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METHOD OF LAYING PREFABRICATED CONCRETE SLABS

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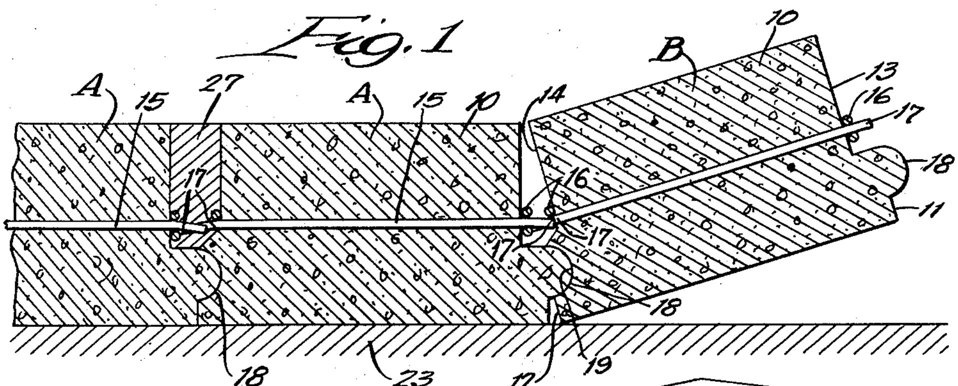

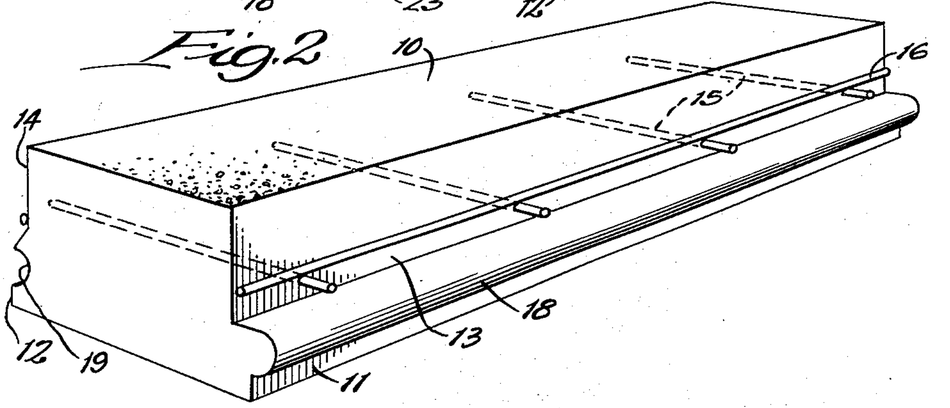

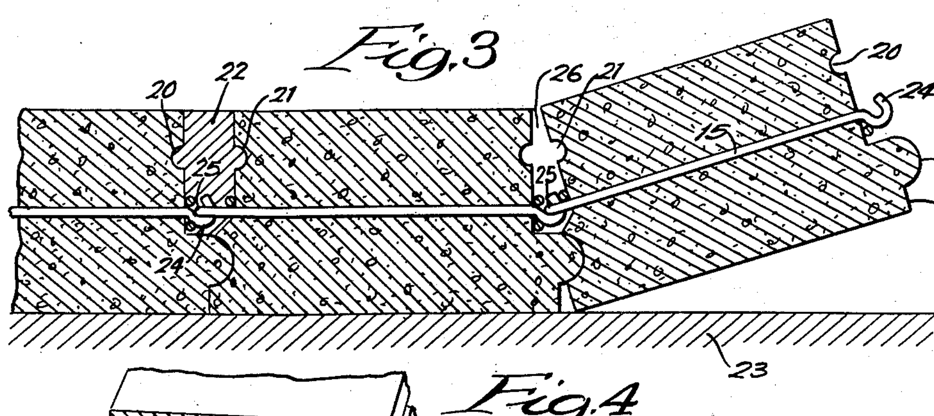

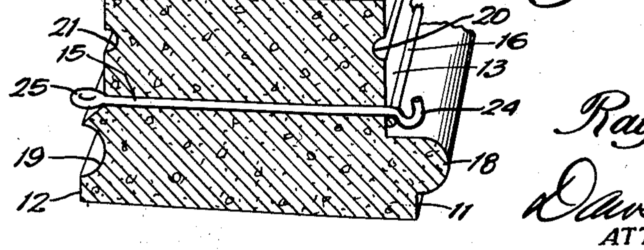

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METHOD OF LAYING PREFABRICATED CONCRETE SLABS

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This invention relates to reinforced concrete and particularly to pre-fabricated concrete structures of the reinforced type which may be used for laying roads and the like.

