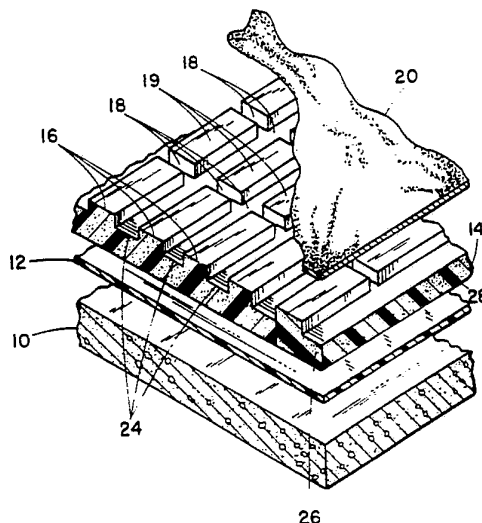




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/US91/02819 (22) International Filing Date: 24 April 1991 (24.04.91) (30) Priority data: 545,154 28 June 1990 (28.06.90) US (71) Applicant: THE DOW CHEMICAL COMPANY [US/ US]; 2030 Dow Center, Abbott Road, Midland, MI 48640 (US). (72) Inventor: PETERSON, Wayne, E. ; 8732 Cottonwood Lane, Eden Prairie, MN 55347 (US). (74) Agent: DEAN, J., Robert, Jr.; The Dow Chemical Com- pany, P.O. Box 1967, Midland, MI 48641-1967 (US).</p>		<p>(81) Designated States: AT (European patent), AU, BE (Euro- pean patent), BR, CA, CH (European patent), DE (Euro- pean patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), HU, IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent).</p> <p><b>Published</b> <i>With international search report.</i></p>

(54) Title: METHOD FOR PLAZA DECK CONSTRUCTION



(57) Abstract

Disclosed is a method to construct a plaza deck/parking structure comprising affixing a porous, water-permeable fabric layer (20) to the top of a plurality of plastic foam panels (14) having a channeled (18) and ribbed surface structure, placing a waterproof membrane (12) on top of a base deck (10), placing the plurality of panels (14) being affixed fabric (20) on top of the waterproof membrane, and pouring wet concrete on top of the fabric layer (20) and allowing the concrete to cure to a solid layer (22). The fabric layer (20) permits the wet concrete to be poured directly onto the fabric (20) covered foam panels (14) as opposed to solid, heavy concrete slabs being transported to and placed on top of the foam panels (14). The channeled (18) ribbed (16) structure of the foam plastic insulation (14) provides for ventilation and moisture removal which leads to better wearability of the insulation material in the plaza deck/parking structure. Further disclosed is a plaza deck/parking structure made according to the above methods.

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## METHOD FOR PLAZA DECK CONSTRUCTION

This invention relates to a method for constructing plaza decks or the like. A plaza deck is typically made up of a structural deck, a waterproof (nonpermeable) membrane, an intervening foam insulation board, and a top concrete wearing slab. A known problem  
5 with this type of structure is a moisture build-up between the wear slab and the membrane. This degrades the insulation value of the foam insulation board and can, and often does, cause freeze/thaw spalling of the cementitious wearing slab. In order to alleviate the  
10 problems caused by moisture build-up between the wearing slab and the membrane, it is understood by the industry (and further supported by ASTM standard) that drainage is required (or at least recommended) between the  
15 insulation and the top covering. Some applications also include drainage between the membrane and the insulation. Drainage reduces the possibilities of moisture accumulation in the insulation (and therefore a reduction in thermal resistance) and moisture  
20 accumulation in the bottom side of the wear slab and, therefore, reducing the potential for freeze/thaw spalling.

