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(54) METHOD OF MANUFACTURING A CONCRETE PIPE BY CENTRIFUGAL MOULDING

(71) We, KURIMOTO HUME PIPE, LTD., a Japanese company, of No. 10-3, Oaza-Okasato, Sohwa-cho, Sashima-gun, Ibaragi-ken, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method of manufacturing 'Hume' or 'spun' concrete pipes in a centrifugal moulding process, and more particularly to a more simple method than has hitherto been used a simple construction of the mould to be employed therein and economization in labour, coupled with improvement of the quality of the pipes produced.

For manufacturing 'Hume' concrete pipes, both a centrifugal moulding process utilizing centrifugal force and a moulding process utilizing roll pressure, have in the past been used, the former process having been adopted to a greater extent.

The conventional horizontal centrifugal moulding process is usually carried out as follows. Firstly, on the interior of a split mould composed of two halves of a cylinder, there is applied a so-called stripping agent. Then, the two halves of the mould are put together and bolted up. After fixing thereon the tires enabling spinning or rotation and the metal fittings for two ends, etc., a steel cage may be inserted in the mould, and concrete slurry is poured in to form the pipe on spinning of the mould. After moulding, the resulting product together with the mould is cured by the use of hot water or steam. Upon thus curing,

the mould is split and the resulting concrete pipe is taken out.

However, the conventional moulding process as above has been defective in that, not only are the pre- and post-moulding operations complicated because of the employment of a split-type mould, but also the time for curing is too long because contact between the moulding and water or steam at the time of curing is made merely on the inner surface of the moulding. To make it worse, in as much as the mould is of split-type, there is sometimes the possibility of the concrete slurry leaking out through the joints of the two mould halves, which therefore not only necessitates extra inspection during the operation but also leaves uncalled-for marks of the joints on the finished product. In the conventional moulding process, in order to shorten the curing time, early dismantling of the mould is necessary. However, dismantling of the mould before a sufficient hardening of concrete can cause surface portions of the moulding to be removed with the mould because of fairly strong adhesion between the stripping agent and the concrete, resulting in a flawed product, and therefore, it has generally been impossible to shorten the curing time.

According to the present invention a method of manufacturing a concrete pipe in a centrifugal mould having a horizontal axis comprises the steps of forming a solidified layer of a stripping agent on the interior of the mould; pouring into the mould a concrete slurry; rotating the mould to form the pipe to shape; partially curing the pipe whilst still in the mould, until it can retain its own shape, by the application of

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heat sufficient to melt the stripping agent; removing the pipe from the mould, and completing the curing of the pipe and the removal of residual stripping agent outside the mould by means of steam applied to the pipe.

The present invention is able to provide a method of manufacturing Hume concrete pipes, which makes it possible to obtain homogeneous, strong and flawless Hume concrete pipes of a specified quality.

Furthermore, the present invention provides a method, which makes it possible to use one and the same mould repeatedly by replenishing the stripping agent, and thereby improving working efficiency of the mould.

As will be clear in the light of the foregoing, the present invention relates to a centrifugal moulding method for manufacturing concrete pipes which differs substantially from the conventional method. In the present invention, a mould having a one-piece cylinder may be employed, and as the stripping agent, a stripping agent which is a solid at normal temperatures and becomes a liquid at the curing temperature. To begin with, this stripping agent is applied to the interior of the mould to form a solid layer of stripping agent thereon prior to the moulding work. Then a steel cage (if required) can be inserted in the mould, concrete slurry is poured in the mould thereafter, and the mould is rotated thereby to effect centrifugal moulding. Next, the resulting centrifugal moulding product as contained in the mould is directly subjected to curing by use of hot water or steam. When the strength of the moulding has reached a desired level, or the moulding has hardened to such an extent as will keep its own shape even if taken out of the mould and left standing still on a flat board while the stripping agent between the mould and the product moulding is of course still in liquid phase by virtue of the curing heat, the moulding may be pushed out of the mould, and is thereafter further subjected to curing by steam for further strengthening. At the same time, the stripping agent attached to the moulding is removed, and, as for the used mould, the stripping agent may be replenished so as to use the mould for moulding again.

One example of a method according to the present invention will now be described with reference to the accompanying drawings in which:—

Figure 1 is a side view of a mould, wherein the mode of moulding is illustrated by partially revealing its longitudinal section;

Figure 2 is a side view of a mould used in a conventional method, but which can none

the less be used in the present method wherein the mode of moulding is illustrated by partially revealing its longitudinal section; and,

Figure 3 is a cross-sectional view taken along the line A—A in Figure 2.