Materials of construction, such as concrete, in order to function in a desirable manner in the purpose for which they are intended, must be able to take the loads to which they are subjected in normal operation while compensating for the effects occasioned from within by changing atmospheric conditions. Advancement towards this end has been the subject of research and investigations for many years. Discussion herein will be limited to road building but it will be understood that the same concepts and conditions apply to other concrete structures.

Responsive to changes in temperature and moisture conditions in the atmosphere, total units of concrete undergo corresponding changes in volume and shape. Likewise, unequal distribution of moisture content, or temperature in the structure, causes unequal volume changes resulting in distortion and bucking of the concrete structure. If these volume changes are restrained, tremendous internal compression and internal stresses build up within the structure depending on the character of volume change. Because of inherent weakness of concrete in tension, the tensile stresses, which cause fracture and/or cracks, are the more injurious. Such fractures do occur independent of and/or with the effect of external loads, but their formation is anticipated in combination with external loads. In flooring or in roadways, the development of such initial fractures and cracks initiates the destruction of the road. When cracks are formed, the ability of the road for carrying the load is reduced, especially if the subgrade is insufficient. Once a crack has formed, spalling is permitted and this has the result of enlarging the openings and aggravating the damage. Water may enter the openings and cracks and reach down to the subgrade where mud is formed upon admixture with the materials of the subgrade. The mud thus formed can be pumped out by reaction to flexture of slabs on the road bed and vibration to the extent that the road bed will become undermined and slowly break down under external load.

The cracks that are developed fault to the extent that an uneven and undesirable roadway results. If the roadway becomes rough, the damage thereto is accelerated by normal use.

Numerous techniques have been developed for the purpose of preventing or controlling the formation of cracks in concrete. Many of these systems employ frequent jointing with load transmission devices across the joints to provide for changes in the volume of the concrete in the attempt to remove the cause for cracking in the first instance by dividing the slab into small section. These have not been altogether successful and irregularly shaped cracks are still formed.

Another method employs the use of reinforcing bars of steel imbedded in the concrete. Such usage, because of the inherent difference in physical behavior of con-

crete and steel, does not prevent cracking. In fact, the lineal feet of cracking is not affected by the amount of steel embedded. However, the opening of the individual crack is held smaller by the increase in amount of steel reinforcing or, in other words, the steel reinforcing controls the cracks after they have been formed. Therefore, by the use of reinforcing steel bars, the intent is to restrain the enlargement of the cracks to the extent that infiltration of water and foreign material which causes spalling might be minimized or prevented. Though successful in some degree, large quantities of steel are required and considerable expense is involved.

Others have tried increasing the thickness and volume of the concrete slab that is originally formed so that external load will have less effect. The causes for cracking are not removed by this technique. In fact, crack formation is increased by the larger dimension of the concrete structure.

The manufacture of concrete constructions in which cracking not only can be minimized and controlled, but actually prevented in a simple and economical fashion, constitutes the principal object of this invention.

Another object is to produce reinforced concrete which uses high tensile strength steel in minimum amount for the purpose of preventing the development of cracks.

A further object is to employ the principle of post-stressing of reinforcing steel members in the manufacture of concrete whereby the concrete is under compressive force in a direction to prevent formation of cracks.

A still further object is to produce a roadway by laying down precast slabs of reinforced concrete, and it is a related object to manufacture precast slabs of concrete embodying means to prevent formation of cracks.

A still further object is to produce a concrete road, and to provide a method for manufacturing same, of prefabricated slabs of concrete with steel reinforcement stressed throughout its length by gravitational force generated as an incidence to the laying of the slabs.

These and other objects and advantages of this invention will hereinafter appear, and for purposes of illustration, but not of limitation, embodiments of the invention are shown in the accompanying drawing, in which—

Figure 1 is a sectional elevational view illustrating concepts of this invention in the manufacture of the concrete structure;

Figure 2 is a perspective view of a precast slab of the type shown in Figure 1;

Figure 3 is a sectional elevational view similar to that of Figure 1, showing modified means for joining reinforcing bars in their assembled relation, and

Figure 4 is a perspective view in section of a slab of the type shown in Figure 3.