25

With standard insulation products currently being used in plaza deck construction, the drainage layer usually consists of loose gravel or epoxy bound gravel. This drainage layer is often covered with a layer of construction fabric which is then covered with poured concrete or a preformed concrete panel. The labor and material costs associated with installation of such a gravel layer above or above and below the membrane are significant because loose gravel and/or epoxy bound gravel require considerable handling expertise in order for them to be transported to the job site, and these materials require intensive labor to be applied. Further, the gravel layer adds weight necessitating structural considerations and height which is often limited in reroof situations causing detailing difficulties.

Ways to avoid the installation of loose gravel or epoxy bound gravel as the drainage layers in these protected membrane roofing structures were recited in U.S. Patents 4,658,554 and 4,712,349. In both of these patents, the insulation layer itself provides the necessary drainage in that the insulation is a type of foamed plastic that is sculpted such that its top surface is made up of elongated ribs arrayed, with cut-out channels interposed between them, with the walls surrounding the channels demarking the ribs. This channel/rib construction provides for drainage of moisture that accumulates between the insulation panels and wearing slabs. In both of these patents all of the insulation panels have a plastic film laminated to the lower surface of the insulation panel such that the plastic film prevents migration of moisture vapor through the insulation to the insulation-wearing slab

interface from the waterproof membrane. This type of dual moisture retarder and drain-away system provides for adequate drainage in these types of roofing structures.

5           The disadvantage of the methods outlined in the '554 and the '349 patent is that in both methods, in order to finish the roofing structure, concrete panels have to be laid directly on top of the polystyrene foam. Because the concrete panels have to be laid directly on  
10 top of the foam, this means that these concrete panels have to be created in one location, then transported to the job site, and at the job site the panels have to be lifted to the working area, wherever it may be--the  
15 roof--or various levels of a parking structure. As is well known, the transportation of extremely heavy, unbalanced concrete slabs is difficult, time consuming and extremely expensive, both from a materials  
20 standpoint and a labor standpoint. Further, a top covering comprised of preformed wearing slabs is typically not appropriate for loads heavier than pedestrian traffic. For loads like vehicle traffic monolithic wearing slabs are needed to adequately  
25 distribute loads and prevent damage to the underlying insulation layer.

30           In the present invention, the need for gravel or epoxy bound gravel layers and/or the need to use only preformed concrete slabs is eliminated by replacing standard solid foam insulation or foam with top channels  
with a foam insulation layer having drainage channels formed in its upper surface and also having a layer of porous construction fabric stretched over said channels and affixed to the foam. This foam composite is laid on the water impermeable layer, fabric covered channels

facing up, and wet concrete or an equivalent construction composite material is poured over said fabric. After shaping to the desired size and thickness, the concrete is allowed to cure in a conventional manner. The resulting structure has excellent properties for its intended use. This method also has a great cost savings advantage over current typical methods of plaza deck construction in that it is less labor intensive because it eliminates certain layers of materials that have to be applied. Also, it is less expensive because the application of concrete is no longer a multi-step process of forming the concrete, transporting it to the job site, and applying it at the required level. With this method the concrete is simply poured wet onto the top of the foam layer and allowed to cure there, which saves time, energy and money.

Fig. 1 is a fragmentary cross-sectional view of a plaza or parking deck structure constructed in accordance with the principles of the present invention;

Fig. 2 is an exploded fragmentary perspective view showing one embodiment of the cross-cutting channels and rib structure in the foam panels and a cut-away view of the porous fabric layer covering the panel without showing the top concrete layer; and

Fig. 3 is a fragmentary cross-sectional view of another embodiment of the plaza or parking deck structure, constructed in accordance with the principles of the present invention, in which the foam layer includes channels on both the top and bottom.

In the preferred embodiment, a waterproof membrane 12 overlies a base deck 10 made of reinforced

concrete or the like. Membrane 12 can be attached to based deck 10, or can be placed loose on the deck. Membrane 12 can be a single sheet of polymeric material, liquid applied, modified bituminous sheet, or it can be an asphalt built up membrane. Insulation foam panels 5 14, preferably made of polystyrene foam, are laid on top of membrane 12. Foam panels 14 include, on the top surface only, (Figs. 1 and 2) integral ribs 16 interspaced by channels or valleys 18.

