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REINFORCED CONCRETE CONSTRUCTION

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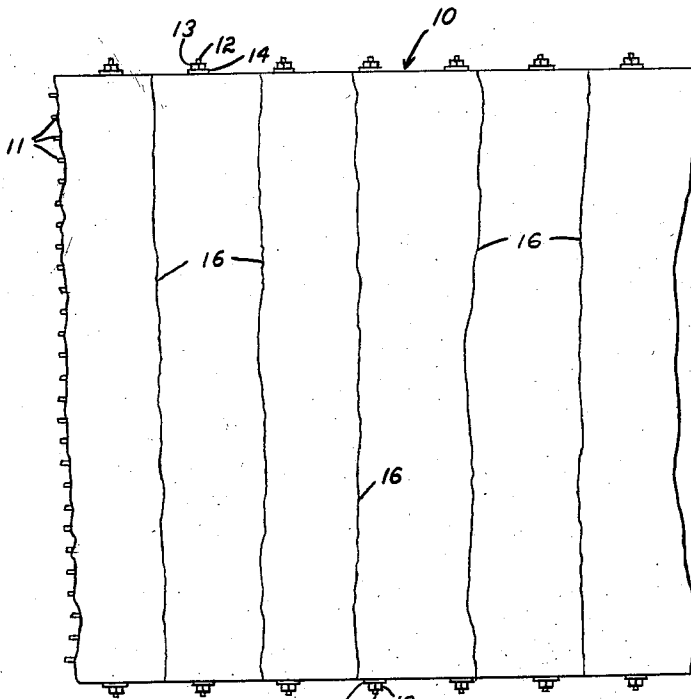


Fig. 1

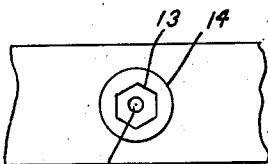


Fig. 2

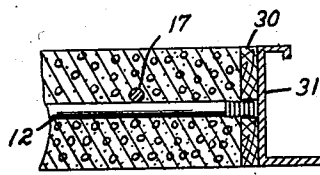


Fig. 4

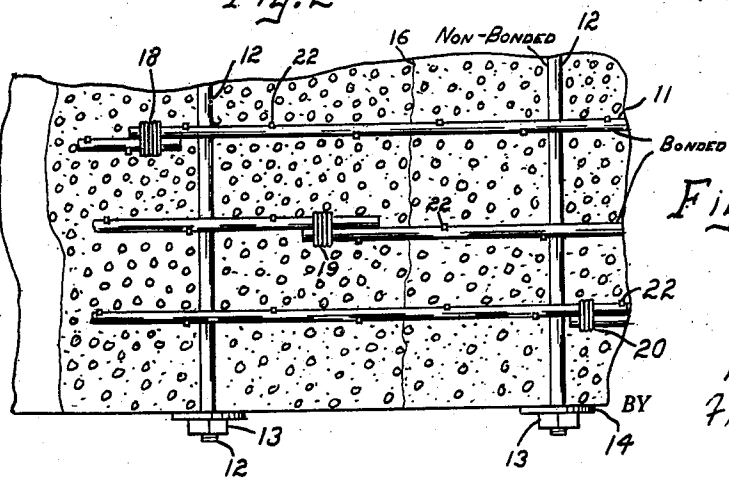


Fig. 3

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REINFORCED CONCRETE CONSTRUCTION

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10 Claims. (Cl. 94—4)

The present invention is concerned with a reinforced concrete structure of considerable length and more particularly with the features of such a structure whereby provision is made for the expansion and contraction arising from varying temperature and moisture conditions.

In relatively long concrete structures, such as concrete highways, it has long been recognized that it is desirable to provide some means for taking care of expansion and contraction of the concrete due to the varying temperature and moisture conditions. Various schemes have been proposed to provide expansion joints at periodical intervals, such as every twenty to one-hundred feet. In spite of the large number of types of such joints available, none have proven entirely satisfactory. I have discovered that, for reasons to be discussed later, much of the difficulty encountered is due to the universal practice of employing relatively wide joints at long intervals and that far more satisfactory conditions can be obtained by providing very narrow joints at relatively short intervals.