Pre-fabrication of unreinforced concrete structures for flooring and road beds and the like, using slip dowel joints, has been tried and abandoned where crackless surfaces are required because it was impractical.

At the present time, road beds are usually prepared by pouring the cement mixture in place in position of use and then allowing the material to set.

It is believed that a precast slab of concrete could be used if reinforcing with steel bars could be arranged to be continuously stressed throughout their lengths in the road bed. Applicant has found a way to reinforce pre-fabricated concrete slabs and to achieve stressing of the reinforcing members throughout after the concrete has set and as an incidence to the laying of the pre-fabricated slab in position of use on the road bed. Thus it has been made possible for the first time to build pre-fabricated roads with continuous stressing of the reinforcing steel bars in a manner which will prevent cracking during changes in volume and shape incident to normal operation and exposure to atmospheric conditions. The production of such structures is a primary object of this invention and it is a related object to produce a precast concrete slab with the reinforcing members already imbedded therein in the desired relation.

In the practice of this invention, a concrete slab is cast with one or more smooth-walled steel bars arranged longitudinally through the interior of the slab. The number of reinforcing steel bars employed depends chiefly upon the width and the cross section of the slab and the amount of reinforcement desired. For example, four units are employed in each of the slabs illustrated in the drawing.

Means are provided on the ends of the bars for joining with the adjacent ends of the bars of slabs to be positioned endwise thereof—jointing being effected while the slab to be positioned is tilted against the positioned slab so that gravitational force operating to lower the tilted slab in position of use may also be harnessed to stress the jointed reinforcing bars throughout their lengths in the endwise direction. Anchors or stops should be provided to limit movement of the bars other than that effected by poststressing in the manner described.

In the modification shown in the drawing, each slab **10** is formed with end walls **11** and **12**, respectively. Each end portion has a rectangularly shaped cutout section **13** and **14**, respectively, extending from the top of the slab to approximately the center portion thereof to make room for center placing of unbonded smooth wall reinforcing bars **15**, and have one or more transverse bars **16**, which are secured, as by welding, to the opposite ends **17** of the reinforcing bars **15**. On one end, just below the cutout section **13**, the slab is formed with a projecting curvilinear shelf in the form of a substantially semi-cylindrical section **18** which may be adapted to extend all the way across the slab **10**. The opposite end of the slab is formed with a recess **19** of substantially the same contour as the shelf **18** and in the same relative position as the shelf.

Further recesses **20** and **21** may be provided across the slab contiguous with the cutout sections **13** and **14**, respectively, for anchoring a grout **22**, when employed.

In assembly, slab B to be positioned in continuous alignment with slab A which is already properly located on the prepared subgrade **23**, is placed with its recess **19** in contacting relation with the shelf **18** of a positioned slab A so as to enable the slab to be positioned to be tilted at a predetermined angle, as illustrated in Figures 1 and 3. While in this position, the free ends **17** of the longitudinal reinforcing bars **15** overlap so that they may be joined together, as by welding or the like, as illustrated in Figure 1. In the alternative, each bar may be formed with a hook **24** in one end and an eyelet **25** in the other so that they may be joined together to establish a connected relation when the slab B is properly tilted with respect to slab A. Slab B is then permitted to rock about the shelf **18** until it rests properly on the subgrade **23**. Such rotation may be effected entirely by gravitational force or additional force may be applied if necessary.

Rocking movement of the slab to its resting position stretches the connected reinforcing bars **15** and automatically generates longitudinal stress throughout their length in a poststressing technique. The joined transverse bars **16** act as stops or anchors for the longitudinal reinforcing steel bars **15** in the poststressing operation. It is important to maintain an unbonded relation between the reinforcing steel bars and the concrete. For this purpose it is convenient to use smooth walled bars and to make use of lubricants or other slip agents on the metal surface, if necessary.

Rods **16** serve also as transverse unstressed members which are often used in reinforced paving slabs. The use of such unstressed transverse members is adequate to control longitudinal cracking because the road is narrow as compared to its length. In fact, it is sufficient if such transverse members or rods are of small cross-section and firmly bonded to the concrete material.

