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CONCRETE CONSTRUCTION AND ROADWAYS

Filed Nov. 8, 1966

2 Sheets-Sheet 1

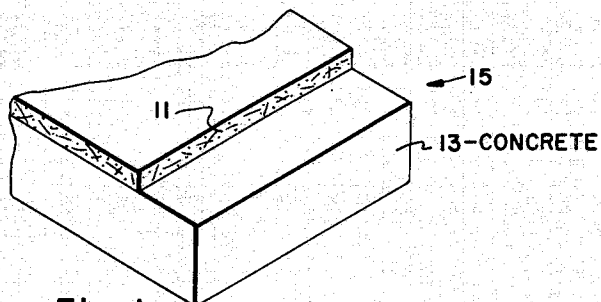


Fig. 1

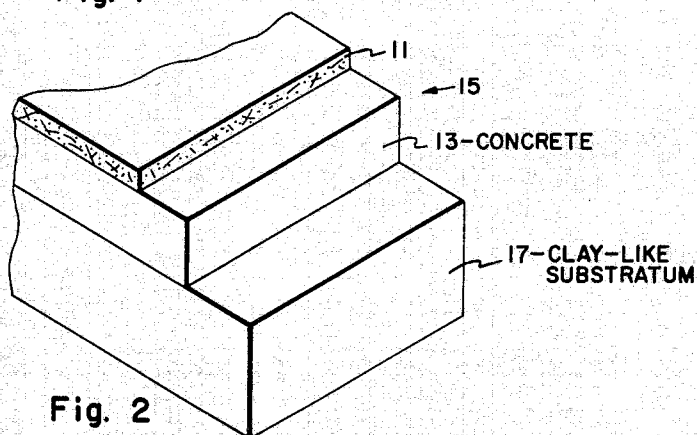


Fig. 2

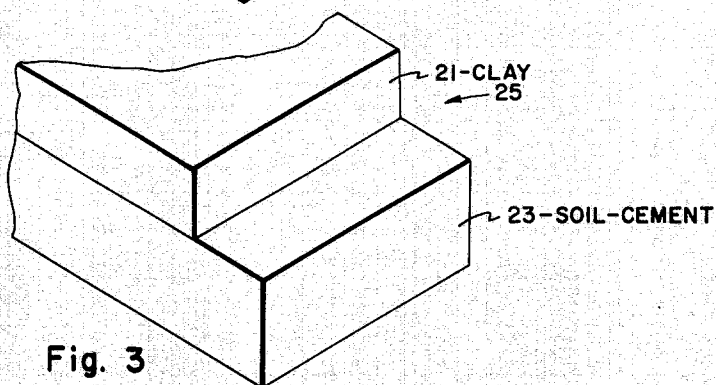


Fig. 3

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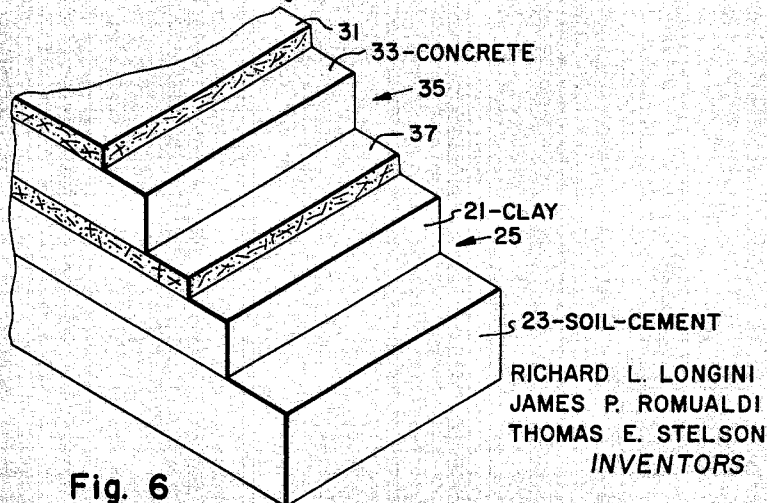
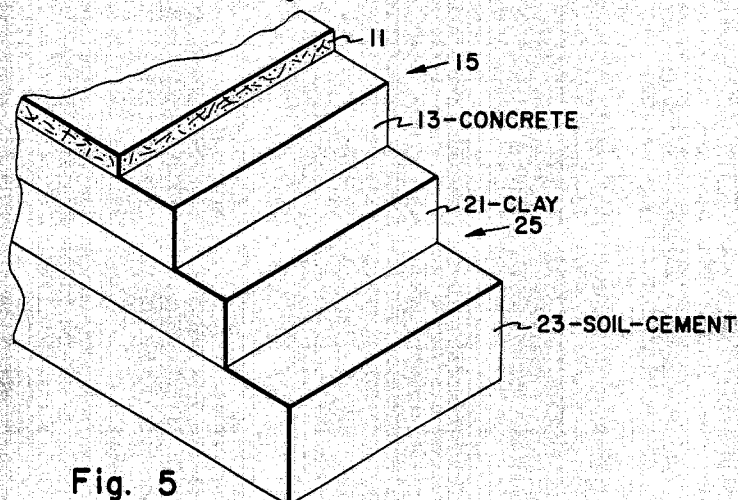
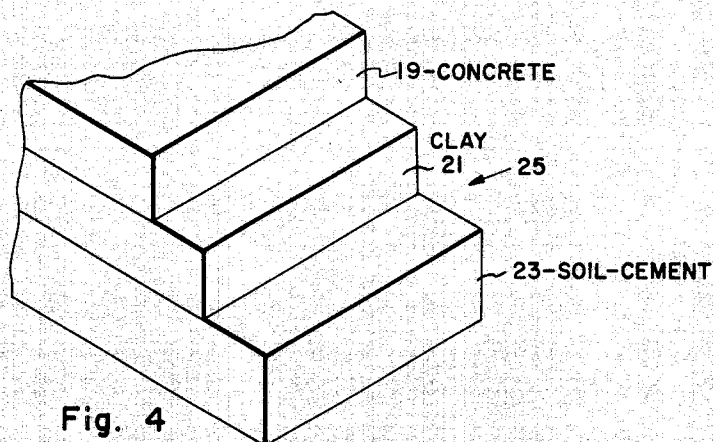
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CONCRETE CONSTRUCTION AND ROADWAYS

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U.S. Cl. 94-10

7 Claims

ABSTRACT OF THE DISCLOSURE

A composite concrete construction comprised of: both (a) a surface layer of concrete including closely spaced wire elements and an underlying layer of concrete, and (b) a substratum comprising a bottom hard layer and a top flexible layer; and either (a) or (b).

This invention relates to construction, particularly in connection with multilayered concrete construction for concrete pavements, roadways, and the like.

All concrete surfaces are subject to cracking and spalling. As used herein, concrete necessarily refers to concrete including sized aggregate as well as mortar. Cracks form during normal use of concrete roadways and the like as a result of flexing of the concrete in response to movement thereover and transmission of the load to the flexible substratum that supports the concrete. The flexing is due to the use of a flexible substrate for the roadway which shares the load with the road. Actually, the road distributes the load over an area of the substratum somewhat larger than the size of the tire. For optimum conditions on a roadway, the thickness of the concrete strip is related to the tire size and weight. For a given load, a large thickness of concrete gives smaller deflections but the surface stresses are essentially the same because the concrete now spreads the load over more substratum. In other words, as between the concrete and the substratum, the thicker concrete carries proportionally more of the load. So far as durability is concerned, no benefit results from concrete of greater thickness. The flexing in response to repeated loading subjects the concrete to the likelihood of fatigue cracking.

Stresses introduced upon contraction of freshly poured concrete also often causes tensile cracks. When fine cracks have developed, crack enlargement follows as a result of alternate freezing and thawing of liquids confined therein. The cracks forming from any of the above mechanisms can serve as passages that carry corrosive liquids to reinforcement or underlying metal. The latter problem is particularly severe in the case of bridge decks where only a single layer of concrete covers the deck without any intermediate flexible layer. Although all concrete pavements, including sidewalks, roadways and the like, are subjected to influences of the above-described type, one of the most severe problems arises in connection with concrete pavement used in the landing strips for airfields. In addition to load carrying problems, landing of a large plane causes excessive heating of the concrete surface when the tire engaging the surface starts to rotate and the resultant thermal shock can be very harmful. These problems will become more serious with the advent of newer and bigger planes.

