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COMPLETE SPECIFICATION

Improvements in or relating to Casting of Concrete Bodies

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 6, State of New York, United States of America, (Assignees of JOHN T. PARRETT and MYERS VAN BUREN), 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 methods and apparatus for molding concrete and the like by spinning operations, the invention being particularly adapted, among other possibilities, for the manufacture of tubular concrete sections having in the walls thereof circumferentially spaced cavities extending longitudinally of the axis of the tubular member.

The invention further relates to the manufacture of concrete members or bodies wherein the concrete being molded is subjected to substantial centrifugal force sufficient to cause liquid to be separated from the mixture. For example, among other possibilities the invention is adapted for the manufacture of tubular concrete members by spinning in a rapidly revolving mold.

Tubular concrete sections or members of the type indicated are well adapted for use in end-to-end relation for forming continuous lengths of concrete pipe and certain types of piles or tubular columns, with the above-mentioned cavities in succeeding sections positioned in alignment whereby wires or other reinforcing means may be threaded therethrough and subjected to heavy tension for longitudinally prestressing the assembly of tubular sections and to hold same tightly together end-to-end with sealing means therebetween if desired, under heavy pressure. There are well known advantages in the method forming tubular concrete members by spinning a mass of concrete in a rotatable molding apparatus, but the forming of longitudinal cavities in the walls of such members accurately, uniformly and economically in connection with such spinning operations involves difficulties which, so far as is known have not heretofore been satisfactorily overcome.

If such cavities are to be used to contain reinforcements under heavy tension for prestressing purposes, it is important that they be accurately formed and positioned, and free of any curvatures against which the prestressing cables or the like might bear and cause unpredictable transverse stresses in the completed assembly of sections when in use. Yet if a simple form of mandrel is used in the rapidly rotating molding apparatus to define such a cavity, the centrifugal force acting on the unsupported portions of such a mandrel will tend to cause it to deflect objectionably, thereby producing a somewhat curved cavity. Further problems arise in providing suitable supporting structure for the mandrels whereby they may be quickly and easily inserted in the mold and easily withdrawn from the set concrete, and at the same time so arranged so as to prevent the wet concrete mixture from escaping about the ends of the mandrels or their supports.

In forming tubular concrete members in this way, a considerable amount of water tends to be separated from the concrete mix by reason of the effect of centrifugal force. Since water has a lower specific gravity than the remainder of the usual concrete mixture, it will tend to travel more or less radially inwardly of the spinning mass of concrete being molded and to accumulate on the inner surface of such mass. Along the middle portions of the concrete mass, no injurious

effects appear to result from such movement of the water. However, at and adjacent the ends of the spinning mass of the mixture, a peculiar action takes place, in that the water tends to be propelled from points in the concrete within an inch or less from said ends, out of the concrete and then along the surfaces of the end barriers of the mold and radially inwardly thereof, with sufficient force and in such amount as to form channels or otherwise erode and carry away particles of the mixture, with the result that the end surfaces of the desired concrete member will have numerous irregularities, and portions near the ends will have a weakened honeycomb-like structure. While these imperfections have evidently not caused serious difficulties with tubular concrete members as generally heretofore used for various purposes, yet if the finished tubular sections are to be assembled end-to-end to form, for example, continuous prestressed lengths of pipe or certain types of piles, it is very important that the end surfaces be accurately and tightly fitted as well as strong and capable of uniformly bearing the pressure of heavy endwise loads.

Suitable means and methods for forming concrete members for such purposes with sufficiently accurate and unweakened end surfaces, by the use of spinning operations, have, despite extensive efforts, heretofore, so far as is known, involved insurmountable difficulties for the reason above indicated.

The present invention provides novel methods and combinations of features for obviating both the difficulties caused by mandrel deflection and those caused by erosion in a way permitting highly economical production of tubular concrete members having cavities in their walls as above referred to, and which will be uniform and accurate.