The body of the mould for use in the present invention, which is denoted by the reference numeral 1 in Figure 1, is a complete cylindrical structure with tires 2 attached thereto for the purpose of rotating the mould body. Accordingly, at the time of using it for moulding or taking out the resulting moulding therefrom, it suffices to remove the metal end fittings 4 from both ends of the cylinder. In the embodiment shown in Figure 1, both ends of the cylindrical body are flanged so as to facilitate the fixing of the metal end fittings; but in the case where some appropriate metal fittings are separately fixed in lieu of the provision of such flanged portions, a plain tube may be used as the mould body. Either a solid drawn tube or an extruded tube will serve as a mould for the invention, and alternatively, according to circumstances, a cast iron tube will suffice. What is essential is that it is of accurate measurements, shows little deformation, and is inexpensive if possible.

The tube may be of uniform diameter, or it may be tapered according to the shape of the Hume concrete pipe desired. Also, it may be one which has not undergone any particular processing, but, from the view point of the convenience of pulling-out the moulding and the quantity of stripping agent to be required, it is preferable to subject it to internal finishing.

In the case of a conventional mould, as is shown in Figures 2 and 3, the split mould members 1' and 1'' constituting the mould proper must be fixed together by fixing means such as a number of bolts 5. Thereafter, the rotation tires 2 which concurrently function as metal end fittings for the two ends of the tube must be fixed on the mould. Furthermore, in order to take out the moulded product after the moulding process, it is necessary to dismantle the tires 2, remove the bolts 5, and separate the moulds member 1', 1''. However, in the case of the mould shown in Figure 1, the construction is very simple, and the time and labour required for assembling and dismantling the mould are drastically reduced.

As the applicable stripping agents in the present invention, there can be cited paraffins, waxes, asphalts, pitches as well as their mixtures; from the view point of efficiency, cost, etc., paraffins are considered the optimum ones at the present. As the curing temperature is usually in the range of from 60° to 80°C,

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the stripping agent for use in the present invention should be such a substance as will melt at a temperature short of this range—preferably at a temperature in the range of from 40° to 60°—while being in the state of a solid at room temperature; besides, the stripping agent for use in the present invention is a substance having a sharp range of melting point as far as possible because such substances are generally low in viscosity.

Coating of the stripping agent on the interior of the mould is simply performed either by spraying the melted stripping agent onto said interior or through the process that the powder of stripping agent is put in the mould and melted by hot blast or other means within the mold and the thus melted stripping agent is coated in uniform thickness on the interior of the mold and let harden while rotating the mold. The thickness of the layer of stripping agent 3 to be thus formed suffices to be usually in the range of from 0.5 to 0.2 mm or thereabouts; the optimum thickness is about 0.1 mm.

Pouring of the concrete slurry in the mold is performed while rotating the mold upon placing it horizontally on a driving roll. The velocity of rotation of said driving roll varies with the diameter of the aimed Hume concrete pipe, etc.; generally speaking, however, the velocity of rotation is such as to provide a force of about 30G. The composition of the concrete slurry suffices to be the same as that for ordinary Hume concrete pipes. Inasmuch as the concrete slurry is possessed of thixotropy, during its being rotated within the mold, the concrete slurry is gradually levelled into uniform thickness along the interior of the mold, and with the squeeze-out of the moisture contained therein, the concrete slurry loses its fluidity to be firm and hard. Even when the concrete slurry has thus hardened, there is still a fear of its fluidification again if pressed by external force; yet as far as it is contained in the mold, it reaches a stiffened state in about 6 to 10 minutes. At the point in time when the concrete has reached said stiffened state, rotation of the mold is discontinued, and after leaving it standing still at room temperature for about 1 hour, the mold together with the product molding therein is put in hot water or a steam chamber thereby to effect curing. Taking-out of the concrete prior to this curing will lead to fluidification and collapse of the concrete for the reason as set forth above. This curing is usually conducted in a room having its temperature elevated to 65°C or thereabouts with steam. The curing time varies with the atmospheric temperature, the diameter as well as the thickness of the

