PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to Prestressed Tubular Concrete Structure

We, RAYMOND CONCRETE PILE COMPANY, a corporation organised under the laws of the State of New Jersey, United States of America, of 140, Cedar Street, New York, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to prestressed tubular concrete structures particularly adapted, among other possibilities, for use as pipes or conduits, certain features of the invention also being well adapted for use in concrete piles and caissons.

This invention is an improvement in or modification of the invention according to application No. 25272/48 (Serial No. 649,681), wherein certain features of the invention are disclosed as embodied in concrete piles.

The present invention contemplates casting or spinning the concrete in relatively short tubular sections, and groups of these sections in use are held together under pressure in end-to-end relation with a suitable simple sealing means interposed therebetween. Heretofore, so far as I am aware, with concrete pipes and the like made in sections, it has been necessary to provide a relatively expensive joint means between sections to insure a fluid-tight durable construction and to provide for expansion and contraction, and where any effective form of so-called prestressing was desired, it was necessary to prestress the pipe sections individually and independently by the use of relatively expensive methods during casting of the sections. On the other hand, with the present invention, pluralities of the sections as assembled end-to-end may be prestressed readily in groups while they are being installed, and in a way such that the possibility of leakage between sections of each group is avoided without any substantial expense for joints between the sections of each group, and expansion and contraction are provided for by a novel form of joint which is used only between successive groups of sections.

In accordance with the invention the walls of each section have formed therein a plurality of longitudinal cavities at circumferentially spaced positions extending within the concrete from end to end of the section, each such cavity communicating with a corresponding cavity through the next adjacent section or sections of a group. Highly tensioned wires extend through the communicating cavities of succeeding sections of the group, such wires being held under tension by suitable means, preferably by a filling of grout introduced into the cavities under pressure and acting securely to bond the successive portions of each wire to the adjacent successive portions of the concrete. These tensioned wires thus act through such grout bond to subject the concrete of each section to substantial compression longitudinally and also to maintain the sections of a group end-to-end under pressure, with the sealing means also tightly retained under pressure.

Circumferentially extending reinforcing means, for example in the form of helically wound wires, are provided for the walls of each section in a position to surround and embrace at least that portion of the concrete of the section walls which contains the tensioned wires. With such construction the effect of the longitudinal compression in conjunction with the confining effect of the circumferential reinforcing means also acts to maintain the inside wall portions of the concrete under substantial compression circumfer-

entially. That is, the concrete as held under longitudinal compression is confined against expansion radially outward by reason of being surrounded by the circumferential reinforcing means, and at the same time the concrete is kept from expanding in directions radially inward of the section by reason of the arch effect of the interior walls. Consequently the concrete as thus confined is caused to be placed under substantial compression in circumferential directions and may thus be referred to as prestressed both longitudinally and circumferentially. It will be apparent that the securing of the longitudinal wires in place under tension not only accomplishes the desired prestressing in two directions, but also makes it possible to prestress the sections in groups with the prestressing means having the further functions of retaining the sections of each group firmly together and maintaining the sealing means therebtween tightly under pressure.

The above-mentioned circumferential reinforcing means is preferably covered and protected by concrete forming the exterior portions of the walls of each section and integral with the concrete forming the interior wall portions, and it will be apparent that as the interior wall portions become subjected to compression circumferentially, the external and internal concrete portions will work under different stresses which, under certain conditions, may tend to cause separation between the two layers of concrete unless reinforcing means is extended from one to the other. In order to prevent such external and internal portions from cracking apart as a result of the relatively opposed strains therein, according to one aspect of the invention additional reinforcing means of a relatively lighter nature (preferably in the form of light mesh wire) is embedded in the concrete, partially in the outer portions thereof and extending partially into the inner or circumferentially compressed portions.

Further and more specific objects, features and advantages of the invention hereof will appear from the detailed description given below, taken in connection with the accompanying drawings which form a part of this specification and illustrate by way of example, preferred embodiments of the invention.

