

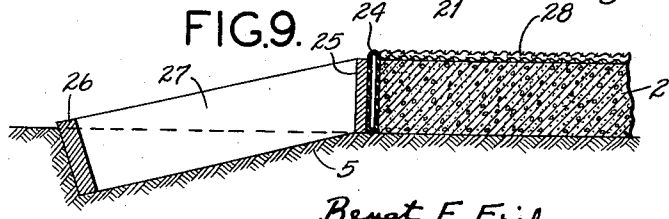
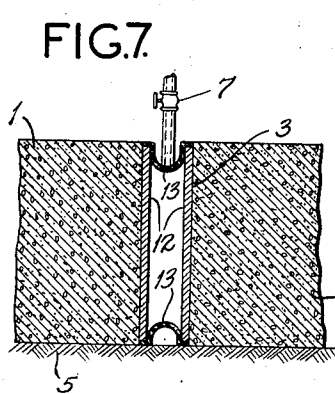
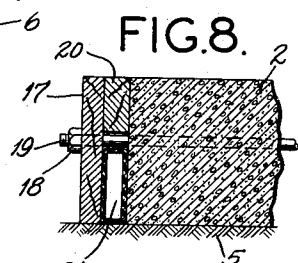
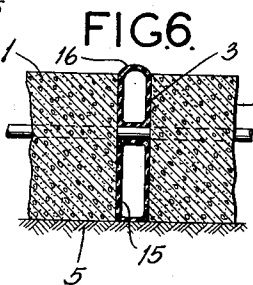
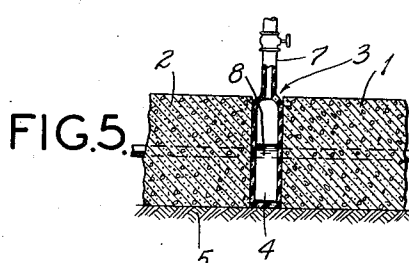
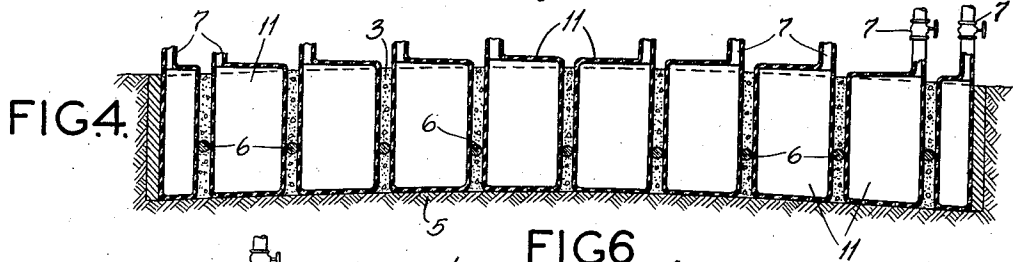
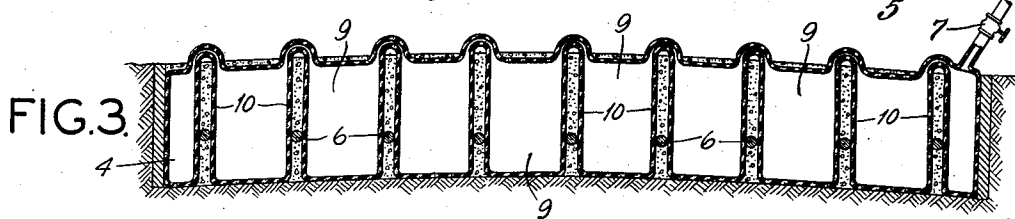
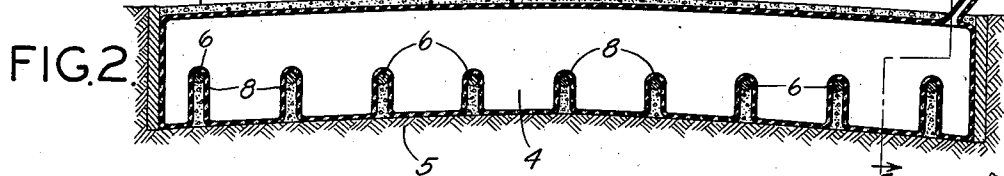
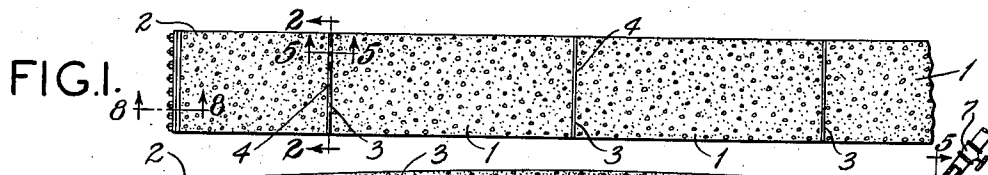
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2,251,672

