

[72] Inventors **Robert Hall Barton**  
**Ridgewood, N.J.;**  
**Martin Luther Brown, Elkton, Md.;**  
**Andrew Mitchell, Newark, Del.**  
[21] Appl. No. **771,993**  
[22] Filed **Oct. 30, 1968**  
[45] Patented **Sept. 7, 1971**  
[73] Assignee **E. I. du Pont de Nemours and Company**  
**Wilmington, Del.**

2,294,247	8/1942	Smith .....	94/24
2,347,233	4/1944	Abernathy.....	94/9 X
2,672,793	3/1954	Rowe .....	94/3
3,000,276	9/1961	Foulger .....	94/10
3,168,019	2/1965	Lynn .....	94/9 X

FOREIGN PATENTS

739,217	10/1955	Great Britain.....	94/7
---------	---------	--------------------	------

Primary Examiner—Jacob L. Nackenoff  
Attorney—Louis Del Vecchio

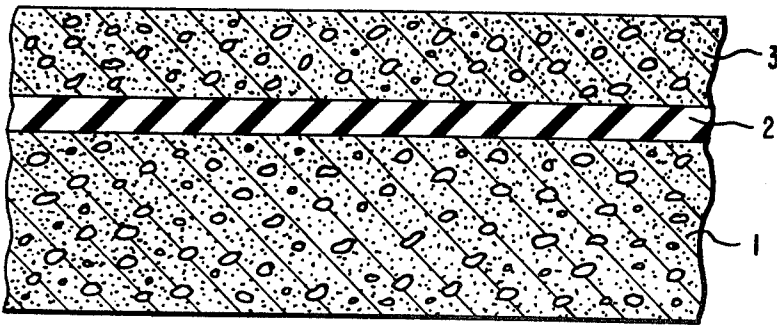
[54] **MULTILAYERED STRUCTURE**  
**10 Claims, 1 Drawing Fig.**

[52] U.S. Cl..... **94/9,**  
**94/7, 94/22**  
[51] Int. Cl..... **E01c 7/18**  
[50] Field of Search..... **94/7, 9, 10,**  
**22, 24, 4, 3; 14/73**

[56] **References Cited**  
**UNITED STATES PATENTS**

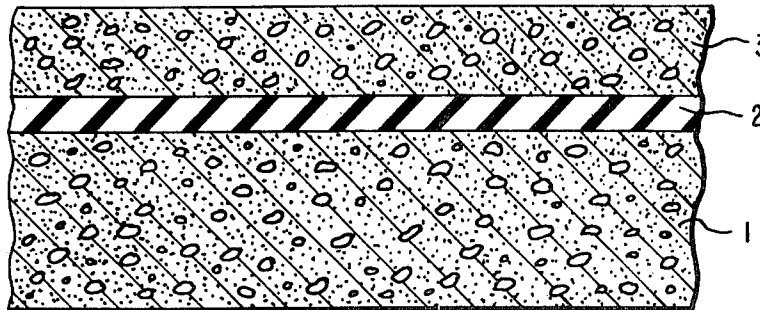
1,862,011	6/1932	Gage .....	94/24
2,210,252	8/1940	Neeld .....	14/73

**ABSTRACT:** A multilayered structure comprising a base support, an unvulcanized elastomeric membrane at least 0.05 inch thick overcoated with an exposed cover layer. This structure is useful in roadway construction with particular application to bridge decks where vibration tends to accelerate crack formation allowing water to penetrate the roadbed where it freezes and thaws resulting in structural damage to conventional roadways. The membrane prevents water from penetrating the roadbed. As a bridge deck the base support is normally Portland cement concrete, the intermediate layer is the elastomeric membrane and the exposed cover layer is asphaltic concrete.



PATENTED SEP 7 1971

3,603,221



INVENTORS

ROBERT HALL BARTON  
MARTIN LUTHER BROWN  
ANDREW MITCHELL

BY

*Louis De Vecchio*

ATTORNEY

## MULTILAYERED STRUCTURE

### FIELD OF THE INVENTION

This invention relates to the use of elastomers in a multilayered structure particularly useful in highway and bridge construction.

