

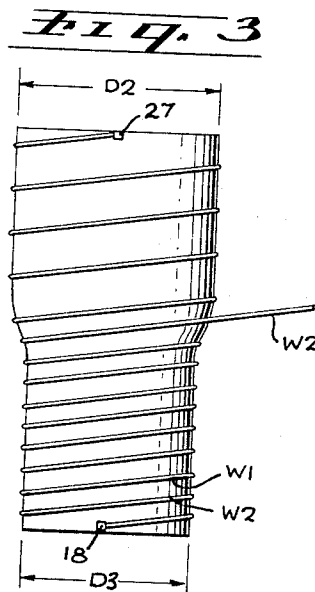
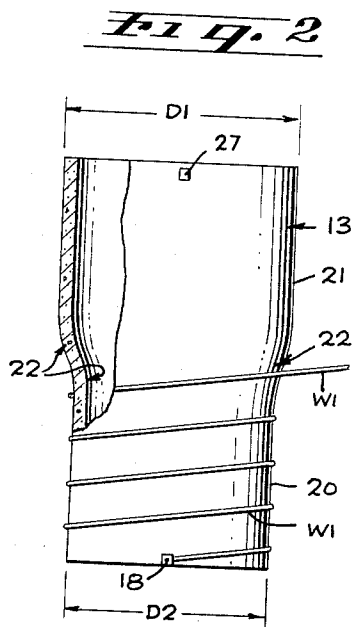
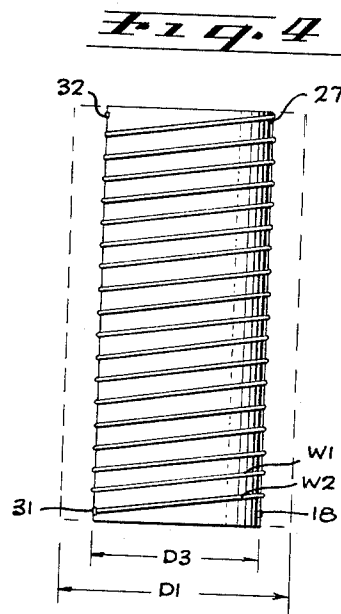
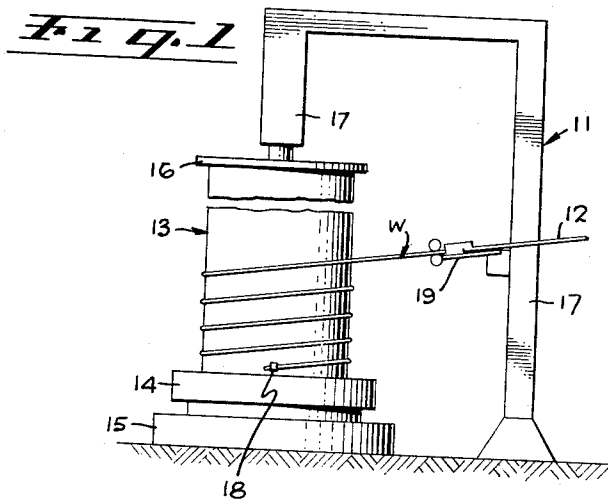
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METHOD OF PRESTRESSING CONCRETE PIPE

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METHOD OF PRESTRESSING CONCRETE PIPE

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This invention has to do generally with methods of making prestressed concrete pipe of the type in which high tensile strength wire is wound about a concrete core under tension and anchored to place the pipe in circumferential compression and thereby enable it to withstand substantial internal fluid pressure and external cover loads without leaking or otherwise failing. More particularly the invention is concerned with prestressing tubular concrete cores which do not have a metal cylinder embedded therein.

In the manufacture of concrete pipe of the type that does not include a metal cylinder in its wall (which would prevent leakage of fluid through cracks in the pipe wall when the pipe is placed in use) the winding of the tensioned reinforcement wire about the concrete core presents a serious problem, since the winding of such a wire under sufficient tension and at the necessary pitch to impart the prestress required would normally cause cracks to form in the concrete body through which water could escape when the pipe is placed in use. The reason for this is that when a concrete pipe core is progressively wound from one end to the other under high winding tension the compressive force of the wire on the core reduces the diameter of the core producing a longitudinal bending moment in the concrete wall. Where the stresses resulting from this longitudinal bending are greater than the tensile strength of the concrete in flexure, the latter cracks circumferentially. This may be prevented by placing the core body in compression longitudinally either by means of tensioned rods embedded in the core wall or by external means as disclosed in my copending application for patent, Serial No. 10,308, filed February 23, 1960, now Patent No. 3,078,561. However, neither of these methods is economically feasible for core bodies of large diameter.