METHOD OF CASTING CONCRETE PAVEMENTS

Filed June 4, 1936



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UNITED STATES PATENT OFFICE

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METHOD OF CASTING CONCRETE
PAVEMENTS

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4 Claims. (Cl. 94—24)

This invention relates to concrete, and with regard to certain more specific features, to concrete which is substantially free of internal stresses and the like, and a method of constructing such concrete.

Among the several objects of the invention may be noted the provision of a concrete of the class described which, in the form of relatively large slabs or the like, is not likely to crack or otherwise become disfigured; the provision of concrete of the class described which may be used, for example, in the construction of roads, pavement, walks, and the like, wherein substantially larger slabs may be provided between joints without placing the concrete under undue stresses; and the provision of a method of constructing concrete of the class described which is relatively simple and economical to carry out. Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, steps and sequence of steps, features of construction and synthesis, and arrangements of parts, which will be exemplified in the structures and processes hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawing, in which are illustrated several of various possible embodiments of the invention,

Fig. 1 is a plan view of a concrete road;

Fig. 2 is a fragmentary enlarged cross section taken substantially on line 2—2 of Fig. 1;

Figures 3 and 4 are views similar to Fig. 2, showing alternative constructions;

Fig. 5 is a cross section taken substantially along lines 5—5 of Figures 1 and 2;

Figures 6 and 7 are cross sections similar to Fig. 5, illustrating alternative constructions;

Fig. 8 is a cross section taken substantially along line 8—8 of Fig. 1; and,

Fig. 9 is a cross section showing a construction alternative to the construction of Fig. 8.

Similar reference characters indicate corresponding parts throughout the several views of the drawing.

One of the principal features of the present invention is the production of relatively large slabs of concrete, such as are used in concrete roads, pavements, walks, and the like, in which the movement of the structure due to contraction and expansion of the concrete is considerable, but wherein such expansion and contraction causes substantially no cracks or joints other than

the expansion joints required for free and unobstructed expansion of the individual slabs to longer than their original length.

The changes in length of concrete by reason of temperature and moisture changes alone are mostly sufficiently small, that expansion joints spaced considerable distances apart will provide ample space for expansion without difficulty. The normal stresses in the concrete incidental to the changes in length, occurring because of friction or uneven temperature in different parts of the concrete cross section, are mostly no greater than that the concrete can resist them without failure, when it has attained full strength, even if the joints were spaced very far apart.

Before the concrete has attained great strength, however, during the first several days after construction, these stresses may be and usually are greater than the early strength of the concrete. As the concrete as a material is very much weaker in resisting tension than compression, the early shrinkage stresses, understood as those incidental to loss of moisture, as well as the early contraction stresses, understood as those incidental to contraction due to decrease in temperature, may prove critical. If the expansion joints are then spaced far apart, the tension stresses will cause the concrete to crack between the joints to relieve the stresses, or they may cause overstressing of the concrete so that cracks occur at a later time. The appearance of transverse cracks as here described is very common on all concrete roads.