An object of the present invention is to provide a reinforced concrete structure of considerable length in which a large number of transversely extending joints are automatically formed in the pavement. In general, this is accomplished by providing the concrete with longitudinal bonded reinforcing and transverse non-bonded reinforcing and maintaining the pavement at an elevated temperature until it has set so as to cause cracking in a transverse direction. During the setting process, the transverse reinforcing is periodically tightened to maintain the concrete in a transverse direction in a continual state of compression so as to obtain the benefits set forth in my prior Patent No. 1,684,663, granted September 18, 1928, for Manufacture of reinforced concrete. By reason of the non-bonded transverse reinforcing tightened in this manner, the cracks are compelled to run transversely of the pavement.

Thus, a further object of my invention is to provide a method of forming an elongated concrete structure which consists in providing the concrete structure with longitudinal bonded reinforcing and transverse non-bonded reinforcing, in maintaining the concrete wet until it has completely set, and in periodically tightening the non-bonded reinforcing to maintain the concrete in a continual state of compression in a transverse direction.

Further objects of the invention will be apparent from a consideration of the accompanying specification, claims, and drawing, of which:

Figure 1 is a top plan view of a section of concrete pavement formed in accordance with my invention;

Figure 2 is a side elevational view of a portion

of the pavement on a much larger scale than that of Figure 1;

Figure 3 is a top plan view of a portion of the pavement on the same scale as Figure 2 and with a portion of the concrete broken away to show the reinforcing; and

Figure 4 is a transverse sectional view of a portion of pavement while the forms are still in place.

Referring specifically to Figure 1, the concrete structure is shown in the form of a concrete highway as generally indicated by the reference numeral 10. As indicated at the left hand end where the concrete section is broken away, there are a number of longitudinal reinforcing rods 11. It is to be understood that these rods extend for the full length of the pavement. While any one rod is not continuous, the rods are overlapped so as to provide the effect of a continuous rod. As will be explained in more detail later, rods 11 are bonded to the pavement in the conventional manner.

The reference numerals 12 are employed to indicate the transverse reinforcing rods. Threaded on the ends of each rod 12 is a nut 13 and interposed between the nut 13 and the edge of the pavement is a washer 14. As will be noted from Figure 1, a plurality of very fine cracks 16 extend transversely across the pavement. These cracks, while hardly visible in an actual pavement, have been exaggerated in the drawing for purposes of illustration.

Referring specifically to Figure 3, it will be noted that successive rods 11 are overlapped and wired together as at 18, 19, and 20. Furthermore, the rods 11 may be provided with projections 22 to insure that there will be a thorough bonding with the concrete. The transverse rods 12, on the other hand, are, as will be noted from the drawing, free of any projections whatsoever and are of entirely uniform diameter throughout. Furthermore, these rods are coated with oil, liquid asphalt, or any other substance which prevents the bonding of the reinforcing rod to the concrete.

In laying a concrete highway, it is conventional to employ standard forms usually made of steel. It is necessary to have the transverse reinforcing rods projecting slightly beyond the edge of the concrete so as to permit the application of washers 13 and nuts 14. In order to provide for this, wooden planks 30 (as best shown in Figure 4) are placed immediately within the steel form. These planks have bored in them holes at suitably spaced intervals corresponding in diameter to that of the transverse rods. The ends of the transverse rods are placed in these apertures and are supported by the wooden planks 30 at their ends and by previously placed concrete or chairs

or other suitable devices intermediate the ends. The longitudinal reinforcing 11 may then be placed on the transverse reinforcing.

After the concrete has initially set, the forms 31 and the wooden planks 30 are removed from each side of the pavement and the washers 14 and nuts 13 are applied. It is preferable to employ rods with rolled threads rather than cut threads in order to decrease the strength of the transverse rods as little as possible.

It is very desirable that the concrete be maintained in an expanded condition until it has thoroughly set. This may be done by keeping it wet and in some cases, keeping it at an elevated temperature. The least expensive way of keeping it at an elevated temperature is to lay the concrete during the first part of the summer months so that it is maintained for a period of two or three months at the highest temperature that it will normally encounter during use. During this time, the concrete is kept wet. Also during this period, the nuts 13 are periodically tightened to maintain the concrete under compression. It is desirable, even after the end of a year, to further tighten the nuts 13.