10           The ratio of channel area to the total surface area of the foam panel is 20 percent to 80 percent. A ratio of 40 percent channel area to the total surface area of the foam panel was selected as the ratio for use 15 in testing of the system. The channel area is defined as the sum of the products of the widths and the lengths of each of the bottoms of channels within the foam panel. The total surface area of the foam panel is defined as the area of the plane of the panel along the 20 surface defining the channeled and ribbed structure therein. Alternately, the total surface area of a panel may be defined as the sum of the channel area plus the area of top surfaces 19 of ribs 16.

25           The channels either can be created when the foam panel is extruded or they can be created by cutting the panels after they have been formed. Methods found to be workable in forming the grooves include cutting them with a router or a hot wire or a hot knife.

30           There are no measurable differences in compressive strength and moisture permeability of foam panels that have had channels formed when the panels

were extruded versus foam panels that had had channels cut into them by one of the above-listed methods.

The panels themselves have length and width dimensions in which the length varies from 7.6  
5 centimeters to 1.2 meters and the width varies from 1.2 meters to 6.1 meters. The dimensions of the panels primarily used in the development of this invention were 0.6 meters by 1.2 meters and 0.6 meters by 2.4 meters.  
10 Product size is not a critical factor, but handleability is. Within these plaza deck construction areas, foam panels 14 must not be so large as to be blown from a roof before concrete can be applied to hold them down.

The width of the channels in the top surface of  
15 each panel varies from 0.16 centimeters to 2.5 centimeters. A midrange of values of the width of the channels is 0.32 centimeters to 1.3 centimeters and the width of the channels on the panels primarily used in  
20 developing this invention was 0.48 centimeters to 0.95 centimeters.

The depth of the channels in the top surface of  
25 each panel varies from 0.25 centimeters to 2.5 centimeters. A midrange of values for the depth of the channels is 0.32 centimeters to 1.3 centimeters and the depth of the channels on the panels primarily used in  
30 creating this invention was 0.64 centimeters to 0.95 centimeters.

The ribs around the channels in the preferred embodiment varied in width from 0.32 centimeters to 12.7 centimeters. An intermediate range of values for the width of the ribs is from 0.64 centimeters to 2.5 centimeters. The width of the ribs in the panels

primarily used in creating this invention was 1.3 centimeters.

The compressive strength of the foam panels varies from 69 kilopascals (kpa) to 1380 kpa. Target values for compressive strength of the foam panels used in developing this invention were 172 kpa, 345 kpa and 483 kpa. The compressive strength of the foam panels would have to be greater when the depth of the channel was reduced, in order for the channel to remain intact because of the weight of the concrete.

The channel-rib structure on the foam panels can be in any pattern desired from straight lines to an interconnecting pattern of rectangular ribs and channels, to some sort of diamond pattern or even a "wiggle-waggle" pattern of interconnecting curved channels with odd-shaped ribs. Fig. 2 shows a rectangular pattern of inter-connected channels and ribs on the top surface of the foam panel.

An additional pattern of channels and ribs can be constructed on the bottom of each foam panel (Fig. 3). Should there be this additional pattern of channels and ribs on the bottom of each foam panel then the ratio of channel area on the bottom to the total channel area (on the top and bottom) is from 5 to 50 percent.

The foam material at the rib section 16 is preferably stronger, more rigid, and more deformation resistant than is the material 24 beneath channels 18. In use, foam panels 14 are abutted together along the longitudinal side edges 26 thereof. The ends 28 of panels 14 also are abutted together. While these panels

are preferably made of polystyrene foam, other foam insulating materials could also be used. The foam panels made of polystyrene are made of the closed cell variety of polystyrene to prevent moisture penetration.