In the drawings:

Figure 1 is a longitudinal sectional view of a portion of a pipeline or conduit embodying the invention;

Figure 2 is a view showing in separated relation a plurality of the pipe sections, intervening sealing means and a joint member, which are to be secured together to form a group of sections;

Figure 3 is a view similar to Fig. 2, but showing the same parts as secured together to form a prestressed group of sections, portions of other sections forming parts of other groups being indicated in dotted lines;

Figures 4, 5 and 6 respectively are transverse sectional views taken substantially along lines 4—4, 5—5 and 6—6 of Fig. 1;

Figures 7 and 8 respectively are enlarged longitudinal sectional views taken substantially along lines 7—7 and 8—8 of Fig. 4;

Figure 9 is a sectional view illustrating a method for forming the longitudinal cavities in the sections for receiving the tensioned wires;

Referring to the construction of Fig. 1 in further detail, three of the above-mentioned end-to-end tubular concrete sections are indicated at 15, 15*a*, 15*b*, sections 15, 15*a* (as indicated in Figs. 2 and 3) forming a part of one group of sections and 15*b* forming one of another group of sections connected to the first group by the novel form of reinforced concrete joint means 16.

As is shown more clearly in Figs. 4, 7 and 8, the walls of each of the sections have formed therein a plurality of longitudinal cavities 18 at circumferentially spaced positions extending within the concrete from end to end of the section, such cavities of one section communicating directly with like cavities of adjacent sections of the same group. Each of these cavities contains a longitudinally extending wire or group of wires at 19, such wires extending from end to end of a group of sections, and as hereinafter further explained, such wires are maintained under heavy tension, for example in the neighbourhood of 125,000 to 150,000 lbs. per square inch (assuming that the ultimate strength of the wires approximates 200,000 lbs. per square inch). With the preferred forms of the invention, the tension is maintained in such wires by filling the cavities 18 about the wires with a high grade of cement grout as at 20 (Fig. 7) introduced under pressure while the wires are being held under the heavy tension as by the use of hydraulic jacks mounted to exert pressure against the end of a group of the sections while pulling on one end of each wire, the opposite wire end at the other end of the group of sections being anchored by any suitable means. Thus, while the grout is being introduced and allowed to harden, the concrete of all of the sections of the group is maintained under substantial longitudinal compression by forces equal and opposite to those

entially. That is, the concrete as held under longitudinal compression is confined against expansion radially outward by reason of being surrounded by the circumferential reinforcing means, and at the same time the concrete is kept from expanding in directions radially inward of the section by reason of the arch effect of the interior walls. Consequently the concrete as thus confined is caused to be placed under substantial compression in circumferential directions and may thus be referred to as prestressed both longitudinally and circumferentially. It will be apparent that the securing of the longitudinal wires in place under tension not only accomplishes the desired prestressing in two directions, but also makes it possible to prestress the sections in groups with the prestressing means having the further functions of retaining the sections of each group firmly together and maintaining the sealing means therebtween tightly under pressure.

The above-mentioned circumferential reinforcing means is preferably covered and protected by concrete forming the exterior portions of the walls of each section and integral with the concrete forming the interior wall portions, and it will be apparent that as the interior wall portions become subjected to compression circumferentially, the external and internal concrete portions will work under different stresses which, under certain conditions, may tend to cause separation between the two layers of concrete unless reinforcing means is extended from one to the other. In order to prevent such external and internal portions from cracking apart as a result of the relatively opposed strains therein, according to one aspect of the invention additional reinforcing means of a relatively lighter nature (preferably in the form of light mesh wire) is embedded in the concrete, partially in the outer portions thereof and extending partially into the inner or circumferentially compressed portions.

Further and more specific objects, features and advantages of the invention hereof will appear from the detailed description given below, taken in connection with the accompanying drawings which form a part of this specification and illustrate by way of example, preferred embodiments of the invention.