Therefore it is an object of the present invention to provide a simple, relatively inexpensive, novel method of prestressing concrete tubular cores in the manufacture of concrete pipe and the like which obviates the above-noted disadvantages and which has certain other advantages.

A further object is to provide a method of prestressing concrete pipe cores which requires no additional reinforcing steel and which does not require placing the concrete core in longitudinal compression.

Another object is to provide a novel method which can be easily and quickly carried out by conventional equipment for the fabrication of prestressed pipe.

Still another object is to provide a method of the type indicated in which the prestress losses due to elastic contraction of the concrete core are substantially reduced.

A further object is to provide a novel prestressed core body.

Applicant's invention comprises the method of prestressing a concrete pipe or the like which involves initially winding an elongated reinforcement member helically about the pipe body and securing it, and subsequently winding at least one other reinforcement member about the body under tension and securing it. The tension and pitch of the winding of the first reinforcement member is such that the winding stress on the body is safely below the magnitude which would induce circumferential cracking thereof. The same is true of the winding of the second reinforcement member.

These and other objects will be apparent from the drawing and the following description. Referring to the draw-

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ing, which is largely diagrammatic and for the purpose of illustration only:

FIG. 1 is a diagrammatic elevational view of a concrete pipe core being wound and apparatus for accomplishing this;

FIG. 2 is a diagrammatic view of a concrete pipe core partially wrapped with circumferential prestressing wire under tension, the compressive effect of the wire on the core being exaggerated;

FIG. 3 is a view similar to FIG. 2 but showing a concrete pipe core wrapped completely from end to end with one prestressing wire and partially wrapped with another, the compressive effect of the partial wrapping being exaggerated; and

FIG. 4 is a view of the completed reinforced pipe core.

More particularly describing the invention, in FIG. 1 I show diagrammatically apparatus 11 for wrapping or helically winding high tensile strength steel wire 12 under tension about a concrete pipe core 13 of cylindrical form progressively from end to end. The apparatus includes a motor-driven turntable 14 for supporting the core 13, a suitable foundation 15, an upper head 16 for engaging and permitting rotation of the core 13, and supporting framework 17. In the wrapping process one end of the wire W is fixed to an anchor 18 provided in the pipe body and the wire is wrapped about the pipe by advancing the feed arm 19 axially of the pipe on the framework 17. The details of the apparatus have not been shown, since they form no part of the invention and are well known in the art. The core 13 may or may not contain a reinforcement wire cage (not shown).

If sufficient wire is wrapped around core 13 under great enough tension to obtain the magnitude of circumferential compression or prestress of the core which is often required by present standards, the core will crack circumferentially, rendering the resulting pipe unsuitable for use where high internal hydraulic pressures are encountered. Referring to FIG. 2, which illustrates on an exaggerated scale the compressive effect of the wire progressively wrapped about the core which causes a reduction in the diameter of the pipe core at 20, as compared to the unwrapped portion 21, circumferential cracks will normally occur just ahead of the wire being wound or in the region 22 if the wrapping stress, that is, the temporary longitudinal stress induced in the core by the progressive reduction in diameter thereof, exceeds the concrete tensile strength in flexure of the core. As previously indicated, while it is possible to prevent the occurrence of such cracks by placing the pipe in compression axially, this is not economically feasible for large-diameter pipe, such as pipe having a diameter of from five to fifteen feet or more.

In order to obviate the apparent necessity of either temporarily or permanently increasing the tensile strength in flexure of the concrete core to prevent circumferential cracking during winding of the prestressing wire, I have found that I can obtain the same ultimate amount of prestress by wrapping the core in stages. I thus reduce the wrapping stress at any one time without reducing or changing the tension of the prestressing wire. Whether two or more separate wraps or separately applied windings will be required depends upon the amount of prestress required, the wire wrapping force required to achieve this, and the tensile strength of the concrete core in flexure. The wire wrapping force is dependent upon the tension of the wire and the cross-sectional area of wound wire as related to unit length of the core. Thus the pitch of the wire and the actual cross-sectional area of the prestressing wire are both factors in addition to the actual tension of the applied wire.

Assuming that a given magnitude of prestress or circumferential compression is required to be obtained in

a concrete pipe core having known or determinable tensile strength in flexure, I determined the total quantity of prestressing wire necessary to achieve this at a given available winding tension taking into consideration the factors noted. I also determine the maximum allowable concrete compression which safely can be induced in the core by winding without cracking the core circumferentially. By way of example:

The maximum longitudinal winding stresses, tension and compression in the concrete core are

$$f_w = \pm 0.284 f_{cl} \quad (1)$$

where f_{cl} is the induced concrete compression.