It has been found, according to the present invention, that the erosion difficulty may be overcome by the relatively simple expedient of interposing a layer or sheet of filtering of filter-like material between the barriers at the ends of the spinning mold and the mass of concrete being cast therein. Such filtering layer or sheet allows the liquid to travel therein gradually and generally radially along the inside surfaces of the end barriers while filtering the cement from the water and maintaining the cement and the remainder of the concrete body in position so that channeling or erosion thereof is prevented and the end portions and surfaces are maintained to the desired accurate dimensions, free of irregularities or weakened portions. Preferably also small outlets for the water are provided in the mold adjacent the periphery of such filtering layer so that the liquid will travel radially outward of the layer and be expelled through such outlets, although if such outlets are not used, the liquid will be forced to travel without serious difficulty along within the filtering layer toward the axis of spinning, due to the pressure of the portions of the concrete having greater specific gravity than the liquid.

The filtering sheet or layer may take various forms, either as a permanent part of the end barriers for the spinning mold or the form of woven or knitted cloth, or fibrous sheet material, held in place on the inside surface of the end barriers by water soluble adhesive for example, and by mechanical means if desired. For the usual concrete mix in the making of tubular concrete sections by spinning, we have found that filter material in the form of an annular area of cloth such as fine muslin is preferable, although fine mesh wire cloth may in some cases be used to provide a more permanent surface covering.

In order that the invention may be clearly understood and readily carried into effect the same will now be described more fully with reference to the accompanying drawings, in which:

Fig. 1 is a horizontal sectional view of a preferred form of apparatus for carrying out the invention and showing the parts of the apparatus in the positions which they occupy during the operation of molding a tubular concrete member with cavities in the walls thereof such as above referred to;

Fig. 2 is a similar view, partly broken away but showing the positions of the parts when the mandrels are partially removed from the molded concrete member.

Fig. 3 is a horizontal sectional view partially broken away, of another form of molding apparatus showing the manner in which erosion is prevented in accordance with the invention and

Fig. 4 is an enlarged view of the lower left hand portion of Fig. 3.

Referring to Figs. 1 and 2 of the drawings, the molding apparatus generally includes a tubular chamber portion or drum 10, the same being cylindrical in the form shown, although other shapes might be used depending on the desired cross-sectional shape of the concrete member to be molded therein. The drum 10 is preferably formed of an area of sheet metal, so shaped that two longitudinal edges thereof are brought together and removably held in place as by bolts 11 which pass through two angle bars as at 12 welded or otherwise secured respec-

tively to such longitudinal edges in a manner which will be readily understood from Fig. 1. Two annular tracks as at 13 are provided around the exterior of this drum and are adapted to roll on rollers as indicated at 16 to permit spinning of the drum (by a suitable source of power, not shown) about its longitudinal axis, with a mass of concrete therein, and so that the centrifugal force of the spinning will cause the concrete to distribute itself over the inside surfaces of the drum to form a tubular concrete member as at 17.

Removable end pieces or barrier members as at 18 or 19 of like construction are provided at each end of the drum, the inner surfaces of these members as at 20, 21 serving to define the end surfaces of the concrete member 17 being molded. Each of these barrier members preferably comprises a cylindrical or annular web portion as at 22 which is cast integral with or is welded to annular flange portions as at 23, 24, said surfaces 20, 21 being formed on the flange portions as at 23, which are also preferably so shaped as to protrude slightly into the end of the sheet metal drum to an extent limited by the small annular lip portions as at 23'.

A plurality of removable mandrel means as at 25 are provided, the same being of the shape and position of the desired cavities to be formed in the concrete body 17, viz. in the particular example shown such cavities are to be cylindrical in form, to extend longitudinally of the concrete member 17 at circumferentially spaced positions around within the walls of the member.

As shown in Fig. 2, each of such mandrel means preferably comprises an inner rigid core member 26 preferably of metal, surrounded by a sheath of readily stretchable rubber as at 27. Natural rubber may be used for this purpose, or if preferred, various suitable well-known types of synthetic rubber or rubber-like stretchable materials are available for the purpose.