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Figure 3 is a view similar to Fig. 2, but showing the same parts as secured together to form a prestressed group of sections, portions of other sections forming parts of other groups being indicated in dotted lines;

Figures 4, 5 and 6 respectively are transverse sectional views taken substantially along lines 4—4, 5—5 and 6—6 of Fig. 1;

Figures 7 and 8 respectively are enlarged longitudinal sectional views taken substantially along lines 7—7 and 8—8 of Fig. 4;

Figure 9 is a sectional view illustrating a method for forming the longitudinal cavities in the sections for receiving the tensioned wires;

Referring to the construction of Fig. 1 in further detail, three of the above-mentioned end-to-end tubular concrete sections are indicated at 15, 15*a*, 15*b*, sections 15, 15*a* (as indicated in Figs. 2 and 3) forming a part of one group of sections and 15*b* forming one of another group of sections connected to the first group by the novel form of reinforced concrete joint means 16.

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which concurrently retain the wires under tension. After the grout has been allowed to set and harden, the means for tensioning the wires may be removed and the wire ends respectively cut off flush with the end surfaces of the group of sections (see Fig. 7).

It will then be found that the successive portions of all the wires along their lengths respectively are firmly and permanently bonded to the adjacent successive portions of the concrete within the cavities 18, thereby in effect permanently affixing each such portion of concrete under compression with respect to adjacent wire portions under tension. Thereby the effect of great tensile strength is permanently imparted to the concrete all along the wires, and this prestressing effect is permanently distributed and maintained throughout the length of each group of tubular sections, rather than being necessarily dependent upon conditions at the ends of each section or at the ends of each group of sections. Also if defects ever occur in portions of some of the wires or in the bonding of the wires at certain points, the prestressing of the concrete at other regions continues to be effectively maintained. Since careful tests have shown that with this way of bonding the wires in place, permanent locking means to hold the ends of the wires against slipping are not necessary or essential, the wires may be cut off flush with the ends of the group of sections whereby the wires will not interfere with the joint means (as at 16) used between groups of sections.

The longitudinal compression attained as above described has the effect of pulling the ends of successive sections of each group so tightly together that the pipe is readily made fluid-tight simply by using a suitable cement, plastic paste, or a simple gasket of corrugated metal or other recognized joint packing between sections as at 21 (Fig. 7). There is here indicated (with somewhat exaggerated dimensions) a sealing means in the form of an annular sheet metal ring 22 with annular corrugations and interposed between thin layers of the cement as at 23. However, if the end surfaces of the concrete sections are formed to closely fit, it will be found that a tight permanent seal may be secured merely by the use of a small amount of cement or plastic paste at this point, since the latter will be held under great pressure by reason of the tensioned wires 19. This function of the tensioned wires makes possible an important saving in the cost of the conduits, through avoidance of the necessity of using any complicated or expensive joint means between the sections of each group. As shown in Figs. 5 and 7, the tensioned wires 19 pass through apertures as at 25 in the sealing means with enough clearance to permit the grout as introduced under pressure surrounding the wires readily to pass along the wire cavities throughout the group of sections and such grout contributes to sealing and protecting the wires at the points where they pass from one section to the next.

During the process of casting the tubular concrete sections, a relatively strong circumferential reinforcing means is embedded in the walls of the concrete, preferably in the form of a helical wire 26 located in a position to surround at least the inner wall portions of the concrete and including that in which the cavities 18 are located. This constitutes the circumferential reinforcing means above referred to, which has the effect of confining the inner portions of the concrete of the walls against radial expansion upon tensioning the wires 19. Since the concrete is also confined against expansion inwardly by reason of the arch effect of the interior walls of the tubular sections, it will be apparent that the heavy longitudinal compression applied shortly after the concrete is set and taken its normal shrinkage, necessarily causes that part of the concrete embraced by the helical wires 26, to be compressed circumferentially sufficiently completely to avoid the formation of any small cracks or openings therein when the pipe is placed under fluid pressure, thus eliminating any danger of leakage and percolation through the walls of the pipe in use. On the other hand, the outer portions of the concrete which serve to cover and protect the wires 26, tend to become subject to tension particularly when the pipe or conduit is filled with fluid under pressure. Hence in order to prevent the integral inner and outer portions of the concrete walls from tending to crack apart due to such opposed strains, an additional reinforcing means is preferably provided in the form, for example, of a light-weight open mesh wire means as at 28 embedded in the concrete as cast, and having generally cylindrical portions as at 28*a* (Fig. 8) surrounding the reinforcing wires 26, but also having a helically indented portion as at 28*b* extending into that portion of the concrete which, as prestressed, is under compression.