As the uncontrolled cracks constitute places of structural weakness, often resulting in progressive failure of the surrounding structure, and permitting passage or accumulation of infiltration material so that in time the cracks open and render the expansion joints ineffective, every effort has been used in the past to construct the concrete slabs to the imposed limitations. By maintaining the surface of the concrete continuously moist the early shrinkage has been minimized, by the same measure or by covering the concrete with heat insulating or heat reflecting material, the early temperature changes in the concrete have been to some degree reduced. Further, the spacing between joints has been limited to what observations indicate to be the minimum length a freely contracting and expanding slab will attain without cracking. This distance is considerably smaller than that necessary between expansion joints, when the present invention is used. For that reason the intermediate so-called contraction joints commonly have been provided for initial contraction only,

and every other or every third joint has been constructed as an expansion joint with possibility for both contraction and expansion of the concrete structure. Except that the contraction joints do not require a defined dimension of compressible or springing joint filler or void for expansion, they must be structurally reinforced and sealed against the intrusion of foreign material in a manner similar to the expansion joints. Even with great precautions and expense it is difficult to avoid weaknesses and shortcomings at the joints, and any construction method or arrangement which permits greater spacing between the joints without increased tendency to intermediate cracking is accordingly highly to be desired, toward the elimination of all but those joints required for expansion as well as contraction.

The invention herein described is predicated upon the property of concrete in exhibiting at all ages much greater strength under compressive stresses than under tensile stresses. Usually the concrete compressive strength is from five to ten times its tensile strength. In the present invention the concrete is placed under compression, in a direction in which the surface of the concrete tends to shrink, very soon after construction, when it has already attained some measure of compressive strength, but as yet quite insufficient tensile strength. The compression is so adjusted during the shrinkage and contraction of the concrete that at no time any excessive tensile stresses can occur in any part of the structure. In this manner tension failures are prevented at this early age, which does not often last more than from four to forty-eight hours. As the compression need only be sufficiently great to overcome the tensile stresses, which would have occurred under unaided movement, there is full assurance under practically all conditions that the applied compressive stress will not be excessive. Should the contracting condition change into one of expansion, the imposed initial stress may be relieved in order that the compression in the concrete may not assume critical proportions, should the manner of application of the initial stress permit of only very slight flexibility. When after several days the concrete has sufficient tensile strength to contract and expand freely between expansion joints without overstressing, the pressure application may cease entirely, or it may be continued indefinitely to maintain at all time compression in the concrete, to which as a material it is most suited.

For the application of the pressure to the concrete, independent, movable and reusable apparatus is conveniently employed. For the range of pressure used, pressure cells may be employed which comprise flexible, reinforced rubber or metal containers, sufficiently narrow to be inserted into the constructed expansion joints, into which containers air, water, oils or other suitable substances are compressed so that the full pressure is imposed upon the concrete on either side of the joint. If a pressure cell with rigid sidewalls is employed it should preferably have been in place while the concrete on either side was still fluid, in order that the sidewalls may be in contact with the concrete at all points so that their pressure is evenly distributed during the pressure application. Mechanical spring devices, jacks, or tie rods extending through the concrete whether bonded to the concrete or free from contact with the structure between the two

or more points of application, may be used alternatively to the pressure cells.

Referring now more particularly to the drawing, Fig. 1 shows a roadway that is in the course of construction according to the method of the present invention. Numerals 1 indicate the individual, relatively long slabs of the roadway. A relatively shorter slab 2 is shown at the left-hand end of the roadway. The end slab 2 in any one construction sequence is preferably made shorter in case pressure is applied only in the intermediate joints, so that only a very short length of the end slab 2 is without compressive stress. Numerals 3 indicate expansion joints formed between the slabs 1 and 2.