The core 26 will usually be hollowed out, that is, in the form of a metal tube, although in some cases, particularly if a light metal is used, the core may comprise a solid rod. But in any event, the mandrel means is so designed as to have an "over-all density" the same as, or approximating the density of the concrete as molded to form the member 17. The expression "over-all density" as used herein and in the appended claims, means the ratio of the total mass of the mandrel to its total volume, including its hollow core if the core is hollow. The "over-all density" of a portion of the mandrel may similarly be calculated from the mass and volume of that portion. It will be apparent that such "over-all density" approximating that of the concrete may be readily obtained by proper selection of the materials used and their relative dimensions, taking into account the specific gravity of each of the two materials and considering the space, if any, provided within the core.

The purpose and advantage of designing the mandrel means in this way is to obviate the deflections or distortions which would otherwise occur in the mandrel means under the powerful centrifugal force to which it is subjected during spinning of the apparatus. That is, since the mandrel means is supported rigidly at its respective ends by means such as hereinafter described, and it will be apparent that the metal portions particularly of each mandrel necessarily have considerable weight, the latter will, upon being subjected to centrifugal force during the spinning operation, be deflected outwardly in the event the concrete mixture is lighter than the mandrel means, or inwardly in the event the concrete mixture is heavier. Since during the setting of the concrete, the drum will ordinarily be subjected to a spinning motion with a circumferential speed for example as high as 3000 feet per minute, it will be apparent that such deflections will be substantial, there is a substantial difference between the specific gravities of the concrete and the mandrel means. The cavities being formed in the concrete would then be curved or distorted in shape, giving rise to the objections above explained.

Commonly used concrete mixtures have a specific gravity in the neighborhood of 2.4. Hence, with such mixtures the mandrel means should be so designed as to have substantially the same over-all specific gravity. However, it will be appreciated that the specific gravity of concrete may vary considerably depending upon the characteristics of strength, weight, etc. desired in the finished structure, but usually if the mandrel means is designed to have a specific gravity somewhere between about 2 and 2.8, this will satisfy the requirements for use with concretes of different weights within the ordinarily practical range, and still enable the mandrel means to be adequately supported and retained by the concrete against prohibitive deflections. In case the mixture has an unusually low specific gravity, as in the case of certain foam-like mixtures for example, then the mandrel means should be designed to have an equally low specific gravity.

As hereinafter explained, the mandrel cores, while in use, are preferably placed under substantial longitudinal tension which will be effective in further preventing deflections of the mandrels in the event their over-all specific gravity differs within reasonable limits from that of the concrete.

Since both end portions of the mandrels will ordinarily be rigidly supported, it is of course not important that such end portions, as distinguished from the middle portions, be designed to have a particular specific gravity, yet for simplicity, and as shown in Fig. 2, it will ordinarily be convenient to form both the core and the rubber sheath portions with uniform cross-sectional dimensions substantially throughout their lengths.

The supporting and tensioning means for the ends of the mandrels will now be described with reference to Fig. 2. One end of each mandrel core member, as shown, is provided with a threaded plug 27 adapted to receive a nut as at 28 to bear against a washer 29, which in turn bears against a flange portion on an end piece 18 or 19. The other end of the mandrel core is formed with a transverse slot or slots 30 through which key means as at 31 (Fig. 1) are adapted to be inserted to retain such end against movement when the nuts as at 28 are tightened to the extent desired for tensioning the mandrels and also to retain the end pieces or barrier members 18 and 19 tightly in position against the ends of the drum 10.

The end of the mandrel core which has the threaded plug 27 is also preferably formed with an external threaded portion 31, which is embraced by the corresponding end of the rubber sheath, the latter being securely retained on the threaded portion 31 as by tightly wrapping same with a helix of wire as at 32, so that the rubber is depressed into the threads at 31 and held against longitudinal displacement with respect thereto.