To insure against breakage of the sections during handling, a number of light-weight longitudinal reinforcing rods or wires may be cast therein as at 29 at circumferentially spaced positions around within the walls, but except for such lightweight and inexpensive reinforce-

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ment desirable during handling of the sections, it is unnecessary to provide any longitudinal reinforcement, and accordingly the expense of such reinforcement in heavy form or in the form of steel cylinders, as heretofore usually required, is avoided with this invention.

If desired, the helically indented portion 28*b* of the mesh 28 may be embraced and held in place inwardly of the concrete against the reinforcements 29 by a small helically extending wire 30.

In casting the concrete sections, the wire mesh and reinforcements 26, 29 may first be put in place in the molding means, and (as indicated in Fig. 9) provision for the cavities 18 may be made by suitably supporting at the desired places rubber tubes as at 32, which are readily removed after the concrete has set. Since with this invention no prestressing is to be accomplished during the manufacture of the sections, they may be readily cast in well known ways without difficulty.

If desired the above described tubular sections as well as the other embodiments of tubular sections hereinafter described may be formed in such manner that the circumferential reinforcing means provided also ~~prestresses~~ the sections circumferentially as initially made prior to the assembly of the sections in groups and the prestressing of the groups longitudinally as above described. This may be accomplished in various ways. For example, the inner wall portions only of the tubular sections may first be cast with the cavities 18 therein and then such tubular castings may be wrapped with circumferential reinforcing means in the form of wire or wires as at 26, which are put under heavy tension in known ways and then covered and protected by applying or casting thereabout the outer wall portions of the concrete, thus producing sectional units which are initially prestressed circumferentially. Thus as these sections are assembled and prestressed as a group by the longitudinal wires, additional circumferential prestressing will be brought about in the manner above described as a consequence of the confining of the concrete during the longitudinal prestressing. This two-stage circumferential prestressing has a substantial advantage for the following reason. As is well understood, the prestressing of concrete generally cannot be carried out to the degree that would otherwise be possible because of the plastic flow effect or "creeping" of the concrete, as well as a somewhat similar effect which takes place in the steel, with the result that after the prestressed structure stands for a short period, the prestressing originally applied is reduced by a substantial percentage. On the other hand, with the above described two-stage circumferential prestressed method, a substantial part of the amount by which the initial circumferential prestressing is reduced by the creeping effects, may be later restored when the sections in groups are installed and subjected to both longitudinal and additional circumferential prestressing by the wires 19.

In order to provide a joint between each succeeding group of sections, one end of an end section of a group is accurately cast or ground to tapered form, as indicated at 33 at the right hand end of Fig. 7. This end is adapted to fit into a correspondingly tapered interior opening 34 of a precast sleeve 16 (see mid-portion of Fig. 1) the opening of which is also accurately cast or ground to fit the tapered end 33. This sleeve is pressed onto the tapered end of the pipe section, the tapered surfaces being suitably grouted, and also preferably formed with complementary grooves respectively, of semicircular cross-section at 33*a*, and 34*a* Fig. 1. These grooves provide an annular cavity of circular cross-section, which, after the sleeve is put in place, is filled with grout through a radial opening 36, and upon the hardening of such grout, it will be apparent that the sleeve will be firmly locked in place and sealed on the end of the pipe section.