5 Porous fabric 20 is adhered by an adhesive, such as a hot melt adhesive or a 1-part or 2-part urethane adhesive, to the top surface 19 of ribs 16, as shown in Fig. 2. (The concrete wear slab 22 is not shown in Fig. 2 so that fabric 20 is clearly visible.)  
10 Fabric 20 may be affixed to foam panels 14 either prior to or after the placement of panels 20 on membrane 12, but is preferably affixed prior to such placement. Fabric 20 is sufficiently porous to permit free passage  
15 of water into the channels, but not so porous as to permit wet concrete to significantly penetrate channels 18 on the top surface of panel 14. Porous fabric 20 can be either a non-woven or woven fabric. Two materials that fabric 20 could be made of include polypropylene  
20 and fiberglass. Typical standards for the fabric are: a weight per panel of 4.10 grams/square meter and grab strength 52.2 kilograms; a flow rating of 42 liters per square meter per minute; and an equivalent opening size on U.S. units of 70 to 100. (These numbers are typical  
25 property values and not to be construed as rigid specifications.)

30 In use, impermeable membrane 12 is first placed on base deck 10. Foam panels 14 are then arranged in a closely adjacent edgewise fashion on impermeable membrane 12, with the fabric covered channels facing up. Once foam panels 14 are all in place, concrete is poured on top of fabric 20 and allowed to cure into concrete slab 22. During the pouring of the concrete, fabric 20

prevents the wet concrete from significantly entering channels 18 in panel 14.

5 There is a slight adjustment in the level of concrete required, for poured-in-place concrete top coverings because the profiled surfaces reduce the modulus of foundation at the foam. Therefore, when a rib profiled product is considered, in order to maintain the same maximum loading capabilities (flat board stock and gravel versus profiled foam), a slightly thicker  
10 concrete layer would be required (about 5 percent) if the apparent foundation modulus of the insulation product is reduced in half.

15 Fig. 3 illustrates an embodiment of the invention in which channels are cut, not only in the top, but also on the bottom of panel 14. Channel 17 on the bottom of panel 14 can be aligned with channels 18 on the top of panel 14 in order to maximize the load bearing strength of ribs 16. The embodiment shown in  
20 Fig. 3, with a top and bottom pattern of channels would have enhanced drainage capabilities.

25 This invention works to drain moisture away from the critical layers in plaza deck construction because the structure of the channels in the surface of the foam insulation panels permits air circulation so that any rain water or other moisture that penetrates to the insulation layer is trapped and ends up dissipating  
30 on hot, dry days. Moisture penetration of the foam panel, and resulting loss of insulating qualities, therefore, is substantially reduced by the present invention. As stated in the previous section, certain interconnecting patterns of channels allow for multi-

directional drainage due to the cross-cutting linkage of the ribs and channels.

5 An existing commercial product that will work in the method of this invention to provide the fabric covered insulation foam panels is STYROFOAM® THERMADRY®  
10 Brand Insulating Drainage Panels of The Dow Chemical Company. Styrofoam® Thermadry® Brand Insulating Drainage Panels have heretofore been recommended for use only in below-ground construction in which the panels are placed vertically against an in-place foundation to aid in drainage of moisture away from the foundation. Styrofoam® Thermadry® Brand Insulating Drainage Panels have not, prior to the present invention, been  
15 recommended by the manufacturer for horizontal plaza deck applications, where concrete would be poured over the upper channeled surface.

20 These and other objects and benefits of the invention will be more clearly understood with reference to the attached drawings and appended claims. This description of the preferred embodiment is not intended to be a limitation on any obvious and expected variations of the above-described invention.