The flange portions 23, 24 are formed with aligned apertures for receiving the end portions of the mandrels. To prevent escape of the concrete mixtures or water therefrom along the mandrels through the apertures in the flanges 23, such apertures are provided with stuffing boxes as at 33, 33^1. These may be formed by providing an annular collar as at 34 welded to the flange portion 23 and adapted to receive a gasket shaped with a cross-section as indicated at 35 and held in place by a thimble member 36. The latter member extends up into engagement with the washer 29 so that when the nut 28 is tightened, the lower end of the thimble member is crowded down against the gasket and the latter is forced into firm engagement around its periphery with the collar 34 and into tightly fitting embracing relation with the rubber sheath 27.

If the tubular concrete members 17 are to be used in prestressed end-to-end relationship as hereinabove explained, it will be desirable to provide an enlargement as at 36^1 at each end of each longitudinal cavity formed by the mandrel means, such enlargement providing space for grout to seal the prestressing wires at the abutting ends of the concrete sections. Such enlargements may be formed by providing a suitably shaped thimble-like member as at 37 fitted into the aperture in the flange portion 23 and having a portion adapted to protrude into the mass of concrete to the extent indicated at 36. Also it is desirable that the concrete member 17 be so formed that the outer peripheral edges of the end surfaces will be rounded. To accomplish this, the flange portions 23 may be formed with inwardly extending annular ridges as at 39.

In using the apparatus, the mandrel parts are first designed or selected so as to provide approximately the proper specific gravity as above explained, and these are inserted in the end pieces and assembled in the manner indicated in Fig. 1, the nuts 28 being tightened with the keys 31 in place whereby the mandrel cores will be longitudinally tensioned and the drum end pieces will be securely held in place. Then with the drum in horizontal position resting on the rollers 16, it is rotated by power driven means at a rate such that its peripheral speed will be several hundred feet per minute. During this time, a mass of the concrete is introduced through either or both ends of the drum structure, and after sufficient concrete is introduced, the spinning speed is increased and maintained for example at about 3000 feet per minute, until the concrete has become set to a degree permitting its removal from the apparatus. Usually some reinforcing means will also be provided in the concrete to facilitate its handling at this stage without breakage. For example, as indicated in Fig. 1, a length of wire may be provided for this purpose, shaped in the form of a helix, the cross-sections of its turns being indicated at 40, and same being located in positions to surround all of the mandrel means.

In order to remove the mandrel means, the drum structure is preferably moved to a vertical position and then the nuts 28 are loosened and the keys 31^1 are removed. Thereupon derrick means may be connected to the lifting eyelet members

41 on the end piece 19, whereupon this member is slowly lifted along with all of the several mandrel means as a unitary assembly. While the rubber sheaths will tend to remain adhered to the concrete, they will stretch first at the upper portions and then progressively further down as at 42, with the result that the successive portions of the rubber will readily become released from the concrete in the cavities as the cores are elevated. That is, the rubber will be released not only because of the upward pulling and stretching, but also because of the consequent reduction in diameter of the sheaths. The exterior surfaces of the core members may be lubricated if necessary to facilitate easy sliding thereof upwardly within such portions of the sheaths as have not been stretched and released at any stage of the operation of withdrawing the mandrels. It will be noted that the loosening of the nuts 28 will serve to release the pressure of the stuffing boxes against the rubber sheaths so that the stuffing boxes will not interfere with the upward stretching and withdrawal of the sheaths.

After the mandrels and end pieces of the assembly are removed, the concrete body 17 may be readily removed upon loosening the bolts 11 along the side of the drum to permit the drum to expand to partially open condition.

After the concrete body has been removed, it will be apparent that all of the parts may be re-assembled and re-used in the manner shown in Fig. 1.

Referring to the embodiment shown in Figs. 3 and 4 of the drawings there is shown a tubular concrete member similar to that of Figs. 1 and 2 and only those features will be discussed which are essentially different from the embodiment of Figs. 1 and 2.