### BACKGROUND OF THE INVENTION

In the construction and maintenance of bridge decks and roadways, one problem that exists is cracking and spalling of the structure due to water penetration into the roadbed. The water freezes, expands and causes cracking then thaws leaving a damaged roadbed.

Another situation that is damaging to a roadbed is heaving of the soil below the roadbed caused by water penetrating the roadbed into the soil below the roadbed followed by freezing of the water. The resultant expansion often breaks the roadbed.

Some methods of alleviating these problems are disclosed in the art. U.S. Pat. No. 1,512,125 discloses a process of making a monolithic roadbed by cleaning, drying and heating the substratum, covering the substratum with a film of soft pitch and laying down a wearing surface over the soft pitch thereby effecting a knitting together of three layers into one monolithic mass.

U.S. Pat. No. 2,183,253 discloses a method of road construction wherein the grade line is established, a water soluble electrolyte is mixed into the soil below the grade line to constitute a subbase with waterproof material to prevent escape of the electrolyte and thereafter overcoating with a wearing surface.

In "Restoring Salt-Damaged Highway Bridges," by R. J. Walsh, *Civil Engineering*, May 1967, the following process of bridge restoration is disclosed: The damaged wearing surface of the bridge is removed exposing the subsurface. The subsurface is then primed and coated with a layer of coal tar pitch emulsion. Into the emulsion is placed a layer of a glass-fibred cloth called Fiberglas, a trademark of Owens-Corning Fiberglas Corp. This forms a waterproofed membrane which is then overcoated with a wearing surface.

The prior art does not provide a method of protecting roadways and bridges that is economical, easy to construct, and durable over a long period of time while subjected to varied weather conditions and constant use.

### SUMMARY OF THE INVENTION

This invention provides a multilayered roadway comprising essentially;

- a. a base support,
- b. an intermediate unvulcanized elastomeric membrane at least 0.05-inch thick, resistant to oxygen degradation and having a brittle point temperature of about 0° C. or less, and

### BRIEF DESCRIPTION OF THE DRAWING

The drawing shows a typical embodiment of this invention in which an uncured elastomeric membrane is sandwiched between a base layer and a traffic-bearing layer of concrete.

### DETAILS OF THE INVENTION

The multistructure element of this invention comprises a base support, an elastomeric membrane, and a traffic-bearing layer.

The attached drawing shows a typical embodiment of this invention in which the base support 1 is Portland cement concrete and intermediate layer 2 is an uncured elastomeric membrane and the traffic-bearing layer 3 is asphalt cement concrete.

The base support can be any flat surface such as a concrete bridge deck or roadbed that has been leveled by a roller. In the case of a roadway the base support can be asphalt, gravel,

broken stone where the voids are filled with sand, a bituminous concrete base course, or an already existing road. In the case of a bridge, the base support is generally Portland cement concrete either precast or poured in place.

The elastomeric membranes of this invention should exhibit the following characteristics. The membrane must not become so brittle that in cold weather it will crack and fail. The term "cold weather" is meant to include the winter conditions found in the North and South Temperate Zones. Accordingly, the desired brittle point of the membrane should be 0° C. or less as measured by the solenoid brittle point test described in ASTM D-746.

The thickness of the membrane should be at least 0.05 inch to provide the necessary structural integrity for installation. The maximum thickness is a matter of economics and it has been found to be uneconomical and unnecessary to use a membrane more than 0.5-inch thick. Membranes 0.10 to 0.25 inch are preferred since they provide the best balance between economics and structural integrity.

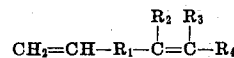
The membrane should be self-healing. This is accomplished by preparing and using the membrane is an unvulcanized state. Therefore, no sulfur or other vulcanizing agents are used in the mix, nor any agent that might cross-link the polymers. The membrane should desirably be very resistant to oxidative degradation. This is accomplished by using an elastomeric material that in itself is practically immune to oxidative degradation or an elastomeric material subject to oxidative degradation compounded with an antioxidant.

Elastomers which best meet the above requirements are the saturated and low unsaturated elastomers such as ethylene/propylene (EP) copolymers, ethylene/propylene/diene (EPDM) terpolymers, butyl rubber, chlorinated polyethylenes, and the like. Natural rubber, styrene/butadiene rubber and the neoprenes can be employed when compounded with antioxidants. For economy and maximum resistance to degradation, the EP or EPDM elastomers are preferred.