Shortly after the slabs 1 and 2 are poured or formed, the expansion joints 3 are filled with pressure elements indicated, for example, in Figures 2 and 5. In Fig. 2, a pressure cell 4 occupies the expansion joint 3. The slab 1 rests upon a subgrade 5. In this construction, dowel structures 6 cross the expansion joint 3, connecting adjacent slabs 1. The dowels 6, however, do not prevent relative movement of the slabs 1 lengthwise of the dowels. In the Fig. 2 embodiment, one pressure cell 4 is employed for entire width of the roadway. At one of the upper ends of the cell 4, a valved connection 7 is provided. In the embodiment shown in Fig. 2, the cell 4 is provided with notches 8 which are adapted to surround and receive the dowels 6.

Fig. 3 shows an alternative construction in which the pressure cell 4 is divided into segments 9, each two of which are connected by a connecting tube 10. Fig. 4 shows still another alternative construction, in which entirely separate pressure cells 11 are provided, each having a separate valved connection 7. An advantage of the embodiments of Figures 2 and 3 is that the entire pressure cell, extending across the entire width of the roadway, is at the same internal pressure.

The several pressure cells shown may be constructed of a relatively soft, elastic material, such as rubber, which is usually sufficiently strong to withstand the pressures employed. In the alternative, a pressure cell of the type shown in Fig. 7 may be employed, this cell being characterized in that it is formed with two rigid plates 12 as side walls, with flexible connecting diaphragms 13 connecting the walls 12. When a cell of the type shown in Fig. 7 is employed, it may sometimes be used as the form for pouring the concrete and making the expansion joint in the first instance.

Fig. 6 shows an alternative construction in which two relatively narrower pressure cells 15 and 16 are supplied, the one pressure cell 15 being located in the bottom portion of the expansion joint 3, while the second one surmounts it in the upper portion of the joint 3. A particular advantage of the construction shown in Fig. 6 is that the two cells 15 and 16 may be put under different pressures, to counteract curling tendencies of the slabs 1, and the frictional resistances concentrated at the subgrade surface 5.

Figures 8 and 9 show alternative constructions either of which can be used for the free end of the end slab 2. Referring to Fig. 8, for example, a header 17 is provided, which is secured by nuts 18 on the end of tie rods 19. A spacer block 20 is provided between the header 17 and the top part of the slab 2. A pressure cell 21, of the type heretofore described, is provided below the tie rods 19, between the header 17 and the lower

part of the end of the slab 2. The pressure reaction of the cell 21 is therefore carried through the header 17 and nut 18 back through the tie rods 19 to other portions of the slab 2.

In the alternative construction shown in Fig. 9, a full-width pressure cell 24 is provided at the end of the slab 2, of the general type shown in Figures 2 and 5. A plate 25 is provided along the opposite face of the cell 24, and a header 26 braces the plate 25 by means of struts 27. The header 26 is partially buried in the subgrade 5.

If the end slab 2 is short, the use of pressure cells at its free end is not always necessary.

The invention is carried out in the following manner: A few hours after the concrete has been poured, when it has passed the plastic and is just entering the elastic stage, the forms which have made the openings for the expansion joints 3 are removed and the selected pressure cells inserted. Or, if the embodiment shown in Fig. 7 is used, the pressure cells are already in place, as they have been used as casting forms. When, thereafter, temperature contraction or shrinkage commences, pressure is applied to the pressure cells as by pumping in a fluid through the valved connections 7, so that the slabs, instead of dragging over the subgrade 5, are pushed over the subgrade 5 an amount substantially equivalent to the free movement of the slabs. It will readily be seen that the pressure is applied in the same direction as the slabs tend to shrink, that is, in the direction tending to shorten the length of the slabs, in this instance. For movement such as here described, the friction is related to the amount of movement, and the pressure is therefore increased as the temperature of the concrete decreases. The ultimate pressure is dependent upon the temperature decrease, the age of the concrete, and its physical properties, as well as upon the distance between the expansion joints. For ordinary concrete and ordinary conditions, however, a pressure within the range of 50 to 150 pounds per square inch is usually sufficient.