To prevent circumferential cracking the longitudinal tensile stress must not exceed the concrete tensile strength in flexure (f'_t), i.e.

$$f'_t > f_w \quad (2)$$

or

$$f'_t = K f_w = 0.284 K f_{cl} \quad (3)$$

where $K > 1$ is a factor of safety against cracking.

The tensile strength of concrete in flexure is approximately given by

$$f'_t = 7.5 \sqrt{f'_{cl}} \quad (4)$$

where f'_{cl} is the concrete cylinder strength at the time of prestressing. Solving Equations 3 and 4

$$f_{cl} = \frac{26.4}{K} \sqrt{f'_t} \quad (5)$$

Assuming a factor of safety $K=1.5$ the maximum allowable concrete compression is

$$f_{cl} = 17.6 \sqrt{f'_t}$$

Having determined the maximum allowable concrete compression that safely can be induced in the core by winding, I wrap the core from end to end with a first prestressing wire (which is necessarily shorter than the predetermined total wire required) at a pitch such that the longitudinal stresses induced in the pipe will be safely below the allowable maximum. This first wire, designated W1, is first secured at one end to anchor 18 of the pipe core, wound helically to the other end of the core, and then secured under tension to a similar anchor 27. One or more additional wires are then wrapped in a similar manner about the core to make up, with the first wire, the total magnitude of prestress required, each such wire being wound at a pitch such that it alone imposes a winding stress in the core safely below the value which would cause circumferential cracking. Normally, only two wires need be used, or in other words, the entire prestressing of the core can be accomplished in two stages of wrapping. Thus in FIG. 3 I show a second reinforcement wire, designated W2 secured to an anchor 31 (see FIG. 4) at one end of the core, wrapped partially around the core. In FIG. 4 the completed prestressed core is shown, the second reinforcement wire W2 being completely wound on the core and secured under tension to an anchor 32. In the completed core, the two wires W1 and W2 make up the total amount of wire required at the tension at which the wires were wrapped, to produce the magnitude of prestress or compression of the concrete core.

It will be apparent that the wrapping of the first wire W1 progressively reduced the diameter of the core from D1 (see FIGS. 2, 3 and 4) to D2 and that the wrapping of the second wire W2 reduced the diameter of the core from D2 to D3, the final dimension. An advantage of my method, in addition to preventing circumferential cracking, is the fact that prestress losses due to elastic contraction of the core are reduced by about 25 percent where the wire is applied in the two stages as compared to application of the wire in a single winding. Losses may be reduced more by resorting to three-or-more-stage windings. This will be apparent when it is considered that the entire body of wire, when applied in a single winding, is sub-

ject to loss of tension from the elastic contraction of the core from D1 to D3. However, where the winding is applied in two stages, only the first winding is subject to such loss while the second winding, which is applied when the diameter is D2, is only subject to one-half such loss, namely that resulting from the contraction of the core from D2 to D3. Thus the total saving is of the order of 25 percent. Also, less total wire is required.

I claim:

1. In the manufacture of prestressed concrete pipe, the method of prestressing a concrete core to a given magnitude comprising the steps of providing a tubular concrete core body in substantially cured condition, securing one end of a first reinforcement wire to one end of the core body and helically winding the wire from said one end of the body to the other end thereof under substantial tension at a pitch such that the magnitude of the winding stress on the core is safely below the magnitude which would induce circumferential cracking of the core body, securing the other end of said wire to the body while maintaining the tension under which the same was wound, securing one end of a second reinforcement wire to one end of the core body and helically winding said second wire from said end to which it is attached to the other end of the core body between the turns of said first wire under substantial tension and at a pitch such that the magnitude of the winding stress on the core is safely below the magnitude which would induce circumferential cracking of the core body but sufficiently great that, together with said first wire, the core is prestressed to said given magnitude, and securing the other end of said second wire to the core body while maintaining the tension under which the same was wound.

2. In the manufacturing of prestressed concrete pipe in which a concrete core is placed in circumferential compression by high tensile steel wire wrapped helically around the core and secured in place, the method of prestressing the core to a given magnitude greater than can be achieved without causing circumferential cracks in the core by progressively singly wrapping the core with the required amount of wire under the required tension to achieve the given magnitude, which comprises the steps of providing a tubular concrete core in substantially cured condition, securing one end of a first reinforcement wire to one end of the core and helically winding the wire under tension from said one end of the body to the other end thereof in a manner such that the magnitude of the winding stress on the core is less than the concrete tensile strength in flexure of the core, securing the other end of said wire to the core while maintaining the tension in the wire, and repeating said steps of securing, winding and securing for as many additional wires as required, together with said first wire, to achieve the given magnitude of compression.

3. The method set forth in claim 2 in which the amount of reinforcement wire required to achieve the given magnitude of prestress of the core is predetermined and in which the amount of wire is divided into separate windings of substantially equal amount.

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