

Insulating Element

The invention relates to an insulating element, particularly for heat and sound insulation of flat roofs or slightly inclined roofs, which insulating element consists of mineral fibers, especially glass fibers and/or rock wool fibers, which are bound with a binding agent, and which comprises a first major surface facing a surface to be insulated and a second major surface which extends parallel to and spaced from the first major surface, said major surfaces being interconnected through lateral surfaces which are oriented at substantially right angles to each other and to said major surfaces, and comprising at least one coating which is arranged on one major surface

From prior art insulating materials from mineral fibers are known which are offered on the market under the name "rock wool" and which are characterized by their high thermal resistance. These insulating materials have a melting point of $\geq 1000^{\circ}\text{C}$ according to German Industrial Standards DIN 4102 part 17 and they are produced from melts comprising stones, slags and other residual materials. The raw materials are melted in cupola or tank furnaces, and the melts are shaped on different fiber making machines.

At the use of customary fiber making machines, mineral fibers and non-fibrous particles are produced. Most of the coarser non-fibrous particles can be separated out from the continuously formed mineral fiber stream. In a fibrous mass which is collected from the mineral fibers there remain approx 5 to approx 10 percent by weight of particles $\geq 63\text{ }\mu\text{m}$ and approx 20 to 30 percent by weight of non-fibrous particles $\leq 63\text{ }\mu\text{m}$. Directly after their formation all the particles that have been formed are quenched with the aid of vaporized water, so that they become glassily solidified on one side and on the other side are cooled down to an extent that binding agents which are dissolved and dispersed in water will adhere to the mineral fibers, but will not solidify.

Usually, organic binding agents are employed, especially mixtures of thermosetting phenolic, formaldehyde and urea resins.

If need be, these mixtures are extended by additives like polysaccharides. In order not to put at risk the classification of the insulating materials as non-combustible or at least flame-retardant building materials, the fractions of organic binding agents are normally limited to less than 4.5 percent by weight and in the case of rock wool insulating materials produced by the nozzle blow method to less than 8 percent by weight.

Rock wool insulating materials are also produced by the methods that are normally applied in the production of glass wool. Such a production method is particularly characterized by the fact that no or only very small amounts of non-fibrous particles are formed.

In addition to the binding agents, the mineral fibers which are formed are impregnated with additives which have a water-repelling effect on one side and, due to the modified boundary properties of the mineral fibers, develop weak holding forces which are able to hold fragments of finest mineral fibers to a minor degree. To this end, there are frequently used high-boiling mineral oils, oil-in-water emulsions, more rarely silicon oils or resins. The fractions amount to approx 0.2 to approx 0.4 percent by weight.

Insulating materials from rock wool are predominantly produced in cascade fiber making machines. These fiber making machines allow the processing of glasses which are rich in alkaline earth and which have a narrow processing range. But there are formed only very short mineral fibers which in addition to that become deformed in themselves, because of the high velocities of air which are required for the transport of the mineral fibers which have been formed. The fiber making machine is arranged at the entrance of a horizontally directed accumulation chamber in which the mineral fiber stream that has been formed

is continuously guided to an air-permeable conveying device arranged at the end of the accumulation chamber, with the aid of an air stream. On the way to this conveying device the coarser non-fibrous particles are separated out. The stream of mineral fibers consists of the mineral fibers which are impregnated with the binding agents and the additives and of the non-fibrous particles. Further, mineral fibers are transported which are not impregnated with binding agents.

The coherence and the deformation behavior of the fiber mass which is formed from the mineral fibers is decisively influenced by blowing-in production waste in the form of ground insulating particles or fibers and is regularly deteriorated in the case of larger amounts. These insulating materials which are prepared by comminution do not reach the actual stream of binding agent and are therefore captured by fiber flakes just being formed only because of their shape. The binding agents which are contained therein carry additional combustible organic substances into the fiber mass and consequently into the insulating materials to be produced from it.

The air-permeable conveyor device has a filtering effect. Due to this filtering effect the mineral fibers become deposited on the conveyor device in the form of an impregnated primary fibrous web having a thickness which depends on the efficiency of the fiber making machine and the conveying speed of the conveyor device. Normally, lower masses per unit area of the primary fibrous weight are aimed at, in order to avoid a premature solidification of the fibers despite low amounts of cooling agents such as water for instance. Thereafter, the primary fibrous web is deposited onto a third conveyor device moving at a low speed transversely and in a diagonally overlapping relationship, with the aid of an oscillating second conveyor device. The way described for forming a sufficiently thick impregnated fibrous web is called indirect collection. Further known is a direct collection in which the mineral fibers which are impregnated with binding agents and additives, where necessary under the inclusion of the

non-fibrous particles, the binder-free fibers and the fine recycled insulating material flakes are deposited onto a slowly moving conveyor device, with the aid of a chute or by redirecting from the horizontal in a correspondingly high collecting chamber up to a desired elevation or the required mass per area. By this more gentle way of collecting the mineral fibers the same are piled up to flatly overlay each other, without a preferred direction.