Accordingly, it is an object of this invention to provide a construction for roadways and the like having the ability to withstand deterioration by cracking.

It is a further object of this invention to provide a construction for roadways and the like having the ability

to efficiently transmit a load to the substratum lying thereunder.

It is still another object of this invention to provide a construction for roadways and the like having the ability to withstand spalling.

It is yet another object of this invention to provide a construction for covering metal structures whereby the covered portions of the metal structures are protected from the action of corrosive fluids.

In its broadest aspects, the invention includes within its scope a composite concrete construction comprising a surface layer of concrete including closely spaced substantially straight wire elements and an underlying layer of conventional concrete. The invention also includes a composite substratum construction comprising a bottom hard substructure and a flexible body thereabove. The invention further includes the combination of said composite concrete construction and said composite substratum.

In the drawings:

FIG. 1 is a perspective view of a concrete construction according to the invention.

FIG. 2 is a perspective view of the concrete construction of FIG. 1 in connection with conventional substratum.

FIG. 3 is a perspective view of a composite substratum structure according to the invention.

FIG. 4 is a perspective view of the substratum structure of FIG. 3 in connection with conventional concrete.

FIG. 5 is a perspective view of the concrete construction of FIG. 1 in connection with the substratum of FIG. 3.

FIG. 6 is a perspective view of another concrete construction according to the invention in connection with the substratum of FIG. 3.

Referring to the embodiment illustrated in FIG. 1, the concrete construction 15 comprises an underlying layer of conventional concrete 13 and a thinner surface layer 11 of concrete including closely spaced substantially straight wire elements. The conventional concrete 13 comprises concrete having sized aggregate distributed therein. The thickness of the conventional concrete 13 varies from 5 to 12 inches. When referring to surface layer 11 as having closely spaced fine steel wires distributed therein, the close spacing means an average spacing between wires not in excess of 0.5 inch, and preferably less than 0.3 inch. The concrete surface layer 11 is the same as that described in copending application Ser. No. 471,505, filed July 7, 1965, which application is assigned to the assignee of this application and is a continuation-in-part of the application Ser. No. 246,819, filed Dec. 24, 1962, now abandoned. In the previously referenced copending application there is taught a novel two-phase material comprising concrete and steel wires of a diameter of at most about 0.3 inch and a modulus of elasticity of about 27 to 32 million p.s.i. with average spacing between wires not greater than 0.5 inch. The various embodiments of the novel two-phase material, as taught in that copending application, include: an embodiment comprising concrete and closely spaced short wire segments uniformly distributed randomly therein so that the average spacing is not greater than 0.5 inch, and an embodiment comprising concrete and substantially straight continuous wire strands spaced within the concrete so that the average spacing between wires is less than 0.5 inch. In accordance with the previously referenced copending application, the wires spaced as set forth provide a crack arrest mechanism in the surface layer 11 that increases cracking strength, toughness and fatigue life. A thickness of surface layer 11 of about 1 inch or less is usually satisfactory. The ratio of the thickness of surface layer 11 to the thickness of

the composite concrete structure 15 is less than 0.5 and usually lies in the range from about 0.05 to about 0.30.

Referring to the embodiment illustrated in FIG. 2, a concrete roadway comprises a substratum 17 covered by a composite concrete structure 15 comprising an underlying layer of conventional concrete 13 and a thinner surface layer 11 of concrete including closely spaced substantially straight wire elements. The substratum 17 shown for purposes of illustration is of a resilient material such as a clay-like material having the ability to share some of the load to which the composite concrete structure 15 is subjected.

