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LAMINATED VAPOR BARRIER SHEET MATERIAL

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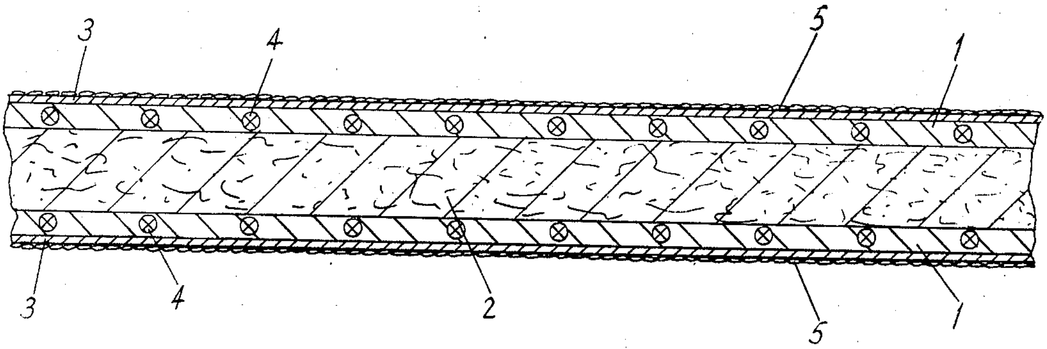


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# LAMINATED VAPOR BARRIER SHEET MATERIAL

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This invention relates to a composite sheet material that is particularly adapted to use as a vapor barrier and moisture shield for building structures. Such a vapor barrier provides essential protection against moisture transmission through walls, foundations and floor slabs which are in contact with, or close proximity to, the earth on which the building stands. This protection is especially necessary where the floor slab is placed directly on the earth without any basement space beneath it. Otherwise, entrance of moisture into the interior of the building by vapor transmission and capillary seepage through the slab is virtually certain, and can result in serious damage to the interior finish materials, floors and furnishings, as well as discomfort to the occupants. To be fully effective, the vapor barrier must seal the slab completely from the on-grade site on which it is placed.

It has been common practice to damp-proof or waterproof foundation walls by application to the outer surface, which will be in contact with the earth, of a layer of solvent cut bituminous coating or mastic, or of melted hot asphalt. This method, if carefully used, affords some resistance to water vapor transmission, but the vapor barrier may be ineffective due to pin holes or voids in the coating in certain areas. In any event this method is not applicable in any practical manner to provide a continuous vapor barrier underneath a floor slab which is to be placed directly on the earth or on a sand or gravel fill. For such a situation the vapor barrier must be in sheet form so that it can be installed before the floor slab is cast in place.

Various sheet materials have been used as vapor barriers for floor slabs and foundation walls and have given more or less satisfactory results. These have included asphalt coated and saturated organic-fiber roofing felt, asphalt coated and laminated (duplex) paper, asphalt laminated organic fiber plyboard, and plastic films such as polyethylene. These materials vary greatly in their effectiveness as vapor barriers and all of them have deficiencies which may cause failure in service.

All the sheet materials made with an organic fiber base, such as the asphalt duplex paper, asphalt coated and saturated roofing felt and asphalt-combined plyboard, are subject to swelling and deterioration by the absorption of moisture. Even more serious, they are vulnerable to attack by soil bacteria and fungi which may in a relatively short time actually destroy the organic fibers and the continuity of the sheet structure, so that the sheet no longer provides a vapor barrier. Obviously, the vapor barrier for a floor slab should be as permanent as the slab itself, and retain its integrity and effectiveness as a vapor barrier throughout the useful life of the building. The organic fiber sheet materials fail to meet this requirement. It is obvious that there is no practical way to repair or replace a vapor barrier that has failed underneath a floor slab or on the exterior surface of a foundation wall.

The plastic film materials such as polyethylene are good moisture vapor barriers if used in proper thickness. However, because of the high cost per pound of these synthetic materials they are invariably used as very thin films on the order of .005 inch thickness or less. Such a thin film lacks strength and is easily damaged by puncturing or tearing during installation at the building site, so that its effectiveness as a vapor barrier may be destroyed even before it is in service. Such damage could be minimized by using a thicker and tougher sheet of the material, but then the cost would become excessive. Thin film vapor barrier sheets also are subject to damage by tearing or puncturing as a result of soil stresses, gravel pressure, and the like, after they are in place.