25

30

1. A method for constructing a plaza deck/parking structure according to the following steps:  
providing a plurality of panels of foam plastic insulation having an alternately channeled and ribbed surface structure;

5

providing a porous fabric layer sufficiently porous to permit the passage of water vapor therethrough but not so porous that wet concrete would significantly penetrate therethrough;

10

affixing the fabric layer to the top of said ribs on each of said panels;

providing a base deck;

15

placing the plurality of panels of foam plastic insulation of top of said waterproof membrane;  
and

20

pouring wet concrete on top of the moisture permeable fabric layer and allowing the concrete to cure to a solid layer.

2. The method for constructing a plaza deck/parking structure of Claim 1 in which said panels

25

of foam plastic have a channeled and ribbed surface structure on both their top and bottom surfaces.

5 3. The method of constructing a plaza deck/parking structure of Claim 1, in which the foam plastic insulation panels are made of foam polystyrene.

10 4. The method of constructing a plaza deck/parking structure of Claim 1, in which the ratio of channel area to the total surface area of the foam panel is between 20 percent to 80 percent.

15 5. The method of constructing a plaza deck/parking structure of Claim 1, in which the ratio of channel area to the total surface area of the foam panel is 40 percent.

20 6. The method of constructing a plaza deck/parking structure of Claim 1, in which said panels of foam plastic insulation are between 7.6 centimeters to 1.2 meters long and between 1.2 meters to 6.1 meters wide.

25 7. The method of constructing a plaza deck/parking structure of Claim 1, in which said channels in said panels of foam plastic insulation are from 0.16 centimeters to 2.5 centimeters wide and from 0.25 centimeters to 2.5 centimeters deep.

30 8. The method of constructing a plaza deck/parking structure of Claim 1, in which said ribs in said panels of foam plastic insulation are from 0.32 centimeters to 12.7 centimeters wide.

9. The method of constructing a plaza deck/parking structure of Claim 1, in which said panels of foam plastic insulation have a compressive strength of from 69 kilopascals to 1380 kilopascals.

5 10. A deck/parking structure constructed according to the method of Claim 1.

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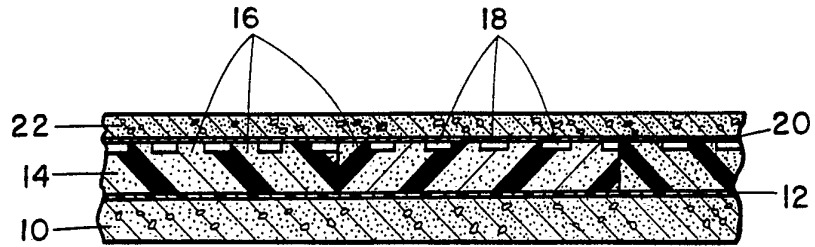