By reason of the fact that the pavement is maintained at an elevated temperature as high as it will encounter in actual use, it is assured that any tendency to change in length due to temperature will be a tendency to decrease in length. Similarly, inasmuch as the pavement is maintained wet throughout this period, any tendency to change in length due to change in moisture conditions will be in the form of shrinkage due to the pavement drying out. Thus, as the pavement cools and dries, it will tend to decrease in length. Inasmuch as the longitudinal reinforcing, being steel, will not be affected by the drying out, its only tendency to decrease in length will be that due to cooling. Since both the steel and the concrete are continuous, they will be placed under tension as they tend to shrink. The steel is able to resist this tension. Due to the greater tendency of the concrete to shrink and its lower tensile strength, it will be forced to crack in order to relieve the tension. Since the concrete is bonded to the steel, it will be forced to crack at frequent intervals instead of at one or two points, as would be the case if no longitudinal reinforcing were used. While experimental concrete pavements have been constructed with continuous bonded reinforcing so that periodic cracking tended to result under certain temperature and moisture conditions, no provision has been made for controlling these cracks. The result is that the cracks instead of proceeding in a transverse direction have tended to follow lines of weakness in the concrete and in many cases have proceeded in a longitudinal direction as much as in a transverse direction. Inasmuch as longitudinal cracks lead to a rapid deterioration of a highway and are unnecessary for purposes of caring for contraction and expansion, such long cracks are highly undesirable. By providing the transverse reinforcing 12, however, and by maintaining this reinforcing under tension at all times, the tendency of the concrete to crack in a longitudinal direction is eliminated. While, the cracks, of course, do not run in an absolutely straight line, they tend to run in a generally transverse direction as illustrated in Figure 1.

The transverse reinforcing has a further function. Because of the fact that it thoroughly compresses the concrete, it tends to cause the concrete to more tightly grip the longitudinal rein-

forcing. The result of this is that when the concrete shrinks, it is held so tightly against the steel by the combined effects of the bonding with the steel and the compression exerted by the transverse reinforcing that it is forced to crack at very frequent intervals in order to shorten itself. As has been mentioned above, it is desirable to have the cracks at relatively frequent intervals. The transverse reinforcing thus serves both to increase the frequency of the cracks and to prevent them from proceeding in a longitudinal direction.

As indicated above, I prefer that the cracks be at very short intervals. By doing this, numerous advantages result. In the first place, by making the cracks extremely frequent, each individual crack will be very fine. This eliminates the need of filling material and provides a more closely fitting articulated joint. As previously indicated, the cracks as shown in the drawing are exaggerated for purposes of illustration. In an actual pavement, these cracks would be difficult to detect because of their fineness. Furthermore, any discomfort due to warping of the slabs is avoided. It has been found experimentally that in a seven inch concrete slab, there can be as much temperature differential as thirty degrees Fahrenheit between the upper and lower surfaces of the concrete pavement. Since concrete tends to expand about .000005 of its length for each degree Fahrenheit, this leads to a difference in length between the top and bottom of .00015 of the length of slab. Since concrete will stretch only .0001 of its length, it is obvious that a substantial degree of warping is necessary in a long slab in order to take care of this difference in length of the lower and upper surfaces. While the degree of curvature of the slab is not great, it can be readily seen that where the slab is twenty feet long as in the typical construction, the actual rise in height of the slab at its ends will be substantial.

The same uncomfortable condition can arise by reason of different moisture conditions on the top and bottom of the concrete. With the concrete saturated on its bottom surface and thoroughly dried out on its top surface, there can be a differential in length between the top and bottom surfaces of as much as .0006 of the length. Where this differential is in addition to the differential due to the difference in temperature between the upper and lower surfaces, it will be readily seen that the warping can be very substantial. The result is that in many highways, under certain conditions, a very distinct "bounce" is given to a vehicle travelling along it.

The frequency of the cracks will depend upon the amount of longitudinal reinforcing that is employed. It is accordingly desirable to employ sufficient reinforcing to insure that the cracks run at very frequent intervals. It is even desirable that the cracks be spaced as little as a foot or two apart. While the amount of steel and reinforcing that is employed is dependent on various circumstances, the use of one-half inch reinforcing rods both longitudinally and transversely with the longitudinal rods spaced about six or eight inches apart and the transverse rods spaced eighteen to twenty-four inches apart will produce desirable results in a typical case. These values may, of course, be varied if desired with the understanding that as the amount of longitudinal reinforcing is increased, the frequency of the cracks is increased. Furthermore, while

more frequent rods of smaller diameter are desirable, the use of such rods increases the expense both of the material and of the labor as compared with fewer rods of larger diameter. In any event, the type of rods and their spacing depends to some extent upon the practice in the particular area, the conditions encountered within the area, and the desired straightness of line desired in the surface of the pavement.