As best shown in Fig. 4, the inner annular surface portion of member 122, which corresponds to member 22 of Figs. 1 and 2, is covered with a layer of one or another of the above-mentioned filtering materials or filter-like materials (as indicated at 132). It will be apparent that such filtering material may be cut in the form of an annular ring-like area and that the inner peripheral edge may be folded down over the inside surface of the member 122. The latter surface is preferably formed with an annular groove as at 134 into which the filter material is pressed and retained by an annularly shaped piece of wire or the like 136. The filtering material, of course, may be formed with suitable apertures allowing the mandrel means 126 to pass therethrough. The outer peripheral edge of the filtering material as at 138 is folded over a part of the outer surface of the member 122 and held in position by the overlying end edge portions 112' of the chamber member 112.

The layer of filtering material 132 is preferably adhered in place by a suitable water releasable adhesive, such, for example, as a simple paste of flour and water. Such adhesion insures that during the introduction of the concrete into the mold, the filtering layer will lie firmly against the surfaces of the end barriers without danger of air pockets forming thereunder and avoiding the possibility that bodies of water or cement will accumulate beneath the filtering material, preventing it from assuming its proper position to define the end surfaces of the desired concrete body being cast.

As best shown in Fig. 4, the inner surface of the member 122 adjacent its periphery is formed with a circumferential groove 140, which groove at several spaced points about the member 122 communicates with longitudinally extending outlet openings as at 142.

It will be understood that, except as above indicated, the two end portions of the molding apparatus may be of the same construction.

In using the apparatus as shown, the wet concrete mix which is to form the concrete member, is introduced into the molding apparatus while the chamber is rotating at a speed fast enough to cause the mixture to distribute itself around the inside of the chamber, and then preferably the speed of rotation is increased, for example to such an extent that the periphery of the chamber will rotate at a linear speed of about 3000 ft. per minute, such spinning being maintained say for about ten minutes. During this time a substantial portion of the water or other liquid in the concrete mix will be caused by centrifugal force to more or less separate from the mixture and travel generally radially inwardly of the concrete and accumulate on the inside surface of the mass. However, as above explained, a considerable amount of the water which is in the concrete near the ends of the mass, as well as the water at the ends of the mass, would normally tend to travel along the easiest path, viz. along the smooth surface of the members 122 and 124 in sufficient amount and with sufficient force to carry along with it a part of the cement or other ingredients of the mixture, thus leaving the end portions of the concrete with a honeycomb-like structure and causing generally radial channels to be eroded away along the end surfaces of the concrete. However, with the above described layers of filtering

material 132 in place, these will act substantially as a filtering means to retain the cement and other particles of the mixture in place, yet allowing the water gradually to pass along the inner surfaces of the members 122, 124 by seepage through the interstices of the filtering material. If cavities and apertures as at 140, 142 are present, the water will be free to pass along within the filtering material radially outward and escape through the passages and cavities. On the other hand, if such passages and cavities are omitted, the pressure of the concrete and the centrifugal forces will be such that water will pass along within the filter-like material radially inward. In either case the concrete at the ends of the mass will remain substantially intact and thus the concrete body will be formed with accurately shaped end surfaces free of channels or weakened areas. As soon as the wet concrete mix comes firmly against the filtering layer 132, it will no longer be necessary to retain the filtering layers by the adhesive against separation from the member 122, and the water in the mix will act to release such adhesive and insure that the interstices in the filtering layer will be sufficiently open to permit seepage therethrough of the water.

As above explained, among other materials as the filtering means, muslin cloth may preferably be used, woven with about 128 threads per inch, for example. If desired, the mesh of the filtering layer may be sufficiently prominent so that its pattern will appear cast in the end surfaces of the concrete member. This, under certain circumstances, will provide a desirable surface to insure firm bonding of whatever sealing means may be applied to the end of the member when in use.

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.