EP elastomeric copolymers useable in this invention are those having at least one  $\alpha$ -monoolefin with the structure  $R-CH=CH_2$  where R is H or  $C_1-C_{16}$  alkyl. Representative copolymers include: ethylene/propylene, which is preferred; ethylene/1-butene; propylene/1-butene; ethylene/5,5-dimethyl-1-octene; 1-hexene/1-decene, ethylene/propylene/1-octadene; propylene/5-methyl-1-heptene; and 1-hexene/1-dodecene. The ethylene copolymers should contain about 25 to 75 weight percent ethylene monomer units.

Representative procedures for making such copolymers are given in U.S. Pat. Nos. 3,000,867 and 2,975,159.

EPDM terpolymers that are useful are made from at least one  $\alpha$ -monoolefin and at least one nonconjugated diene having only one polymerizable double bond. The  $\alpha$ -monoolefins have the structure  $R-CH=CH_2$  where R is H or  $C_1-C_{16}$  alkyl and are preferably straight-chained. Representative nonconjugated hydrocarbon dienes include: open-chain  $C_6-C_{22}$  dienes having the structure



wherein  $R_1$  is an alkylene radical;  $R_4$  is H;  $R_2$ ,  $R_3$  independently selected from the group consisting of hydrogen and alkyl radicals; dicyclopentadiene; 5-methylene-2-norbornene; 5-ethylidene-2-norbornene; 5-alkenyl-2-norbornene; 2-alkyl-2,5-norbornadiene; cyclopentadiene; and 1,5-cyclooctadiene. EPDM terpolymers and procedures for making them are given in U.S. Pat. Nos. 2,933,480; 3,000,866; 3,063,973; 3,093,620; 3,093,621; 3,260,708 and French Pat. No. 1521,726. When cyclic nonconjugated dienes are employed, it is preferred that the resultant copolymer contain ethylene and at least one other  $\alpha$ -monoolefin, e.g., propylene. The ethylene copolymers should contain about 20 to 70 weight percent ethylene monomer units.

Representative EPDM copolymers include: ethylene/1,4-hexadiene; ethylene/propylene/1,4-hexadiene; ethylene/propylene/dicyclopentadiene; ethylene/propylene/5-methylene-2-norbornene; ethylene/propylene/2-ethyl-2,5-norbornadiene; ethylene/propylene/5ethylidene-2-norbornene; and ethylene/propylene/1,5-cyclooctadiene.

Elastomers that are useful, provided they are compounded with an antioxidant, are neoprenes and SBR (styrene(butadiene) rubber. Neoprenes are polymers and copolymers of chloroprene. These are well known and fully described in many U.S. Patents and various texts such as *Introduction to Rubber Technology*, edited by M. Morton, Reinhold Publishing Corp. New York, 1959, and *The Neoprenes*, R. M. Murray and D. C. Thompson, published by E. I. du Pont de Nemours and Co., Wilmington, Delaware, 1963. Chlorosulfonated saturated aliphatic hydrocarbon polymers are best exemplified by chlorosulfonated polyethylenes. These elastomeric materials are well known and can be prepared in a number of ways as shown in U.S. Pat. Nos. 2,212,786; 2,586,363; 2,879,251 and 2,982,759. These chlorosulfonated polymers contain at least 20 percent chlorine and at least 0.5 percent sulfur by weight. Representative preferred polymers contain about 20 to 40 percent chlorine and about 1 to 1.5 percent sulfur by weight. The polyethylene before chlorosulfonation is frequently a linear type having a density greater than 0.94 and a melt index of about 0.2 to 200.

Neoprenes can be made by polymerizing chloroprene or copolymerizing chloroprene with up to about 50 percent of another ethylenically unsaturated copolymerizable monomer, e.g., acrylonitrile, styrene, acrylic and methacrylic acids and esters, 1,3-butadiene isoprene and 2,3-dichlorobutadiene-1,3. These are also useable.