FIG 1

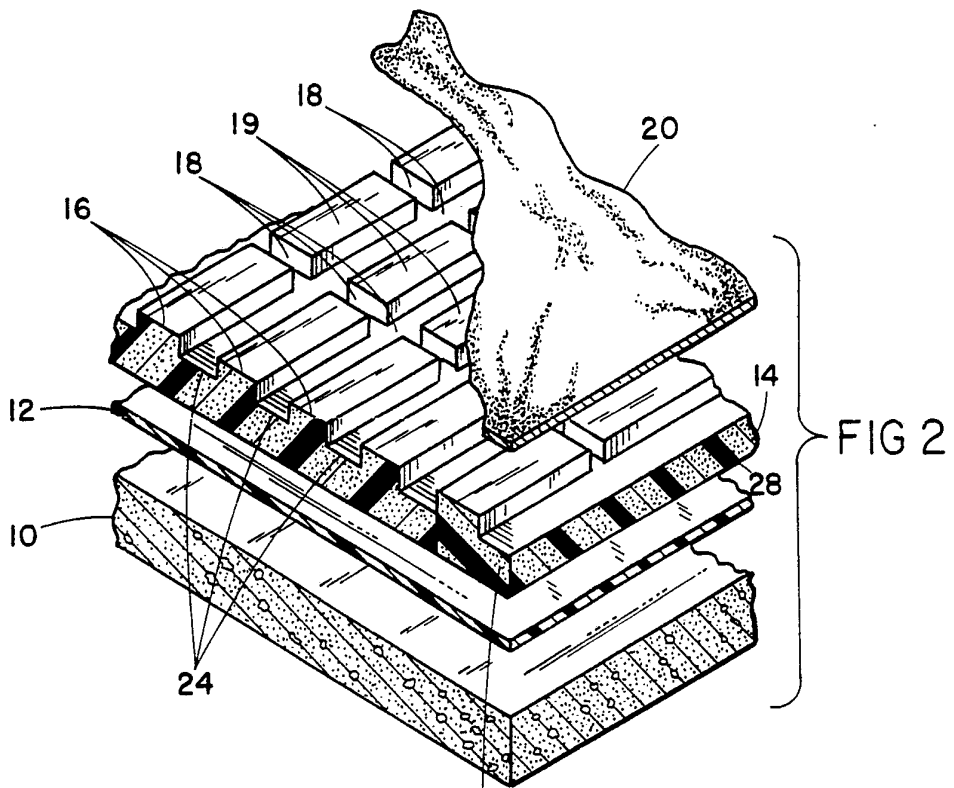


FIG 2

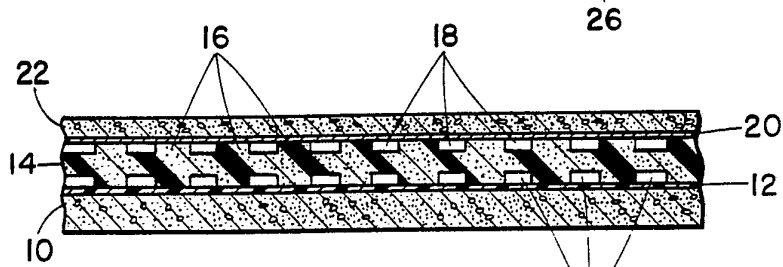


FIG 3

# INTERNATIONAL SEARCH REPORT

International Application No PCT/US91/02819

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>3</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC(5): E04G 21/00; E04B 5/16		
US CL: 52/741		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>4</sup>		
Classification System	Classification Symbols	
US	52/199, 302, 309.5, 309.12, 309.8, 408, 410, 741 156/324.4	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>5</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <sup>1,4</sup>		
Category <sup>6</sup>	Citation of Document, <sup>10</sup> with indication, where appropriate, of the relevant passages <sup>11</sup>	Relevant to Claim No. <sup>12</sup>
Y	US, A, 4,658,554, RILEY ET AL., 21 APRIL 1987, (See column 4, lines 8-11 and 44-50; column 5 lines 64-65; column 6, lines 21-24 and 41-42; and, fig. 3)	1-28
Y	US, A, 3,619,961 STERRETT ET AL., 16 NOVEMBER 1971 (See column 2, lines 26-33 and fig. 3)	1-28
A	US, A, 4,677,800 ROODVOETS, 07 JULY 1987 (See fig. 1)	
A	US, A, 3,455,076 CLARVOE, 15 JULY 1969	
A	US, A, 4,712,349 RILEY ET AL., 15 DECEMBER 1987	
A	STYROFOAM THERMADRY BRAND INSULATING DRAINAGE PANELS FOR SUPERIOR INSULATION AND WATER DRAINAGE DOW CHEMICAL COMPANY LITERATURE, FORM NO. 179-3084-788 RJD	
<p><sup>3</sup> Special categories of cited documents: <sup>13</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search <sup>1</sup>		Date of Mailing of this International Search Report <sup>1</sup>
03 JUNE 1991		15-AUG 1991
International Searching Authority <sup>1</sup>		Signature of Authorized Officer <sup>10</sup>
ISA/US		<i>Deborah McGann Ripley</i> DEBORAH MCGANN RIPLEY