The endless impregnated fibrous webs which are formed during both the indirect and direct fiber collection may thereafter be compressed and then compressed in a hardening furnace, wherein said hardening furnace comprises two pressure-transmitting conveyor belts which are arranged one above the other. The two conveyor belts of the hardening furnace consist of U-shaped elements which are fixed to revolving pulling members, thus forming an endless belt. In the pressure-transmitting surfaces of the lamella-shaped elements elongate and round holes are provided, through which hot air is sucked through the endless fibrous web in the vertical direction. During the entry of the endless fibrous web into the hardening furnace especially the mineral fibers are pressed into these e.g. 5 to 7 mm wide elongate holes and into the joints between the individual elements, which fact leads to the characteristic profilings of the two major surfaces of the endless fibrous web which is transformed into an endless insulating web, due to the solidification of the binding agents.

By the use of longitudinal and cross-cutting saws the insulating web may be cut into board-like bodies and, if necessary, also into thinner boards, by means of horizontal saws.

The non-combustible insulating materials from mineral fibers, especially rock wool, are used on a big scale for insulating especially light-weight flat roof constructions. According to the specific standards a roof is called a flat roof when the outer surface is horizontal or is inclined at an angle not exceeding 10°. These slightly inclined flat roof constructions frequently include as a supporting

roof shell wide-spanning and thin profiled metal sheets. Extremely profiled metal sheets have an inner width between the edges of the top chord of up to 172 mm. Occasionally, the profiled metal sheets are also installed in a negative position, so that the wider upper chords are now downwardly directed, by which fact the inner width between the now upwardly facing lower chords is increased. The light-weight flat roof constructions will strongly bend already under their own load and later also under the load of water and snow. In addition to that, they are extremely susceptible to vibration and may be easily excited by wind loads. Onto the roof shells either thin plastic films are laid as a vapor sealing air-tight layer, or also bitumen or elastomeric webs coated with metal layers are bonded to the upper chords or the upwardly facing chords of the profiled metal sheets.

The insulation boards are mostly laid in a braced fashion onto the supporting roof shell or vapor sealing air-tight layer in the form of large-format boards having dimensions of e.g. 2 m length x 1.2 m width. These large-format boards thus form multi-array supports, of which the load-bearing capacity is much higher than that of the smaller boards or of the formerly used small-format boards having dimensions of e.g. 1 m length x 625 mm width. But in all these cases it shall be avoided that the ends of the boards protrude over the lower chords. Due to the fact that the upper chords do not match with the available dimensions of the insulation boards, the insulation boards must be tailored, so that the joints of the boards are respectively positioned on the center of the upper chord. In order to avoid complicated cutting operations, pressure-resistant form-locking seam fillers may be installed into the profiles above the upper chords, where the joints of the boards of adjacent insulation boards bear on.

Thereafter, roof sealing webs are glued to or roof sealing films are laid onto the insulation layer formed from the insulation boards. The roof sealing webs or films as well as the insulation boards are connected to the profiled metal sheets

by means of screws. For the introduction of forces appropriate for both materials, pressure-distributing washers or bars are fixed together with the screws.

Insulation materials from rock wool offer the advantage that they do not chemically react with the different sealing materials. The insulation boards which are fabricated from these insulation materials are not subject to dimensional changes caused by thermal conditions and they additionally have smooth edges, so that both facts prevent mechanically-caused influences on the sealing materials. Moreover, the insulation materials are diffusion-open, which fact allows for an unhindered passage of water vapor and for the drying of possibly wet top constructions of a roof, provided that sufficient amounts of energy are available.

Contrary to parking decks or terraces for instance, the above-described flat roof constructions are not intended for being utilized. After their construction they are only occasionally accessed for maintenance work. Partial areas which are to be regularly accessed, for instance runways, are protected by pressure-distributing layers on the sealing webs or films as well as by constructions erected on supports. But there further exists the possibility of placing high-load bearing constructions onto the supporting roof shell. But the same will penetrate through the sealing construction and insulating layer, so that bad spots and leaks may be caused.