tube, etc.; but it is usually about 1 to 2 hours. By virtue of the curing to this extent, the content of the mold can attain a strength enough to retain its own shape even when taken out of the mold. The strength of the content of the mold enough to retain its own shape herein means a condition of the content, i.e., the Hume concrete pipe, being strong enough to avoid the occurrence of flaws on the upper and lower part of the interior of the pipe due to dead load thereof when it is taken out of the mold and left standing still on a plane. This strength is determined as follows: assuming that $N_1 = 0.239 W r$ (wherein N_1 represents the maximum moment arising from dead load of pipe, W represents the weight per metre of the length of pipe, and r represents the distance from the center of pipe to the center line of the thickness of pipe) for instance, the moment of resistance M_2 of the pipe suffices to be equivalent to N_1 or more, and in the case of Hume concrete pipes with inside diameter of 300 mm and thickness of 3 cm, for example, the tensile force of concrete suffices to be 1.7 Kg/cm² or more. Accordingly, in the case of a molding as above, once the curing has progressed to attain a tensile force of concrete of more than about 3 Kg/cm² as the safe strength for proceeding with the operation, said molding will be no longer vulnerable to collapse in the course of ordinary manufacturing operation even when taken out of the mold. In the present invention, when the molding in the mold has attained to such a condition, the stripping agent is of course already liquified by virtue of the curing heat. Therefore, the molding can be pushed out of the mold by undoing the metal fittings of both ends of the mold, and the thus taken out molding is further subjected to steam curing continuously.

During the steam curing within the mold, the contact between the concrete and steam is merely on the interior of the pipe, while during the steam curing after taking out from the mold, the periphery of the pipe also comes in contact with steam. As the steam curing is performed by way of both the interior and the exterior of the pipe, not only the curing time is drastically shortened, but also the quality of the pipe wall is markedly homogenized compared with the conventional Hume concrete pipes and the strength thereof is also much enhanced. Besides, this secondary steam curing brings on extra effects as follows. A molding taken out of the mold usually carries 30 to 40% of the stripping agent employed. But, this stripping agent attached to the molding can be removed almost completely by conducting said secondary steam curing for 10 to 20

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minutes. (Stripping agent attached to Hume concrete pipe changes the color of the exterior thereof to dark grey, and particularly when paraffin adheres to the exterior of the product, the product is apt to slip in the course of transportation and/or on the spot of laying work and its handling is very hazardous. Therefore, removal of the stripping agent from the product is a must). Thus, according to the method of the present invention, not only the product is quite free of adhesion of residual stripping agent, but also the curing time—which has been as long as 4 to 6 hours according to the conventional methods—is reduced to less than about 3½ hours in all, i.e., about 2 to 3 hours for the primary curing inclusive of the time for leaving standing still and about 10 to 20 minutes for the secondary steam curing. Consequently, the time for operation can be shortened by several hours, and the time for employing the mould is reduced to about ¼ to ½ of that in the prior art, resulting in the merit that the turnover rate of the mould employed increases two- to three-fold. In other words, the number of moulds necessary for attaining the same operation efficiency suffices to be theoretically ¼ to ½ of what has been required in the prior art.

As there is left about 30 to 40% of paraffin or the like employed as the stripping agent within the mould after discharging the moulding, said stripping agent has to be replenished before the mould is used again.

Of course, a split tyre mould may be used with the method of the present invention, the separation of the mould halves not being necessary if the partially cured pipe is pushed out of the mould.

Further elucidation of the present invention will now be given with reference to two examples.

Example 1

A paraffin having a melting point of about 49°C was melted and applied on the interior of a cylindrical mould having an inside diameter of 36 cm and a length of 2 m by spray coating, whereby a 0.1 mm-thick layer of stripping agent was formed thereon. After inserting a steel cage in the mould and setting metal fittings on both ends of said mold, 160 Kg of concrete slurry were poured therein, and the mold containing said concrete slurry was rotated for 8 minutes by applying a force equivalent to about 30G in terms of gravimetric acceleration unit and was thereafter put in a curing chamber. The composition of the concrete slurry (per 1 m³) employed was as follows:

Portland cement	430 Kg
water	172 Kg
sand	908 Kg
gravel	906 Kg
specific gravity of mixture	2.35

As for the configuration of the Hume concrete pipe, the inside diameter was 300 mm, the thickness was 30 mm, the length was 2,000 mm, and weight was 151 Kg. Curing was performed within a chamber saturated with steam and having a temperature of 70°C. After 2 hours' primary curing, the metal fittings were undone and the content of the mold was pushed out. The force required for the pushing-out was about 150 Kg. The tensile strength of the thus obtained unfinished molding was presumed to be 5 Kg/cm² in terms of M₁ on the basis of the compressive strength test value of a test piece picked at the same time, and no occurrence of damage was observed even when left standing still.