The other end of the sleeve 16 is formed with an opening 37 having its outer portion at least at 38 also somewhat tapered or suitably shaped to readily receive and firmly retain the end portion 39 of a section such as 15*b* (Fig. 1). The latter section end, around its exterior surface, is preferably formed with a groove 40 containing an annular plastic or rubber gasket 40*a* providing a fluid-tight seal when forced in under pressure against the interior walls of the opening of the sleeve 16. After the two pipe sections have been put in place within the sleeve 16 (as shown in Fig. 1) and pressed together, the joint between the ends thereof at 41 may also be filled with grout or other sealing means from the inside of the pipe to provide additional protection against the escape of fluid.

The sleeve 16 is preferably reinforced by forming the same with a helical wire as at 43 embedded therein, and if desired also by a plurality of circumferentially spaced longitudinal reinforcing wires or rods as at 44. This form of joint or sleeve means, which includes a comparatively small amount of steel, may be manufactured economically as compared with joint constructions heretofore generally considered necessary for concrete pipe,

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and embodying relatively more expensive closely fitting steel parts which have to be welded or otherwise secured, generally to steel cylinders or other reinforcing means extending throughout the pipe. At the same time, the joint as here shown, while permanently, rigidly and tightly locked to the end of one pipe section, engages the adjacent pipe section in a manner such as to permit limited longitudinal travel to occur without leakage, thus meeting the problem of expansion and contraction which is involved with most long pipe lines, but without resorting to the expense of providing such joint means between every adjacent pair of sections. The number of joints used, or in other words the number of pipe sections comprised in each group, may be varied according to conditions prevailing on each job. In some cases quite long lengths of the pipe may be made of sections all prestressed as one group. Under most other circumstances, at least one-half to three-quarters of the expense of joints may be eliminated by prestressing the sections in groups of from two to four.

In installing pipe according to this invention, the individual sections as at 15 and joint sleeves 16 as precast may be transported before assembly to the place where they are to be used, and there arranged (as in Fig. 2) with sealing means interposed between sections or with sealing cement or paste applied to the adjacent section ends. Thereupon the tensioning wires may be threaded through the cavities and put under tension by jacks as above explained, and the wire cavities are then pressure grouted. When the grout has set and hardened, the jacks may be removed and the tensioned wires cut off flush with the ends of the group of sections. Meanwhile a sleeve 16 may be fitted and grouted in place on one end of the group of sections. Successive groups of the sections as thus assembled are then pressed into end-to-end relation in the trench where the pipe is to be laid.

Although certain particular embodiments of the invention are herein disclosed for purposes of explanation, various further modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Improvement in or modification of the prestressed tubular concrete structure according to Specification No. 649,681, wherein a plurality of tubular concrete sections are positioned end to end axially in alignment and have highly tensioned wires extending through communicating cavities of adjacent sections, characterized by sealing means interposed between the abutting end surfaces of the sections, said sealing means being held under heavy pressure between said end surfaces by means of said highly tensioned wires.

2. A concrete structure according to Claim 1, wherein said sealing means is in the form of a plastic paste.

3. A concrete structure according to Claim 1 or 2, adapted for use as an extended pipe line, comprising a plurality of prestressed groups of said sections joined group to group by one or more joint members each of which is adapted to embrace one end of one group and to slidably embrace the adjacent end of the next group to provide for expansion and contraction by the joints between groups rather than at every section joint.

4. A concrete structure according to Claim 3, wherein each group has a tapered end, and the joint member is in the form of a sleeve having a correspondingly tapered interior opening, means being provided for grouting the tapered surfaces together whereby said sleeve is firmly locked in place and sealed on the end of the pipe section.

5. Improvement in or relating to the method of forming a tubular, prestressed concrete structure according to Specification No. 649,681, which comprises positioning a plurality of tubular concrete sections end to end axially in alignment and subjecting said sections to compressive force by means of highly tensioned wires extending through communicating cavities of adjacent sections, characterized by interposing between the abutting end surfaces of the sections sealing means adapted to be held under heavy pressure by means of said highly tensioned wires.

6. The concrete structure substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

7. The method of forming a tubular concrete structure substantially as hereinbefore described.

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