The insulation boards from rock wool are adapted in the first line for a high pressure resistance, with the general aim of maintaining a thermal conductivity of $\leq 0.040 \text{ W/m K}$. In accordance with the German Industrial Standard DIN EN 13162, insulation boards which are provided underneath of sealing constructions shall have a minimum compressive strength of CS(10Y)60, i.e. $\geq 60 \text{ KPa}$ at a compressive strain of 10%, at medium pressure loads like those occurring in non-utilized roofs. In order to achieve such values of compressive

strength, the insulation boards must exhibit either a high bulk density and/or high contents of binding agents. For limiting the required bulk densities, the fiber mass and the mass to be used as well as the weight of the individual insulation board, the insulation boards for use in the flat roof construction area are strongly folded into a corrugated shape, so that the mineral fibers are steeply oriented with respect to the major surfaces, whereby the compressive strength, the compressibility in the horizontal direction transversely to the folding direction and also the thermal conductivity are increased. The tensile strength in the plane of the board, the bending strength in the folding direction and the shearing strength in the loading direction at right angles to the major surfaces of the insulation boards are decreased.

In the case of a mineral fiber web which is produced in accordance with the known folding technique, the boards produced from said web exhibit an extremely high bending strength at right angles to the folding direction and hence transversely to the production direction of the mineral fiber web. For this reason, insulation boards having this longitudinal orientation are also laid across the profiled metal sheets of the supporting roof shell. Consequently, the bending strength of the insulation boards in the direction of the profile is clearly lower, whereby the risk is increased that the insulation boards are not sufficiently stable if they are frequently loaded parallel to the profilings.

The forces for folding the impregnated fibrous web are introduced through the major surfaces of the primary fibrous web. Since in the hardening furnace forces of a similar dimension and direction act on the fibrous web via the conveyor belts, mineral fibers in and under the two major surfaces of the fibrous web and the insulation boards produced there from are oriented with respect to the major surfaces relatively flatly or at least more flatly than with respect to a region between said two major surfaces of the insulation board. This analogously applies to insulation boards produced from said insulation web.

If the insulation web is horizontally divided into one or more layers, at least one of the major surfaces of a partial web that is obtained in this way lies in a region of the insulation web which exhibits less strength.

In order to make the insulation boards more resistant to loads occurring when the boards are walked on and at the same time providing for an improved introduction of forces into the insulation layer through the boards and/or bars, insulation boards are offered which include a high layer on one surface. This layer mostly has bulk densities of approx 150 to approx 170 kg/m², so that insulation boards which are formed in this way have bulk densities of approx 180 to approx 220 kg/m³.

A further improvement of the load bearing capacity of the insulation layer is achieved by the fact that two highly compressed layers are arranged one above the other in a fashion offset to each, so that one highly compressed layer bears on top and the other one bears on the supporting roof shell or the vapor sealing and air sealing layer.

Since the insulation boards which are arranged in a sandwich fashion are not connected to each other non-positively, the load bearing capacity of an insulation layer which is formed in this way is not or only insignificantly increased.

Independently of the arrangement of the fibers in the insulation boards, the strength of the insulation layer will decrease in the course of time due to relaxation effects, i.e. by the relief of the tension that has been induced by the compression and the folding. These effects are accelerated and increased by a repeated mechanical load. In connection with the influence of water the mechanisms of hydromechanical effects caused thereby may result in considerable losses of strength as a consequence of a breakup of the structure.

The replacement of insulation layers that have been damaged and/or have lost their load bearing capacity as a consequence of influences of humidity is complicated and incurs among others high costs of disposal. In many cases it is expedient to supplement the damaged or insufficiently insulated top of the roof construction by additional insulation layers or by corresponding sealing constructions. For this purpose, the existing old sealing constructions are removed and, if their water vapor diffusion resistance is not too high, left in situ unchanged or after a perforation. Now, the easily deformable insulation layers each must exhibit a sufficient moment of resistance in the two horizontal axes of space, which fact requires both a bending-resistant cover layer and a bending-resistant basis.

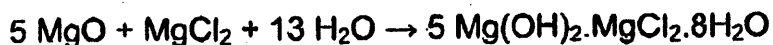
For the effectiveness of the cover layer a connection to the mineral fibers of the insulation layer is advantageous which is as intensive as possible. In this respect gluing with organic artificial resins has shown itself as a possible solution which, however, leads to a classification in a lower building material class. As an alternative solution inorganic glues modified with synthetic material are known, but these glues are frequently brittle and cannot be worked sufficiently deep into the insulation layer from mineral fibers which has the effect of an extremely fine filter, so that only thin layers will be formed. Thin layers of less than 20 mm thickness are too brittle for being effective here. On the other hand, the thicknesses of these layers cannot be increased at discretion, which is due to the thermal bridge effects.