What we claim is:—

1. A method of molding a concrete body by subjecting the concrete to spinning movement in a casting chamber during the molding thereof, characterized by forming a cavity in the concrete by providing a removable mandrel means having the shape and position of the desired cavity and having an over-all density (as hereinbefore defined) substantially approximating that of the surrounding concrete.

2. A method according to claim 1, wherein said mandrel means extends generally longitudinally of, but in spaced relation to the axis of spinning.

3. A method according to claim 1 or 2, wherein, during the spinning, said mandrel means is maintained under a substantial longitudinal tensioning force reacting inwardly on the end walls of the casting chamber.

4. A method of molding concrete and the like in molding apparatus having a casting chamber rotatable at such speed as to subject the concrete to substantial centrifugal force, and forming in the concrete a cavity positioned in spaced relation to the axis of rotation, which comprises providing in the molding apparatus, a removable mandrel means supported adjacent its end and having the shape and position of the desired cavity, such mandrel means being designed to have an over-all density (as hereinbefore defined) at least at its portions spaced from the point of support sufficiently close to that of the concrete molded about the same, whereby substantial deflection of such mandrel means due to said centrifugal force is avoided.

5. A method according to any one of the preceding claims, wherein said mandrel means comprises a relatively rigid core surrounded by a readily stretchable sheath.

6. A method according to any one of the preceding claims characterized by providing a barrier at the end of the casting chamber with a surface transverse to the axis of rotation and covering said end barrier surface with an area of filtering material, introducing the wet concrete mix into said casting chamber and spinning the latter about a longitudinal axis at a sufficient speed to cause the concrete to be distributed over the inside of the chamber and forcefully to expel water from the mix by centrifugal action, said filtering material acting to protect the end surface of the member against erosion by filtering water from the adjacent portions of the mix through the material and such material providing interstices along the end barrier surface through which such water is expelled radially by said centrifugal force.

7. Apparatus for molding concrete and the like by a spinning operation and for forming in the concrete a cavity extending in an off-center position relative to the axis of spinning, which comprises a rotatable mold, a mandrel means having the shape and position of the desired cavity during the spinning of the mold, such mandrel means having a relatively rigid removable metal core surrounded

material 132 in place, these will act substantially as a filtering means to retain the cement and other particles of the mixture in place, yet allowing the water gradually to pass along the inner surfaces of the members 122, 124 by seepage through the interstices of the filtering material. If cavities and apertures as at 140, 142 are present, the water will be free to pass along within the filtering material radially outward and escape through the passages and cavities. On the other hand, if such passages and cavities are omitted, the pressure of the concrete and the centrifugal forces will be such that water will pass along within the filter-like material radially inward. In either case the concrete at the ends of the mass will remain substantially intact and thus the concrete body will be formed with accurately shaped end surfaces free of channels or weakened areas. As soon as the wet concrete mix comes firmly against the filtering layer 132, it will no longer be necessary to retain the filtering layers by the adhesive against separation from the member 122, and the water in the mix will act to release such adhesive and insure that the interstices in the filtering layer will be sufficiently open to permit seepage therethrough of the water.

As above explained, among other materials as the filtering means, muslin cloth may preferably be used, woven with about 128 threads per inch, for example. If desired, the mesh of the filtering layer may be sufficiently prominent so that its pattern will appear cast in the end surfaces of the concrete member. This, under certain circumstances, will provide a desirable surface to insure firm bonding of whatever sealing means may be applied to the end of the member when in use.

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.

What we claim is:—

1. A method of molding a concrete body by subjecting the concrete to spinning movement in a casting chamber during the molding thereof, characterized by forming a cavity in the concrete by providing a removable mandrel means having the shape and position of the desired cavity and having an over-all density (as hereinbefore defined) substantially approximating that of the surrounding concrete.

2. A method according to claim 1, wherein said mandrel means extends generally longitudinally of, but in spaced relation to the axis of spinning.

3. A method according to claim 1 or 2, wherein, during the spinning, said mandrel means is maintained under a substantial longitudinal tensioning force reacting inwardly on the end walls of the casting chamber.