Referring to FIG. 3, there is shown a composite substratum 25 of substrate comprising a top flexible layer 21 and a bottom hard layer 23. The top flexible layer 21 is considerably thinner than the conventional flexible layer 17 of FIG. 2. The bottom hard layer 23 serves to take the principal load directly without excessive spreading of the load. The bottom hard layer 23 is, in itself, a roadway laid on a base such as a conventional roadway rests on. The bottom hard layer 23 can be cement or soil-cement comprising cement mixed with clay or dirt which is alkaline or of controlled pH. The bottom hard layer 23 and the top flexible layer 21 are of about the same order of thickness. The actual thicknesses of the layers 23 and 21 depend on the loads involved and the material of layer 23. For ordinary heavy duty highways, the bottom hard layer 23 is about 1 foot thick and the top flexible layer 21 is about 10 inches thick. Because the top flexible layer 21 is thinner than the conventional flexible substratum (see 17 of FIG. 2), it cannot yield as much with a given force and will take a larger proportion of the overall stress from a given load. When the top flexible layer 21 comprises clay, it may be necessary to incorporate into it other granular bodies, or in fact, use the clay more as a lubricant for other granular bodies than for its own strength to prevent the thin layer from losing its resilience.

Referring to FIG. 4, the substratum construction 25 of FIG. 3 is shown supporting a conventional concrete strip 19 to form a roadway. Excessive spreading of the load in the conventional concrete strip 19 is reduced and distortion minimized as the greater portion of the load is taken up by the substratum 25. The conventional concrete strip 19 does less to spread the load than with conventional substratum (as 17 of FIG. 2) and more to keep the substratum 25 in position.

Referring to FIG. 5, the concrete construction 15 of FIG. 1 is shown as a strip for the substratum construction 25 of FIG. 3 to form a roadway. The concrete construction 15 is uniquely adapted for use in combination with the substratum construction 25. Because the concrete 15 need not spread the load over a large area when it is used together with the substratum construction, a thinner layer of surface concrete can be used. Although some savings of concrete and especially improved durability are achieved in the roadway of FIG. 4, it has been found that the tensile strength of the concrete construction 15 makes it uniquely adaptable to the substratum construction 25 in allowing the use of a thinner layer of concrete.

In FIG. 6, a concrete construction 35 comprises conventional concrete 33 sandwiched between a thinner surface layer 31 and a thinner bottom layer 37 of concrete including closely spaced substantially straight wire elements. The concrete construction is shown in combination with the substratum 25 of FIG. 3. The substratum 17 of FIG. 1 may also be used.

The concrete construction 35 is especially useful for roadways for airstrips where excess thickness of concrete is required. In a typical situation, the ratio of the thickness of the surface layer 31 to the thickness of the layer 31 plus the concrete 33 is less than about 0.10. In addition to top and bottom concrete layers including closely spaced substantially straight wire elements, intermediate layers of the concrete including closely spaced substantially straight wire elements may be provided. The layered con-

struction limits cracking due to contraction of freshly poured concrete and will limit the stress concentration of any cracks that do arise.

In the preparation of the roadway from the concrete construction of FIG. 1, the substratum 25 of FIG. 3 or of FIG. 5 is first built up and graded in the conventional manner. The conventional concrete 13 is poured to the desired depth above the substrate layer 17. Before the conventional concrete 13 has set, the surface layer 11 is poured thereover as to become bonded thereto. To aid in bonding of the layers 11 and 13, the conventional concrete 13 is roughened following pouring thereof and immediately thereafter the surface layer 11 is poured thereon. Instead of pouring the top surface layer, it may be continuously extruded by means of a road machine.

The material for surface layer 11 can be prepared in a conventional manner merely by mixing sand, cement, and water in a mixer and subsequently adding sufficient volume percent of wire to the mixture to give the desired wire spacing. In addition to sand, cement, and water, the concrete mix for layer 11 may also include coarse aggregate. Where a random distribution of wires within concrete results from the mixing technique described above, the average spacing of wires operating to benefit cracking strength is more difficult to define than when a purposeful arrangement of wire elements is used. A higher volume percent of randomly oriented wires must be added because not all wires will be oriented to act in the direction of principal tensile stress. For the case of randomly oriented wires, mathematical derivation can be made to describe the spatial relationship of randomly oriented wires. Although numerous manners of calculation may be employed to describe these relationships, it has been found that a rule of thumb calculation to determine the volume percent of wire needed to achieve a particular average wire spacing of short wires is provided by the formula:

$$S=13.8d\sqrt{1/P}$$

where

S=average spacing of short wires, in.

d=wire diameter, in.