It is the purpose of our invention to overcome the deficiencies that have been inherent in previous sheet form vapor barrier materials, and to provide a new vapor barrier sheet for building structures that has (1) extremely high resistance to permeation by water vapor or water in the liquid state, (2) great strength and toughness to resist damage caused by handling during installation, or by earth stresses or punctures after installation, and (3) retention of high resistance to vapor transmission, and the greater part of its original strength properties, even after long periods of contact with water or with moist earth containing soil bacteria and fungi.

We have discovered that the above stated purposes can best be accomplished by fabricating the vapor barrier as a composite, laminated sheet material of substantial thickness, in which each of the component layers is of material which inherently has high resistance to moisture vapor transmission and to deterioration by moisture or soil contact. When combined into the laminated structure these components then cooperate to enhance the overall properties of the finished sheet product so that the results in strength, toughness and long term resistance to moisture vapor transmission are more than merely additive for the individual layers.

The accompanying drawing illustrates a typical embodiment of our invention. The laminated structure is seen to be composed of a central layer **2** of a bituminous mastic composition, encased between two layers **1** of bitumen-saturated asbestos felt or paper. The asbestos felt layers **1** are shown as containing embedded glass threads **4** as mechaniual reinforcement of their structure. The outer surfaces of the asbestos felt layers are coated and sealed with a thin layer **3** of a bituminous coating. Thus each surface of the asbestos felt is sealed with a bituminous coating. To prevent sticking together of the laminated sheets in storage and shipment the outer surfaces are provided with an anti-stick surfacing **5**, which may be a fine mineral material, such as mica, talc or sand, or may be a thin film of organic material such as soap.

The glass thread reinforcement greatly enhances the toughness and tear strength of the laminated vapor barrier sheet. The threads are shown as embedded in the asbestos felt layer **1** which is conveniently done while the asbestos sheet is being produced on the paper machine. The glass threads are normally inserted parallel to the machine direction of the paper and spaced from ¼ inch to 1 inch apart. However, the vapor barrier sheet may also be reinforced with glass fibers in other ways. For example, the glass threads may be placed at the interface between the saturated felt layer **1** and the mastic layer **2**, either as parallel threads or as random fibers, or as continuous thread applied as a "swirl" from a gun or other feeding device. Similarly, preformed glass fiber mat or fabricated open mesh glass scrim can be inserted into the laminated structure either at the interface between layers **1** and **2** or embedded entirely within the layer **2**. While the reinforcement of our laminated vapor barrier sheet with glass threads or fibers is considered preferable, such reinforcement can be omitted without detracting appreciably from its very high resistance to vapor transmission and without loss of its retention of the original properties of the product in service under extreme moisture conditions.

The bituminous materials used as saturant, mastic and coating for our laminated vapor barrier sheet may be either of asphaltic or coal tar origin. Generally, we prefer to use asphaltic materials because of their greater durability, lower susceptibility to temperature changes, and lower tendency to oxidation and embrittlement with age. The bituminous mastic between the saturated asbestos sheets, which holds the combined structure in laminated form, is preferably an air-blown coating type asphalt. It may, if desired, be compounded with a mineral stabilizer such as slate flour, limestone dust, fine mica, pulverized oyster shell or other finely divided minerals which have been demonstrated to increase the durability of asphaltic compositions. We exclude from the mastic composition any substantial amount of any mineral stabilizer which is hygroscopic or water soluble, such as hydrated lime, or which swells or disperses in contact with water, such as plastic clay or bentonite, as we have found that such minerals affect deleteriously the resistance to moisture transmission and the retention of properties of the vapor barrier in service.

The laminated vapor barrier sheet may be made in various thicknesses depending on the severity of the service conditions or strength requirements, but usually is in the range from 0.100" to 0.250" thickness and weighs from 80 to 200 lb. per 100 sq. ft. For most service conditions a thickness of ⅛ inch (0.125") is adequate. To minimize the cementing of sheet laps it is desirable that the sheets be as large in area as is practical for handling and installation. Sheets or rolls can be produced in machine widths, usually from 36" to 72", and in various lengths as required. The product of our invention may be described as semi-rigid, but has sufficient pliability to enable the sheet to conform to considerable irregularity of the earth contours over which it is laid.

As a specific example of one preferred embodiment of our invention we have fabricated a laminated vapor barrier sheet, as follows:

Two sheets of asbestos felt, reinforced with parallel glass threads spaced ¼ inch apart, and each weighing about 5.5 lb. per 100 sq. ft. were each saturated with about 1.8 lb. of asphalt. These two sheets were combined under heat and pressure with about 74.0 lb. of an asphalt mastic composed of about 60% coating-type asphalt and 40% limestone dust by weight. The outer surfaces of the combined sheet were each coated with about 3.0 lb. of coating asphalt per 100 sq. ft. One surface of the combined coated sheet was surfaced with about 2.0 lb. of flake mica, and the other surface was coated with about 1.0 lb. of a water soluble soap, both to function as anti-stick materials. The completed vapor barrier sheet had a thickness of about 0.125" (⅛ inch) and weighed about 100 lb. per 100 sq. ft.

