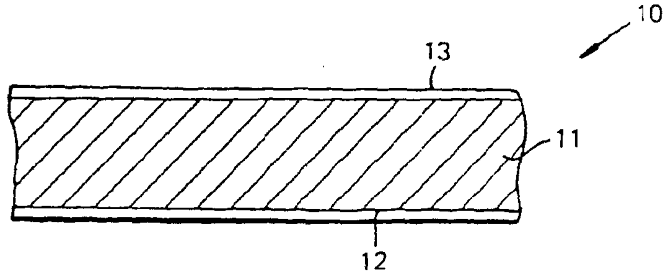


FIG. 1

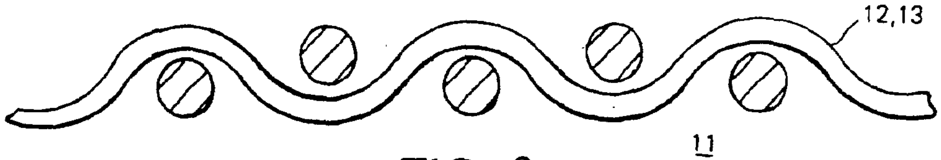


FIG. 2

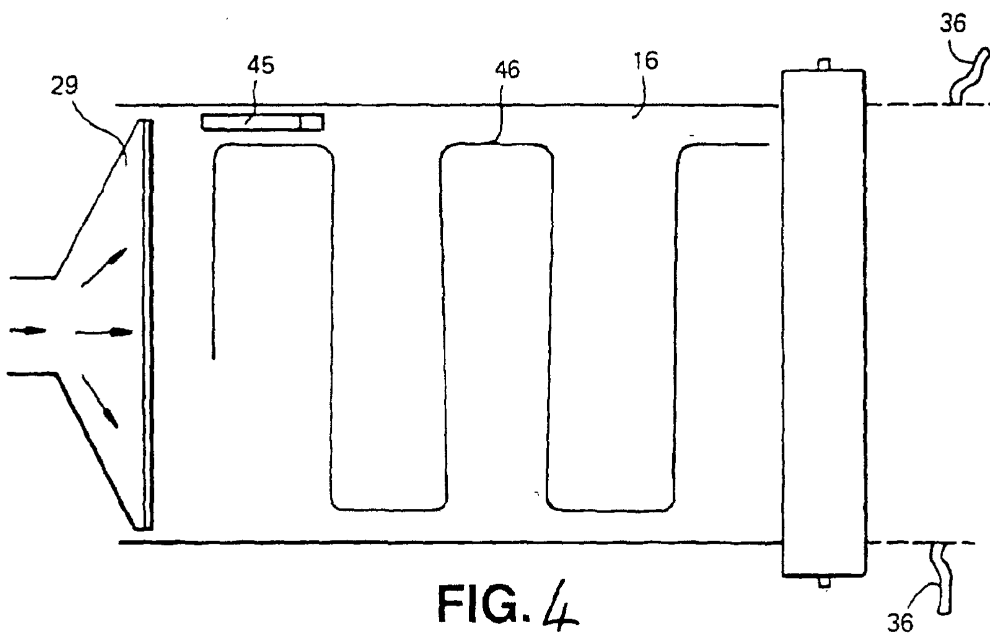
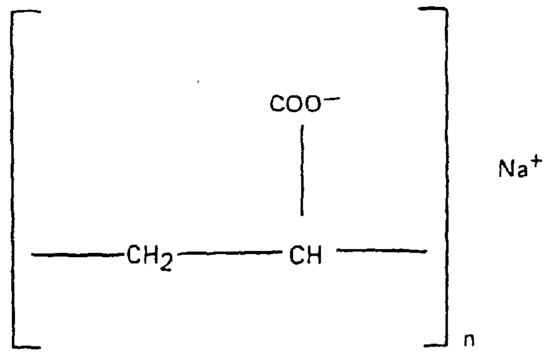