P=percent of steel by volume

For example, to obtain an average spacing between wires of not greater than 0.5 inch., 0.027 volume percent of wire having a diameter of .006 inch or 0.07 volume percent of wire having a diameter of .010 inch would be required. For the more favorable average spacing of 0.3 inch, .08 volume percent of wire having a diameter of .006 inch or .21 volume percent of wire having a diameter of .010 inch would be required.

As long as wires are short enough in relation to the shortest dimensions of the concrete section in which they are included, a random distribution can be maintained. Where greater lengths are used the distribution is no longer random, and the volume percent of wire needed decreases from that required for a random distribution. A similar result would follow where the top surface layer is extruded and wires tend to align themselves in the direction of extrusion. This is because more wires are distributed in the direction of principal tensile stress. Similarly, when wires of any length are purposely placed in the direction of principal tensile stress, the amount needed is less than that required for a random distribution.

The crank arrest mechanism operating in the surface layer as a result of inclusion of wire elements is enhanced by the use of straight and stiff wire elements that can act to prevent extension of minute flaws in the concrete. Crimped wires or wavy configurations not properly aligned in a direction perpendicular to a flaw would be considerably less efficient than straight wires. Similarly, a wire element having a modulus of elasticity less than that of steel (e.g., about 27 to 32 million p.s.i.) would be less

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effective. The crack arrestor must have considerably greater stiffness than the matrix. The smaller the wire spacing, the greater the tensile strength that can be achieved.

Although the invention described herein has numerous uses and advantages, the most significant advantages arise in connection with its use for roadways. Flexing and transmission to a substratum is more readily done. The likelihood of fatigue cracks occurring at the roadway surface is minimized. When using the concrete construction of the invention, in some cases the roadway actually improves its strength upon repeated load cycling. Further, the surface of the roadway is rendered resistant to thermal shock and spalling. Corrosion of underlying metal bridge decks is significantly reduced. Numerous economies are achieved by restricting the concrete portion including wire elements to a relatively thin surface layer. When using the concrete construction of the invention in combination with the substrate construction of the invention, the foregoing advantages of the invention are achieved with further economies in the amount of concrete that must be used.

Numerous other uses and advantages of this invention will be apparent. It will be understood that various changes in the details, materials, steps and arrangements of parts, which have been herein described and illustrated in order to explain the nature of the invention may be made within the principles and scope of the invention.

What is claimed is:

1. In concrete construction comprising concrete overlying and covering a supporting substratum, the improvement and in combination therewith of

(a) a surface layer of concrete containing closely spaced wire elements distributed therein so that the average spacing between wires is not greater than 0.5 inch, and

(b) the substratum which comprises

(i) a top flexible layer comprised of clay,

2. The construction of claim 1 for concrete roadways and the like wherein the substratum comprises:

(ii) a bottom hard layer of cement or of a soil-cement which comprises cement mixed with clay or dirt which is alkaline or of controlled pH, and

(i) the top flexible layer comprised of clay which rests upon the bottom hard layer.

3. The construction of claim 2 wherein said bottom hard layer is soil-cement.

4. The construction of claim 2 wherein said top flexible layer is clay having granular bodies incorporated therein.

5. The construction of claim 1 wherein said surface layer overlying and covering said substratum consists essentially of:

(a) a layer of concrete bonded to and supporting

(b) a surface layer covering of said concrete containing said closely spaced wire elements distributed therein so that the average spacing between wires is not greater than 0.5 inch.

6. The construction of claim 5 wherein the ratio of the thickness of said surface layer covering to the thickness of said surface layer is in the range of about 0.05 to 0.30.

7. A roadway construction comprising:

(A) a substratum which comprises

(i) a top flexible layer comprised of clay, and

(ii) a bottom hard layer, supporting said top flexible layer, of cement or of a soil-cement which comprises cement mixed with clay or dirt which is alkaline or of controlled pH; and

(B) a surface layer overlying and covering said substratum, which surface layer consists essentially of

(a) a bottom layer overlying and supported by said substratum and of concrete including closely spaced substantially straight wire elements distributed therein so that the average spacing between wires is not greater than 0.5 inch bonded to

(b) an intermediate layer of concrete overlying said bottom layer, bonded to

(c) a top surface layer of concrete including closely spaced substantially straight wire elements distributed therein so that the average spacing between wires is not greater than 0.5 inch.

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