It is thus apparent that while the composite vapor barrier sheet of our invention has the form of a sturdy semi-rigid board which can be readily handled in pieces of large unit area, it is in fact composed of about 83% by weight of asphaltic mastic, coating and saturant materials which afford high resistance to vapor transmission.

While we have given a specific example of the construction of a laminated vapor barrier sheet in accordance with our invention, it will be apparent that considerable variation in the components is permissible while still obtaining the principal advantages and superior properties and serviceability of our product. Thus, the asbestos felt may vary in weight from about 5.0 to about 10.0 lb. per 100 sq. ft. before saturation. Normally, this felt will absorb about 30% to 50% of asphalt or other bituminous saturant by weight. Thus the saturated felt will weigh from about 6.5 to about 15.0 lb. per 100 sq. ft. The bituminous coating used to coat and seal the outer surfaces of the laminated sheet will range from about 2.0 to about 10.0 lb. per 100 sq. ft. of surface. Less than 2.0 lb. would not be adequate to seal the surface against moisture.

The product of the above-described exemplary embodiment of our invention was found to have the extraordinarily low vapor permeance of 0.0047 perms when tested by A.S.T.M. Standard Method E 96–53T, Procedure A. The perm is defined as a vapor transmission rate of 1 grain of water vapor per sq. ft. per hour per inch of mercury vapor pressure difference. A vapor barrier is a material which is sufficiently resistant to vapor transmission (i.e., which has a sufficiently low vapor permeance) to retard the passage of water vapor from zones of high to those of lower vapor pressure. For dwellings, a vapor barrier is generally required to have a permeance of less than 1.0 perm, but for slab-on-ground construction the requirement has varied from 0.2 to 0.5 perm, depending on variations of the A.S.T.M. test procedure used for its measurement and on the limits established by the specifying authorities.

As compared with the most rigid such specification requirement (0.2 perm) the above example of our new laminated asbestos vapor barrier sheet has a water vapor transmission resistance about 40 times as great. Water vapor transmission rates of various vapor barrier sheet materials that have been generally used are typically of the following orders.

| | Water vapor transmission, perms |
|---|---|
| Asphalt coated roofing (organic fiber) felt | 0.03 |
| Asphalt coated duplex paper | 0.30 |
| Polyethylene film 0.004" thickness | 0.10 |

In combination with its extremely high effectiveness as a vapor barrier, our new product has exceptional strength and toughness. Even more important, it has the ability to retain a large part of its vapor resistance and strength even after long exposure to severe moisture and soil contact conditions.

The requirements for satisfactory performance of vapor barrier materials for use with slab-on-ground construction have been investigated by the Building Research Advisory Board (BRAB) for the Federal Housing Administration (FHA) and their report was published by the National Academy of Sciences—National Research Council in 1956 as Publication 445. In addition to the A.S.T.M. water vapor permeance test above referred to, this report recommended several tests of a performance nature intended to measure the degree and rate of deterioration of the original (as installed) properties of the vapor barrier sheet under severe moisture and soil contact condition to which such vapor barriers are exposed in service.

To illustrate the effectiveness of our new asbestos laminated vapor barrier sheet, particularly in respect to its retention of the essential properties of vapor resistance, integrity and strength under service exposure, we have compared it with a substantially identical laminated vapor barrier sheet in which the components, thickness and weight are all virtually identical with those of our new product except that an organic fiber felt was used in the structure instead of the glass-reinforced asbestos felt. The tests used were those of the above BRAB-FHA publication.

BRAB-FHA TEST NO. 1 AS MANUFACTURED

| | Water vapor transmission, perms (A.S.T.M. E96–53T) |
|---|---|
| Asbestos laminated vapor barrier sheet (A) | 0.0047 |
| Organic fiber laminated vapor barrier sheet (O) | 0.0082 |

BRAB-FHA TEST NO. 2 (MODIFIED)

Resistance to water vapor transmission after alternate wetting and drying (13 days)

| | Water vapor transmission, perms (A.S.T.M. B96–53T) |
|---|---|
| Asbestos laminated vapor barrier sheet (A) | 0.0047 |
| Organic fiber laminated vapor barrier sheet (O) | 0.2868 |

The results of this test show no loss of moisture vapor transmission resistance for our new asbestos laminated vapor barrier. The alternate wetting and drying, however, has greatly increased the permeance of the vapor barrier sheet fabricated from organic fiber felt. After completion of the test the (O) vapor barrier shows 60 times as great a rate of water vapor transmission through the sheet as for the asbestos laminated (A) vapor barrier which had been subjected to the same alternate wetting and drying.