4. A method of molding concrete and the like in molding apparatus having a casting chamber rotatable at such speed as to subject the concrete to substantial centrifugal force, and forming in the concrete a cavity positioned in spaced relation to the axis of rotation, which comprises providing in the molding apparatus, a removable mandrel means supported adjacent its end and having the shape and position of the desired cavity, such mandrel means being designed to have an over-all density (as hereinbefore defined) at least at its portions spaced from the point of support sufficiently close to that of the concrete molded about the same, whereby substantial deflection of such mandrel means due to said centrifugal force is avoided.

5. A method according to any one of the preceding claims, wherein said mandrel means comprises a relatively rigid core surrounded by a readily stretchable sheath.

6. A method according to any one of the preceding claims characterized by providing a barrier at the end of the casting chamber with a surface transverse to the axis of rotation and covering said end barrier surface with an area of filtering material, introducing the wet concrete mix into said casting chamber and spinning the latter about a longitudinal axis at a sufficient speed to cause the concrete to be distributed over the inside of the chamber and forcefully to expel water from the mix by centrifugal action, said filtering material acting to protect the end surface of the member against erosion by filtering water from the adjacent portions of the mix through the material and such material providing interstices along the end barrier surface through which such water is expelled radially by said centrifugal force.

7. Apparatus for molding concrete and the like by a spinning operation and for forming in the concrete a cavity extending in an off-center position relative to the axis of spinning, which comprises a rotatable mold, a mandrel means having the shape and position of the desired cavity during the spinning of the mold, such mandrel means having a relatively rigid removable metal core surrounded

by a sheath, and means for maintaining such core under substantial longitudinal tension during such spinning, said mandrel means also having an overall density (as hereinbefore defined) sufficiently close to that of the concrete molded about the same, whereby substantial deflection of such mandrel means due to centrifugal force during spinning is avoided.

8. Apparatus according to claim 7, wherein said mandrel means comprises a relatively rigid core surrounded by a readily stretchable covering.

9. Apparatus according to claim 7 or 8, wherein said mandrel means is supported adjacent its ends in the apparatus and extends generally longitudinally within the concrete member being formed.

10. Apparatus for molding a tubular concrete member having longitudinal cavities at circumferentially spaced positions within its walls, which comprises a rotatable tubular chamber, barrier means at the ends of said chamber for defining the ends of the concrete member, at least one of said barrier means being removable, a plurality of mandrel means each longitudinally removable and supported at its ends respectively by said barrier means, said mandrel assemblies having the shape and positions, as thus supported, of the desired cavities, and means at the mandrel means ends for longitudinally tensioning same, the overall density (as hereinbefore defined) of each mandrel means being substantially the same as that of the surrounding concrete.

11. Apparatus according to claim 10, wherein the securing means for the mandrel assemblies at one end are detachable whereby the removable barrier means at the other end together with the mandrel assemblies as a group may be withdrawn from the chamber.

12. Apparatus according to claim 10 or 11 including stuffing boxes through which the mandrel means pass and releasable means at the mandrel ends for retaining same against longitudinal displacement, the latter means being constructed and arranged to releasably apply tightening pressure to said stuffing boxes.

13. Apparatus according to claim 10, 11 or 12, including an area of filtering material covering the surface of the end barrier, for protecting the end surface of the concrete against erosion due to radial expulsion of water from the spinning concrete mixture, said filtering material providing interstices along the end barrier surface through which water filtered thereby may be expelled radially by the centrifugal force of the spinning.

14. Apparatus according to claim 13, wherein said material is initially secured to the end barrier by water releasable adhesive, said filtering material upon release of said adhesive by action of the water in the concrete mixture, providing the desired interstices along the end barrier surface.

15. The method of centrifugally casting a concrete member substantially as hereinbefore described.

16. Apparatus for centrifugally casting a concrete member substantially hereinbefore described with reference to and as illustrated in the accompanying drawings.

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