After the slab has been lowered to its position of use on the road bed, the open notch **26** formed by the cutout sections **13** and **14** may be filled with a precast block **27**, preferably coated with a cement slurry on the forward and rearward walls to establish a better bond with the slabs. This is suggested to prevent or minimize entrance of moisture and foreign material into the road structure. Instead, the notch **26** may be filled with cement grout **22** which anchors in the recesses **20** and **21** provided and, when allowed to harden, provides a well integrated road structure.

In accordance with the practice of this invention, the formation of transverse cracks in the road bed are prevented by continuous compression exerted by poststressed reinforcing steel deployed in precast sections of concrete and joined together throughout their lengths. The amount and quality of reinforcing steel required for the practice of this invention is as little as one-third to one-fourth that which has heretofore been required in ordinary reinforcing, such as mild steel, by unstressed construction. With the substantial elimination of cracks, the need of a base of granular or aggregate material is minimized since pumping no longer constitutes an important factor.

It has been found that concrete slabs placed lengthwise and compressed by poststressing in the manner described will reduce tension stress and the resulting slab is able to support greater road per unit thickness. Thus the initial cost and the weight of the slab per unit area may be appreciably reduced while still maintaining the quality and the operating characteristics of the road structure or the like.

By the use of slabs of reinforced concrete manufactured in sections which can be handled, mass production systems which save time, labor and material may be employed and constructions which are formed thereby can be used immediately after laying operation is completed. This eliminates the need for the construction of expensive feeder lanes or by-passes which have no practical use after the road has been laid. The major changes of dimension which occur upon setting of the concrete from its plastic or fluid mixture takes place before the slab is located in position of use. As a result, one of the major problems in road construction, that of initial shrinkage upon cure of the concrete, is overcome so that high maintenance cost and means for compensating for such shrinkage can be greatly reduced. Pre-fabrication provides other economies and advantages, such as the possibility of laying roads throughout the twenty-four hours of the day with the result that the tie-up of machines and equipment can be greatly reduced.

Defects in roads occasioned by irregularities in subgrade can be minimized by employing a mechanical grader extending all the way across the roadway in advance of the laying of the precast slabs, and/or else fluid fillers or sealers may be pumped under the positioned sections to fill all voids and insure ideal bedding. Under the circumstances, it will be evident that the amount of sealer fluid that will be needed will be at a minimum.

A road or the like employing precast, reinforced concrete slabs prepared in accordance with this invention enjoys considerable flexibility in that it can be extended from time to time merely by the further addition of slabs or the roadway may be repaired in an effective and simple manner merely by the replacement of slabs. In the event of such replacement, other means such as turnbuckle means, may be used to achieve continuous stressing with the new section introduced.

It will be manifest that construction employing precast slabs reinforced with continuously poststressed steel bars will provide maximum, safe and continuous service with less maintenance and repair and with less initial cost and cost of upkeep.

It will be understood that numerous changes may be made in the details of construction, arrangement and operation without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. In the method of laying concrete roads, the steps of providing precast slabs of concrete having reinforcing steel bars extending longitudinally through an intermediate portion of the slab in unbonded relation with the concrete and having end portions projecting beyond the end walls of the slab, said slabs having a curvilinear portion extending outwardly from the end wall at a level below the reinforcing rods connecting transverse members to said steel bar end portions across end walls of the slabs for anchoring purposes, leaning the end wall of one slab upon the adjacent end wall of the other slab already in position of use with one of said walls having the projection thereon, joining the end portions of adjacent steel bars, and then allowing the leaning slab to drop toward position of use on the road bed whereby the spaced relation between the upper end portions of the slab increases responsive to engagement between the projection on one and the end wall of the other during movement of the leaning slab into position of rest whereby the reinforcing bars are gravitationally poststressed throughout their lengths.

2. The method of laying concrete roads as claimed in claim 1, which includes the additional step of filling the open space between slabs formed upon rocking the slab in position of use to provide a unitary structure.

3. In the method of laying concrete roads, the steps of providing precast slabs of concrete having a cylindrical shelf across the lower portion at one end and a receiving recess across a corresponding portion at the other end and having reinforcing steel bars extending longitudinally therethrough at a higher level than the shelf and recess and in unbonded relation with the concrete, tilting one slab upon the other while in position of use with the recess of the one slab resting upon the shelf of the other, joining the end portions of the adjacent steel bars while the tilting relation is maintained, and then allowing the tilted slab to rock toward position of use whereby the bars are gravitationally poststressed throughout their lengths.

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