FIG. 4

FIG. 9



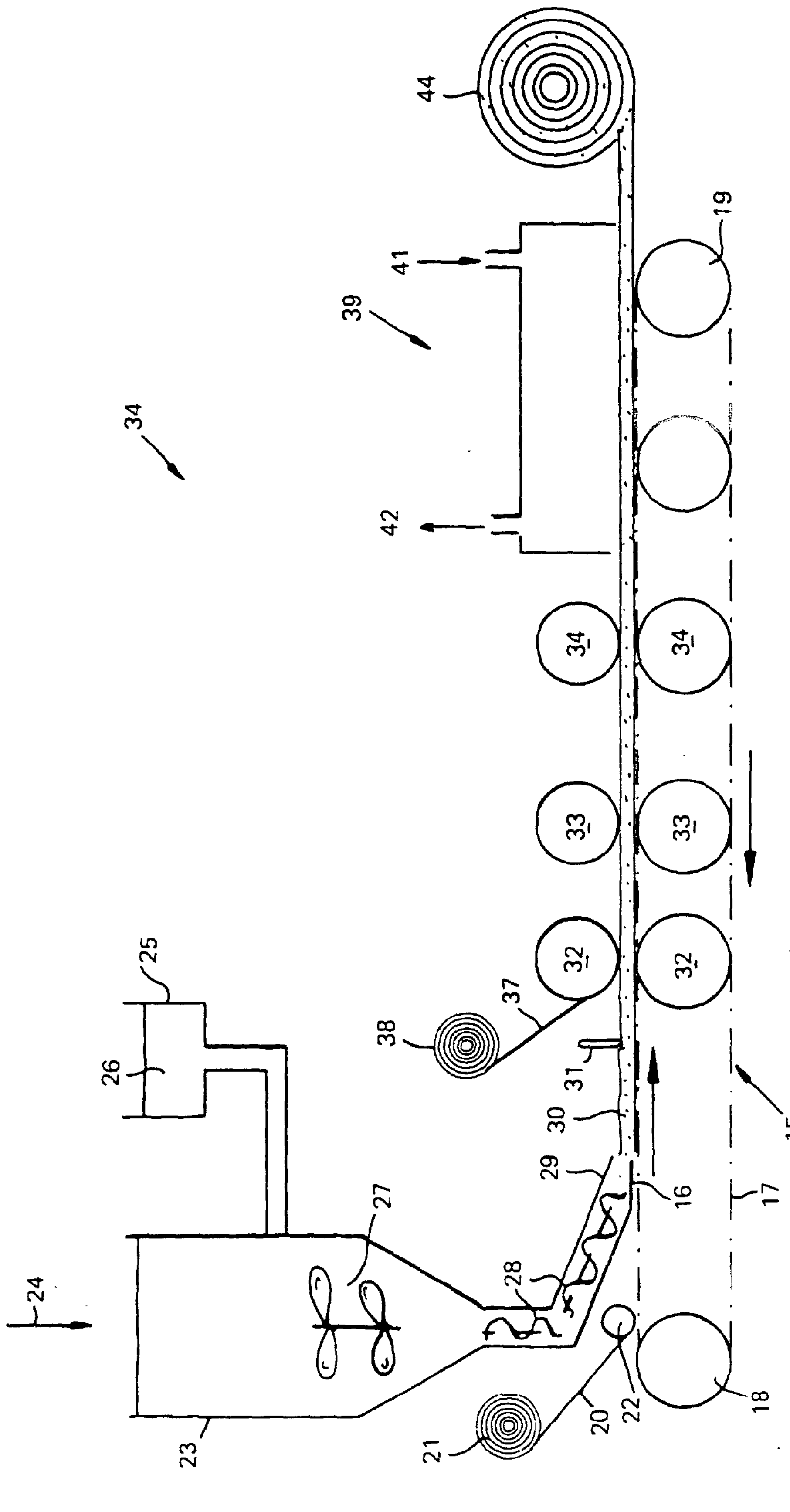

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FIG. 3

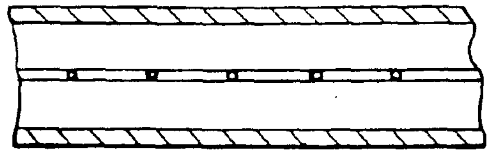

FIG. 5

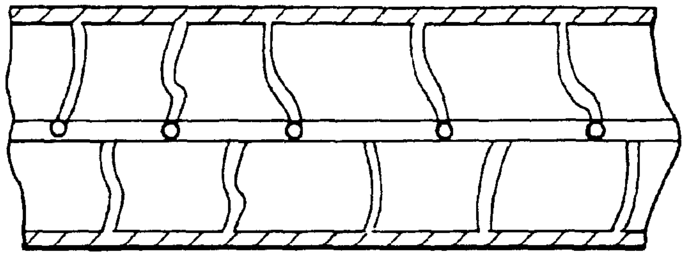

FIG. 6

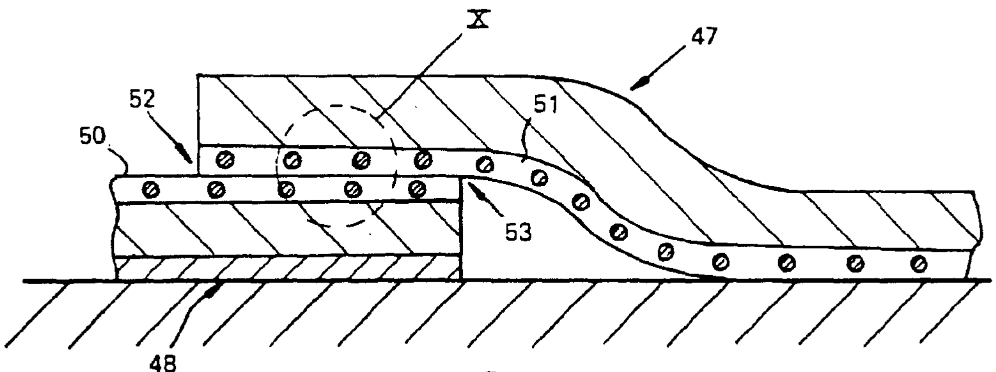

FIG. 7

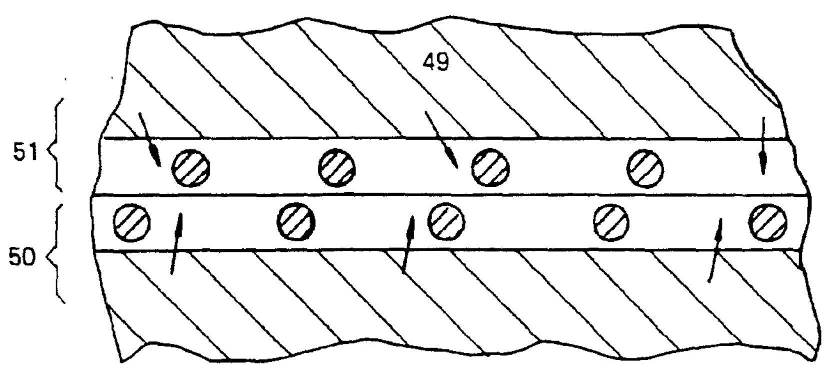

FIG. 8