As the concrete thereafter again expands (for example, during the warmer part of the day), the pressure is held constant or decreased so that movement will be limited. When the temperature thereafter again decreases (for example, during the night), the pressure is applied again or increased as required to gauge the movement. These operations are repeated during the first several days at least, until the concrete has gained its full strength, that is, has become fully cured. The pressure cells may then be removed from the expansion joints for reuse elsewhere, and a conventional type of expansion joint filler inserted, unless for special reasons it is desired to maintain the concrete permanently under pressure, in which case the pressure cells are left in place.

If construction conditions are unusual, and the temperature decrease in the cast slabs is so rapid that there is danger of the concrete being overstressed before it has gained sufficient compressive strength to withstand the pressure treatment of the present invention, it is then desirable that insulating or even heated protection be applied to the upper surface of the slabs until such time as the proper compressive strength has been reached. Such protection, for example, can take the form of insulating pads indicated by numeral 28 in Fig. 9.

In concrete construction of this general type, it is usually the custom to place expansion joints

about one hundred feet apart, and contraction joints (to prevent transverse cracking) about thirty-three feet apart. By following the procedure of the present invention, the contraction joints may be entirely eliminated, and single monolithic slabs as long as one hundred feet between expansion joints may satisfactorily be constructed. The elimination of the so-called contraction joint represents a decided step forward in the art, as any joint is a point of weakness.

While concrete is commonly treated as an elastic material in construction, it actually exhibits properties quite objectionable in a material so used. Its strength and modulus of elasticity vary with its age. When loaded it will continue to deform under the load for a very long time after the application of the load. It has been found possible with the use of the present invention, if the pressure is carefully applied at the proper time, to improve in a major degree the elastic behavior of the concrete under load, so that concrete under load will show improved elastic behavior, as well as increased strength.

These improvements are all brought about by the present invention, wherein the concrete undergoes its full shrinkage and contraction at an early age, and is actually consolidated in a permanent manner without any substantial internal tensile stress.

The application of the invention is by no means limited to the construction of large roadway slabs. On the contrary, the method of the invention may be applied to the casting of concrete in substantially any form. Even in relatively small concrete building forms or structures, for example, the concrete constructed according to the present invention is consolidated at an early age in such manner as to relieve incipient stress conditions.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in carrying out the above constructions and processes without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A method of constructing concrete pavements, roadways, and the like which comprises casting said pavements in a series of slabs with intermediate expansion joints, permitting said cast concrete to attain its elastic state, and shortly thereafter applying pressure to the individual slabs to produce compressive stress in the slabs in a direction of surface shrinkage of the slabs, and in such manner as to consolidate the concrete.

2. A method of constructing concrete pavements, roadways, and the like which comprises casting said pavement in a series of slabs with intermediate expansion joints, permitting said cast concrete to attain its elastic state, and shortly thereafter applying pressure to the individual slabs to produce compressive stress in the slabs in a direction of surface shrinkage of the slabs, and in such manner as to consolidate the concrete and relieve it of tension stresses which tend to form as a result of the setting and cooling and shrinking of the concrete, said compressive stress, however, being less than the ultimate compressive strength of the concrete.

3. A method of constructing concrete pavements, roadways, and the like which comprises casting said pavements in a series of slabs with intermediate expansion joints, permitting said cast concrete to attain its elastic state, and shortly thereafter, applying pressure to the individual slabs to produce compressive stress in the slabs in a direction of surface shrinkage of the slabs and in such manner as to consolidate the concrete, and increasing said compressive stress from time to time as the compressive strength of the concrete increases, maintaining however, the compressive stress at a value of less than the compressive strength of the concrete at all times.

4. A method of casting concrete pavements, roadways, and the like which comprises casting said pavements in a series of slabs with intermediate expansion joints, permitting said cast concrete to attain its elastic state, and shortly thereafter applying pressure to the individual slabs to produce compressive stress in the slabs in a direction of surface shrinkage of the slabs, said compressive stress being less than the ultimate compressive strength of the concrete at the time of application of said compressive stress.

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