BRAB-FHA TEST NO. 4.—EFFECT OF SOAKING IN WATER FOR 7 DAYS ON STRENGTH

| | Average tensile strength, per inch of width | |
|---|---|---|
| | Dry | Wet |
| Asbestos laminated vapor barrier sheet (A) | 62 | 61 |
| Organic fiber laminated vapor barrier sheet (O) | 95 | 52 |

The test results show that after only 7 days of water soaking the (O) organic fiber sheet has lost almost half (45%) of its original tensile strength while our asbestos laminated sheet (A) has lost almost none.

Similar results are obtained when the two products are subjected to the Mullen bursting strength test, after 7 days water soaking.

| | Mullen strength, lb. | |
|---|---|---|
| | Dry | Wet |
| Asbestos laminated vapor barrier sheet (A) | 135 | 132 |
| Organic fiber laminated vapor barrier sheet (O) | 151 | 117 |

When the two products were tested, dry and wet, by the General Electric impact puncture test (A.S.T.M. Method D781–59T) again the test results showed that the asbestos laminated vapor barrier sheet retained its original puncture resistance after 7 days water soaking, but the organic fiber product did not.

| | G.E. puncture test | |
|---|---|---|
| | Dry | Wet |
| Asbestos laminated vapor barrier sheet (A) | 240 | 240 |
| Organic fiber laminated vapor barrier sheet (O) | 280 | 190 |

Thus, it is evident that while the original strength properties of the asbestos laminated vapor barrier sheet are somewhat lower than those of the similar laminated vapor barrier made with organic fiber felt, the asbestos laminated product has superior retention of its original strength when subjected to moisture conditions. In fact, it shows virtually no loss of strength as a result of water soaking.

BRAB-FHA TEST NO. 5.—RESISTANCE TO DECAY IN 28 DAY SOIL BURIAL TEST

| | Water vapor transmission, perms (A.S.T.M. E96–53T) | |
|---|---|---|
| | Original | After soil burial |
| Asbestos laminated vapor barrier sheet (A) | 0.0047 | 0.00098 |
| Organic fiber laminated vapor barrier sheet (O) | 0.0082 | 0.1327 |

In this test the specimens of the two vapor barrier sheets were buried under identical conditions in a special composted soil rich in bacteria and other forms of microbial life. The soil was moistened, and the specimens held under these conditions for 28 days at a temperature of 82° F. The specimens were then removed from the soil, air dried and their water vapor transmission determined, following the procedure of BRAB-FHA Test No. 1 above.

The unexpected and amazing results of the soil burial test, given above, show that our asbestos laminated vapor barrier sheet did not deteriorate but actually improved in vapor transmission resistance as a result of this test exposure and its vapor permeance became virtually nil and remained so during the 71 days that the vapor transmission test was continued. The organic fiber laminated vapor barrier sheet (O) on the contrary, lost nearly all of its original moisture vapor transmission resistance as a result of the soil burial and at the end of the test period its vapor permeance had increased to 16 times its original value.

The installation of our new asbestos laminated sheet as a vapor barrier for slab-on-ground construction of large areas is quite simple. The sheets are simply laid directly over the prepared earth or gravel fill with the sides and ends lapsed about 6 inches. The lapped areas are cemented together with a continuous layer about $\frac{1}{16}$ inch thick of a heavy consistency, solvent-cut bituminous cement or hot mopping asphalt, and the laps then are rolled to insure complete and effective sealing. This provides a complete, prefabricated vapor barrier membrane, upon which the concrete slab may then be cast directly.

Where the asbestos vapor barrier sheet is to be applied on the exterior surface of a foundation wall this is most conveniently done by cementing the sheets to the surface with a trowel consistency bituminous cement or hot mopping asphalt, with the sheet edges butt joined. Then a batten strip of the vapor barrier sheet cut to suitable width is cemented in the same manner over the butt joint to completely seal the joint.

It will be understood that the asbestos laminated vapor barrier of our invention may be made in a variety of modifications within the ranges that we have disclosed. It is not our intention to limit our invention except as set forth in the following claims.