In view of this prior art, the invention is based on the p r o b l e m of improving an insulating element of this kind with regard to its static properties, especially with regard to its bending strength and additionally with regard to its workability.

The s o l u t i o n of this problem provides that the coating consist of at least one reaction product from the reaction of light-burned magnesia (MgO) with at least one concentrated magnesium chloride solution.

The gist of the invention accordingly resides in the fact of forming insulating elements known per se, especially roof insulation boards, on one surface thereof with at least one bending-resistant layer which is non-positively connected to the said surface. Preferably, the coating consists of a Sorel cement to which are added, where appropriate, inorganic additives, finely ground glass fibers and/or waste material from mineral wool insulation materials. For reinforcing purposes also synthetic short fibers, wood and/or cellulose fibers may be added either supplementary or alternatively.

Sorel cement is an acid-base-cement, wherein an aqueous magnesium chloride solution serves as an acid and caustic burned magnesite (magnesium oxide) serves as a base. Depending on the reactivity of the magnesium oxide, the mixture will become hard within minutes or possibly only after hours, whereby the coating may be adjusted in such a manner that it hardens in a variable fashion within the manufacturing process of such insulating elements, so that depending on the manufacturing process quick or late hardening is selected. This may be useful with regard to the following processing steps, in which the coating is required to cure or is not yet required to cure. The stoichiometric formula reads as follows:



The resulting compound is a magnesium oxide chloride.

According to a further feature of the invention it is provided that the coating comprises a reinforcement. Preferably, the reinforcement consists of at least one, perforated two-dimensional element, especially from at least one tangled non-woven from glass fibers, woven glass fiber or cellulose and/or glass fiber staple fibers. These two-dimensional perforated structures have the advantage that at the use of coarser additives a possible filter action of the two-dimensional reinforcing materials is reduced or compensated. The number of

reinforcement layers amounts to one at minimum and to seven at maximum. The thickness of the reinforcements or of the coating is varied between 2 and 10 mm. There are built up particularly layer thicknesses of approx 3 and approx 7 mm. The coating may have recesses which are distributed over the surface area, in order to improve the water vapor diffusion through the element.

According to a further feature of the invention it is provided that on the coating a contact layer from a thin roof insulating board from mineral fibers, especially rock wool, is arranged. This contact layer has a layer thickness of between 5 and 40 mm, in particular between 15 and 25 mm, wherein it turned out advantageous to glue the contact layer together with the coating.

A further development of this embodiment provides that the gluing between the contact layer and the coating is caused by the gluing effect of the non-cured coating.

The contact layer establishes a contact between the coating and the roof sealing materials, for instance lengths of bitumen, laid on the insulating elements. The contact layer further serves as a water vapor pressure compensating layer. All in all, an insulating element according to the present invention is hence three-layered in the form of a sandwich element, wherein the coating is in connection with both the mineral fiber body of the insulating element and the contact layer. Here the gluing effect of the applied coating prior to its curing is utilized. If the contact layer is applied only after the curing of the coating, a non-reinforced thin Sorel cement layer can be used for this purpose which forms a connection between the contact layer and the coating on the mineral fiber body of the insulating element.

The above-described contact layer from a relatively thin mineral fiber board exhibits a relatively low strength and serves as a powder layer. The thickness of this contact layer is selected so that on one side mechanical fixing elements,

especially fixing washers bearing on the insulating element, will not penetrate into the insulating element so deeply that depressions are formed in which surface water may possibly accumulate. Moreover, this contact layer also has a thermal insulation effect and protects the coating from Sorel cement beneath the contact layer at least against influences of low temperatures which may lead to frost.

According to a further feature of the invention it is provided that the coating is treated and especially covered with diffusion-open impregnating and/or hydrophobing agents or with diffusion-open paints, especially silicate and/or latex paint systems. These diffusion-open impregnating and/or hydrophobing agents and/or diffusion-open paints reduce the effect of condensate which is frequently released from the rear side of the roof covering elements.

Finally, it is provided that the insulating element is formed as an insulation board having rectangular or triangular surfaces or as molded body having especially semi-cylindrical, spherical or arbitrarily vaulted surfaces.

Further features and advantages of the invention will become apparent from the following description by way of the drawings illustrating a preferred embodiment of the present invention. In the drawings it is shown by:

Figure 1 a first embodiment of an insulating element in the form of an insulation board and

Figure 2 second embodiment of an insulating element in the form on an insulation board.