SBR rubbers which can be used are characterized in the publication entitled *Rubber: Natural and Synthetic* by H. J. Stern, second edition, 1967.

Antioxidants, to be compounded with SBR rubber, neoprenes and natural rubber fall into three (1) secondary amines, (2) phenols, and (3) phosphites. Useable amines are phenyl-alpha- and phenyl-beta-naphthylamines; useable phenols are those alkylated with isobutylene; and useable phosphites are those of the alkylated phenol phosphite class. These antioxidants are well known to the art.

The elastomeric composition can contain relatively large proportions of filler which should be of the type that has a limited tendency to absorb water. Carbon black, whiting (calcium carbonate) and baryta (barium sulfate) are suitable fillers. At least 100 parts of filler per 100 parts of elastomeric is suggested for use. However, as much as 500 parts can be used. Preferably 200 to 400 parts are used to give the best workable consistency to the membrane.

Although not necessary for obtaining the benefits provided by the present invention, a petroleum oil is usually included in the present elastomeric membrane composition in order to lower the materials cost and to improve the ease of processing. Plasticizing oils can be used at concentrations of 100 to 300 phr (parts per hundred parts of elastomer by weight). These oils should be a permanent nonvolatile type compatible with the particular elastomer used. Aromatic and naphthenic petroleum oils have been found useful.

Stabilizing agents such as metal oxides, or extrusion aids such as waxes and stearic acid can be employed if desired.

In the manufacture of the elastomers of this invention, industrial processing internal mixers such as Banbury mixers are frequently used to compound the elastomer and a membrane is formed by conventional calendaring or extrusion techniques. When it has an inherently sticky nature, the membrane must be protected by a release paper or plastic film if it is to be stored or transported. The plastic film may be polyethylene terephthalate, polypropylene or the like. It is sometimes desirable to leave the plastic film in place as part of the finished structure. During construction it can be used as a walking surface for workmen and it protects the membrane until the cover layer is applied. For large scale installations it is

practical to extrude the membrane directly into the base layer of the roadway or bridge during construction.

The traffic-bearing layer can be any of the conventional types known to the art of highway and bridge construction. Some examples are sheet asphalt, a dense mix of bituminous concrete or Portland cement concrete pavement. The traffic-bearing layer is applied over the membrane by conventional methods known in the art of highway and bridge construction.

It is sometimes necessary to roll or compress the traffic-bearing layer particularly when it is asphalt. During the compression operation aggregate may be forced into the membrane and perhaps rupture it. Due to the self-healing qualities of the membrane it seals around the aggregate maintaining its protective shield.

The multilayered structure of this invention has been particularly defined in terms of its use as a roadway or bridge deck. Nevertheless, with a few simple modifications it can be adapted to other uses. It can be used as a roof wherein the base layer is wood, plastic, paper, cloth, metal plating, etc.; the intermediate layer is the unvulcanized elastomeric membrane described above; and the exposure layer is conventional roofing such as pebbles, tile, etc. This membrane would keep water from penetrating the roof and should a crack develop, e.g., from settling of the structure or someone walking on the roof, the self-healing healing properties of the membrane would operate to seal itself and prevent leakage or damage from the weather.

Another use may be weather guarding for basement walls where the base layer is cinder block, concrete, or brick; the intermediate layer is the membrane described above and the outer layer can be wood, sheet metal, gravel drain or the earth. Still other uses may be in sidewalls, racetracks or athletic fields.

This invention is illustrated by the following examples.

#### EXAMPLE I

The following ingredients are compounded in a Banbury mixer:

Ingredients	Parts by Weight
EPDM Copolymer	100
Zinc oxide	5
Stearic acid	3
FEF carbon black	150
Austin Black	100
Sundex 790	175

The EPDM copolymer is made by copolymerizing ethylene with propylene and 1,4-hexadiene in solution in tetrachloroethylene in the presence of a coordination catalyst in accordance with the general procedures of U.S. Pat. No. 2,933,480. Hydrogen modification is employed during the preparation in accordance with U.S. Pat. No. 3,051,690. This copolymer has a Mooney viscosity of about 45 (ML-4/250° F.) and contains about 0.33 g.-mol of ethylenic unsaturation per kilogram. The following monomer unit composition is present by weight: 63 percent ethylene, 33 percent propylene, 4 percent 1,4-hexadiene. The inherent viscosity is about 2.2.