While I have shown a specific embodiment of my invention for purposes of illustration, it is to be understood that the invention is to be limited only by the scope of the appended claims.

I claim:

1. In a concrete structure relatively long as compared with the width thereof, a plurality of reinforcing rods extending longitudinally within said structure for substantially the full length thereof and bonded thereto, and means for clamping the concrete transversely to hold it in a continual state of compression even after complete setting thereof.

2. In a concrete structure relatively long as compared with the width thereof, a reinforcing rod extending longitudinally within said structure for substantially the full length thereof and bonded thereto, and a plurality of rods extending transversely within said structure and unbonded to said concrete, said rods being provided with means for holding the concrete adjacent thereto in a continual state of compression even after complete setting thereof.

3. In a concrete structure relatively long as compared with the width thereof, a plurality of reinforcing rods extending longitudinally within said structure for substantially the full length thereof and bonded thereto, and a plurality of rods extending transversely within said structure, said rods being coated with a substance to prevent their bonding to the concrete, and said rods being provided with means for holding the concrete adjacent thereto in a state of compression.

4. In a concrete structure relatively long as compared with the width thereof, a reinforcing rod extending longitudinally within said structure for substantially the full length thereof and bonded thereto, a plurality of rods extending transversely within said structure and unbonded to said concrete, and nuts on at least one end of said transverse rods clamping the concrete transversely and holding it in a state of compression.

5. In a concrete structure relatively long as compared with the width thereof, a plurality of reinforcing rods extending longitudinally within said structure for substantially the full length thereof and bonded thereto, a plurality of rods extending transversely within said structure, said rods being coated with a substance to prevent their bonding to the concrete, washers disposed over the ends of said transverse rods, and nuts on the ends of said transverse rods clamping the concrete transversely and holding it in a continual state of compression.

6. The method of providing for the expansion and contraction in an elongated block of concrete which consists of forming the concrete with effectively continuous, longitudinally extending reinforcing rods bonded thereto, maintaining said concrete wet until it has reached a substantial state of rest so that upon subsequent drying, the concrete cracks at frequent intervals, and maintaining said concrete in a con-

tinual state of compression in a transverse direction.

7. The method of providing for the expansion and contraction in an elongated block of concrete which consists of forming the concrete with effectively continuous, longitudinally extending reinforcing rods bonded thereto and with transversely extending reinforcing rods free to move transversely of the concrete, maintaining said concrete at a temperature substantially as high as the highest temperature encountered in use until it has reached a substantial state of rest so that upon subsequent cooling, the concrete cracks at frequent intervals, and periodically tightening said transverse rods only against the concrete to maintain the concrete in a continual state of compression in a transverse direction.

8. The method of providing for the expansion and contraction in an elongated block of concrete which consists of forming the concrete with effectively continuous, longitudinally extending reinforcing rods bonded thereto and with transversely extending reinforcing rods, coating said last rods with a lubricant so as to cause them to be free to move transversely of the concrete, maintaining said concrete wet until it has reached a substantial state of rest so that upon subsequent drying, the concrete cracks at frequent intervals, and periodically tightening said transverse rods against the concrete to maintain the concrete in compression.

9. The method of providing for the expansion and contraction of concrete in a concrete highway which consists of forming the concrete with effectively continuous, longitudinally extending reinforcing rods bonded thereto and with transversely extending reinforcing rods free to move transversely of the concrete, laying said transverse rods so that the edges thereof project beyond the edges of the highway, maintaining said concrete at a temperature substantially as high as the highest temperature encountered in use until it has reached a substantial state of rest so that upon subsequent cooling the concrete cracks at frequent intervals and applying clamping means to the ends of said transversely extending rods only and periodically tightening said clamping means against the concrete to maintain the concrete in a continual state of compression.

10. The method of providing for the expansion and contraction of concrete in a concrete highway which consists of forming the concrete with effectively continuous, longitudinally extending reinforcing rods bonded thereto and with transversely extending reinforcing rods free to move transversely of the concrete, said concrete being laid within forms supporting said transversely extending rods with the ends of said rods extending into said forms, removing said forms, applying clamping means to the ends of said transversely extending rods only, periodically tightening said clamping means against the concrete to maintain the concrete in a continual state of compression, and in maintaining said concrete at an elevated temperature until it has reached a substantial state of rest so that upon subsequent cooling the concrete cracks along transverse lines at frequent intervals.

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