In figure 1 a first embodiment of the insulating element 1 is shown. The insulating element consists of a mineral fiber body 2 which includes two major surfaces 3 which extend parallel to each other and spaced from each other. At

right angles to the major surfaces 3 the mineral fiber body 2 includes four lateral surfaces 4, two of which being shown in figure 1. The lateral surfaces 4 extend at right angles to the major surfaces and to each other.

On the surface 3 which is shown in figure 1 the insulating element 1 includes a coating 5 from Sorel cement.

The coating has a reinforcement 6 which consists of a two-dimensional element in the form of a tangled non-woven from glass fibers which is perforated.

Moreover it can be seen in figure 1 that the coating 5 includes two circular recesses 7 which penetrate through the entire coating 5 in the direction of the surface normal of the major surface 3.

The coating 5 has a thickness of 5 mm. The insulating element is formed as an insulation board.

A second embodiment of an insulating element 1 is illustrated in figure 2. Compared to the embodiment according to figure 1 the embodiment according to figure 2 is supplemented by a contact layer 8 which is connected to, namely glued together with the coating 5. The contact layer 8 consists of a thin roof insulation board from mineral fibers and has a layer thickness of 20 mm. The gluing between the contact layer 8 and the coating 5 is caused by a Sorel cement layer which is not further illustrated and which has been previously applied to the cured coating 5 free from reinforcements.

List of reference numbers

- 1 insulating element
- 2 mineral fiber body
- 3 surface
- 4 lateral surface
- 5 coating
- 6 reinforcement
- 7 recess
- 8 contact layer

Claims

1. Insulating element, particularly for heat and sound insulation of flat or slightly inclined roofs, which insulating element consists of mineral fibers, particularly glass fibers and/or rock wool fibers, which are bound with a binding agent, and comprising a first major surface facing a surface to be insulated and a second major surface extending parallel to and spaced from said first major surface, wherein said major surfaces are interconnected through lateral surfaces which are oriented substantially at right angles to each other and to the major surfaces, and comprising at least one coating which is arranged on one major surface,
c h a r a c t e r i z e d i n t h a t
the coating (5) consists of at least one reaction product from the reaction of light-burned magnesia (MgO) with at least one concentrated magnesium chloride solution.
2. Insulating element according to claim 1, characterized in that the coating (5) consists of a Sorel cement element.
3. Insulating element according to claim 1, characterized in that the coating (5) includes inorganic additives, finely ground glass fibers, mineral wool insulating material wastes, synthetic fibers and/or cellulose fibers, particularly wood fibers.
4. Insulating element according to claim 1, characterized in that the coating (5) includes a reinforcement (6).
5. Insulating element according to claim 1, characterized in that the reinforcement (6) consists of at least one, preferably perforated two-dimensional element, particularly from at least one tangled non-woven

from glass fibers, glass fiber or cellulose woven and/or glass fiber staple fibers.

6. Insulating element according to claim 1, characterized in that the reinforcement (6) includes seven layers of two-dimensional elements at maximum.
7. Insulating element according to claim 1, characterized in that the coating (5) includes at least one recess (7) which penetrates through the entire coating (5) in the direction of the surface normal of the major surface (3).
8. Insulating element according to claim 4, characterized in that the reinforcement (6) or the constituent parts thereof have, altogether or individually, a layer thickness of between 2 and 10 mm, particularly between 3 and 7 mm.
9. Insulating element according to claim 1, characterized in that on the coating (5) a contact layer (8) from a thin roof insulation board from mineral fibers, especially rock wool fibers, is arranged.
10. Insulating element according to claim 9, characterized in that the contact layer (8) has a layer thickness of between 5 and 40 mm, particularly between 15 and 25 mm.
11. Insulating element according to claim 9, characterized in that the contact layer (8) is glued together with the coating (5).
12. Insulating element according to claim 11, characterized in that the gluing between the contact layer (8) and the coating (5) is formed by the gluing effect of the non-cured coating (5).

13. Insulating element according to claim 11, characterized in that the gluing between the contact layer (8) and the coating (5) is formed by Sorel cement layer which is arranged on the cured coating (5) free from reinforcements.
14. Insulating element according to claim 1, characterized in that the coating is treated, particularly covered with diffusion-open impregnating and/or hydrophobing agents and/or diffusion-open paints, particularly silicate and/or latex paint systems.
15. Insulating element according to claim 1, characterized by a configuration as an insulation board having rectangular or triangular surfaces or by a configuration as a molded body, especially with semi-cylindrical, dome-shaped or arbitrarily vaulted surfaces.