FEF Carbon Black is characterized in the ASTM manual under Standard Specifications for Carbon Blacks Used in Rubber Products. This material is identified as ASTM: D-1765-, Type FEF 30.

Austin Carbon Black is a finely pulverized bituminous coal of specific gravity 1.25, containing 77 percent carbon and 17 percent volatile components. It is commercially available from the Chemical Products Division of Slab Fork Coal Company, Slab Fork, West Virginia.

Sundex 790 is a process oil sold commercially by the Sun Oil Company. Its standard designation is ASTM D-2226, Type 102. This oil is characterized as follows: specific gravity

at 60° F. of 0.9806; density 0.9769; molecular weight 37.5 and a viscosity 2 gravity constant of 0.932.

After mixing, the composition is calendered into a sheet 50 inches wide and 0.100-inch thick. It is installed as the sealing membrane on a heavily traveled bridge deck, over an 8-inch thick Portland cement concrete base, and under a 1½-inch thick asphaltic concrete traffic bearing layer. After 6 months of service the membrane is intact and is giving full protection to the Portland cement concrete base layer. Core borings are taken and analyzed. The structural integrity of the roadway is as good as it was in the beginning.

#### EXAMPLE II

A multilayered structure comprising a base layer of Portland cement concrete, and intermediate layer of elastomeric membrane prepared as described in Example I and a top layer of amesite is constructed in the following manner. A concrete slab having a surface area of 8×16 inches is poured and curved according to conventional methods. An elastomeric membrane is placed on top of the concrete slab with the ends turned up to form a pan. Hot amesite, 2 inches thick, is placed in the pan and compressed under a 200 p.s.i. hydraulic press to complete the structure.

The structure is cracked in half, the pan formed by the elastomeric membrane is filled with salt solution and multilayered structure is placed on a vibrator to flex the joint. Electrodes are placed between the concrete slab and the elastomeric membrane. The sample is vibrated and if the crack causes rupture of the membrane to allow salt solution to reach the concrete the electrical resistance of the electrodes will drop. After one week of flexing the crack by continuous vibration, the electrical resistance of the electrodes remains the same indicating the self-healing elastomeric membrane is still containing the salt solution.

We claim:

1. A multilayered structure consisting essentially of
  - a. a base layer,

- b. an intermediate unvulcanized elastomeric membrane at least 0.05-inch thick, resistant to oxygen degradation and having a brittle point of less than 0° C., said elastomer being a polymer from the group of ethylene/propylene copolymers and ethylene/propylene/diene terpolymers,

- c. an exposure layer.

2. A multilayered structure according to claim 1 wherein the base layer is Portland cement concrete.

3. A multilayered structure according to claim 1 wherein the exposure layer is asphalt.

4. A multilayered structure according to claim 1 wherein a plastic film is interposed between the unvulcanized membrane and the exposure layer.

5. A multilayered structure according to claim 1 wherein the elastomeric membrane has at least 100 to 500 parts of filler per 100 parts of elastomer and at least 100 to 300 parts of plasticizing oil per 100 parts of elastomer.

6. A multilayered structure according to claim 1 wherein the elastomeric membrane is made from a copolymer of ethylene, propylene and at least one nonconjugated diene having only one polymerizable double bond.

7. A multilayered structure according to claim 1 wherein the copolymer is ethylene/propylene.

8. A multilayered structure according to claim 6 wherein the copolymer is ethylene/propylene/1,4-hexadiene.

9. A multilayered roadway comprising essentially
  - a. a base layer of Portland cement concrete;

- b. an intermediate unvulcanized elastomeric membrane at least 0.05-inch thick, resistant to oxygen degradation and having a brittle point of less than 0° C. wherein the elastomeric membrane is 100 parts ethylene/propylene copolymer, 100-500 parts filler, and 100-300 parts plasticizing oil; and

- e. an exposure layer of asphalt.

10. A multilayered roadway according to claim 9 wherein a plastic film is interposed between the unvulcanized membrane and the exposure layer of asphalt.

40

45

50

55

60

65

70

75