What is claimed as new and what it is desired to secure by United States Letters Patent is:

**1.** A laminated vapor barrier sheet material having high resistance to moisture vapor transmission and to deterioration by moisture and moist earth, comprising a layer of bituminous mastic encased between sheets of bitumen-saturated asbestos felt, the outer exposed surfaces of said asbestos felt sheets being coated and sealed with a thin layer of a bituminous coating, and said coated surfaces having a thin layer of anti-stick material thereon, said vapor barrier sheet being characterized by high strength, toughness, sufficient pliability to conform to irregularities of earth contours, and high retention of moisture vapor transmission resistance, integrity and strength during prolonged exposure to moisture and to contact with moist soil.

**2.** Sheet material according to claim **1**, wherein said layer of bituminous mastic is thicker than said sheets of abestos felt.

**3.** A laminated vapor barrier sheet material having high resistance to moisture vapor transmission and to deterioration by moisture and moist earth, comprising a layer of an asphaltic mastic encased between sheets of asphalt saturated asbestos felt, the outer exposed surfaces of said asbestos felt sheets being coated and sealed with a thin layer of asphalt coating, and said coated surfaces having a thin layer of anti-stick material thereon, said vapor barrier sheet being characterized by high strength, toughness, sufficient pliability to conform to irregularities of earth contours, and high retention of moisture vapor transmission resistance, integrity and strength during prolonged exposure to moisture and to contact with moist soil.

**4.** Sheet material according to claim **3**, wherein said layer of asphaltic mastic is thickner than said sheets of asbestos felt.

**5.** A laminated vapor barrier sheet material in accordance with claim **3**, having an intermediate layer of glass fibers as strength reinforcement for the laminated structure.

**6.** A laminated vapor barrier sheet material in accordance with claim **3**, in which the asbestos felt sheets are reinforced with glass threads placed within the asbestos sheet structure.

7. A laminated vapor barrier sheet material in accordance with claim 3, in which the asphaltic mastic contains about 40% by weight of a finely divided, substantially water-insoluble, substantially non-hygroscopic mineral stabilizer.

8. Sheet material according to claim 7, wherein said mineral stabilizer is selected from a group consisting of slate flour, flake mica, limestone dust and pulverized oyster shell.

9. A laminated vapor barrier sheet material having high resistance to moisture vapor transmission and to deterioration by moisture and contact with moist earth, composed of a layer of as asphaltic mastic encased and bonded between two sheets of asphalt saturated glass-fiber-reinforced asbestos felt, each of said saturated asbestos sheets weighing at least about 6.5 lb. per 100 sq. ft., said laminated vapor barrier sheet being coated on both its outer surfaces with at least about 2.0 lb. per 100 sq. ft. of coating and sealing asphalt and said coated surfaces being covered with an anti-stick surfacing, said laminated vapor barrier sheet having a total thickness of at least 0.100 inch and weighing at least 80.0 lb. per 100 sq. ft., said vapor barrier sheet being characterized by high strength, toughness, puncture and abrasion resistance, having sufficient pliability to conform to irregularities of earth contours, and by high retention of moisture vapor transmission resistance, toughness, integrity and strength during prolonged exposure to moisture and to contact with moist soil containing bacteria and fungi.

10. Sheet material according to claim 9, wherein said asphaltic mastic is compounded with a finely divided substantially water-insoluble, substantially non-hygroscopic mineral stabilizer.

11. A laminated vapor barrier sheet material having high resistance to moisture vapor transmission and to deterioration by moisture and contact with moist earth,



composed of a layer of an asphaltic mastic encased between two sheets of asphalt saturated asbestos felt, each of said saturated asbestos sheets being in the range of 6.5 to 15.0 lb. weight per 100 sq. ft., said laminated vapor barrier sheet being coated on both of its outer surfaces with from 2.0 to 10.0 lb. per 100 sq. ft. of coating asphalt and said coated surfaces being covered with an anti-stick surfacing, said laminated vapor barrier sheet being in the thickness range from 0.100 inch to 0.250 inch and weighing from 80.0 to about 200 lb. per 100 sq. ft., said vapor barrier sheet being characterized by high strength, toughness, puncture and abrasion resistance, having sufficient pliability to conform to irregularities of earth contours, and by high retention of moisture vapor transmission resistance, toughness, integrity and strength during prolonged exposure to moisture and to contact with moist earth containing bacteria and fungi.

12. Sheet material according to claim 11, wherein said asphaltic mastic is compounded with a finely divided, substantially water-insoluble, substantially non-hygroscopic mineral stabilizer.


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