When the unfinished molding taken out of the mold was further subjected to 15 minutes' steam curing by applying saturated steam having a temperature of 70°C, the stripping agent attached to the exterior of the molding was completely removed. Subsequently, the thus treated molding was subjected to natural curing and a strength test was conducted by applying load on the top of the pipe 36 hours after the centrifugal molding. As a result, the pipe proved capable of bearing the load of 2,300 Kg per 1 m of the length of pipe. This verifies that the pipe according to the method of the present invention is stronger by more than 40% than a pipe 3 days after molding by the conventional method employing a split-type mold and subjecting to 6 hours' steam curing.

Further, as there was left about 40% of paraffin still in the state of liquid by virtue of the remainder of the curing heat in the mold just after taking out the molding therefrom, when the mold was rotated immediately, said residual paraffin spread uniformly all over the interior of the mold to form a layer so that the mold could be served for molding again upon making good the deficiency of paraffin by spraying. Besides, by placing the molding taken out of the mold in the steam curing chamber for 15 minutes, the stripping agent attached to the molding was almost completely removed, and the paraffin let drop on the floor was entirely collected and could be reused upon removing impurities therefrom by means of a filter.

Example 2

This example relates to the manufacture

of Hume concrete pipe with socket according to JIS (Japanese Industrial Standard). The concrete pipe with socket in this example was 600 mm in inside diameter, 50 mm in thickness, 2,430 mm in length, and 660 Kg in weight. In the same way as in Example 1, a paraffin having a melting point of 49°C was melted and applied on the interior of a cylindrical mold by spray coating, whereby a 0.15 mm-thick layer of stripping agent was formed thereon. After cooling and hardening this layer, inserting a steel cage in the mold and setting metal fittings on both ends of said mold, concrete slurry was poured therein. After conducting centrifugal molding for about 20 minutes, the mold containing the molding was left standing still for 1 hour. Subsequently, primary steam curing was effected at a temperature not exceeding 70°C for about 1.5 hour, and immediately thereafter the molding was pushed out of the mold and introduced into the steam curing chamber having a temperature of 70°C to stay therein for 20 minutes. The thus treated molding was then subjected to natural curing like in Example 1, and a strength test of the product was conducted in the same way as in Example 1 36 hours after the centrifugal molding. As a result, the product proved to have attained a strength to bear the load of 2,800 Kg per 1 mm of the length of pipe. This verifies that the present pipe is stronger by 40% than a pipe 3 days after molding by the conventional method employing a split-type mold and steam curing for about 6 hours (of which 1.5 hour at the outset is the time for leaving the molding standing still at room temperature) which showed a strength to bear the load of 2,000 Kg per 1 m of the length of pipe when subjected to the same strength test. Further, as there was residual paraffin still in the state of liquid within the mold like in the case of Example 1, the mold was rotated immediately after taking out the molding so as to spread it uniformly all over the interior of the mold, and then just the deficiency of paraffin was filled up by spraying. Besides, the paraffin attached to the exterior of the product molding taken out of the mold could be removed almost completely by subjecting said molding to secondary steam curing for 20 minutes. The thus removed paraffin was of course recovered; the gross amount of recovered paraffin was as much as about 60% of the amount of paraffin employed. This proves that the present method is very economical in stripping agent.

The composition of the concrete slurry (per 1 m³) used in the present example was as follows:

Portland cement	400 Kg	65
water	160 Kg	
sand	835 Kg	
gravel	1,027 Kg	
specific gravity of mixture	2.35	70

WHAT WE CLAIM IS:—

1. A method of manufacturing a concrete pipe in a centrifugal mould having a horizontal axis, the method comprising the steps of forming a solidified layer of a stripping agent on the interior of the mould; pouring into the mould a concrete slurry; rotating the mould to form the pipe to shape; partially curing the pipe whilst still in the mould, until it can retain its own shape, by the application of heat sufficient to melt the stripping agent; removing the pipe from the mould, and completing the curing of the pipe and the removal of residual stripping agent outside the mould by means of steam applied to the pipe.

2. A method of manufacturing a reinforced concrete pipe by subjecting concrete slurry with a steel cage buried therein to a centrifugal moulding process within a mould having a horizontal axis while rotating said mould, the method comprising forming a solidified layer of stripping agent on the interior of the mould; pouring concrete slurry into the mould; partially curing the pipe whilst in the mould, until it can retain its own shape by the application of heat sufficient to melt the stripping agent; removing the pipe from the mould, and completing the curing of the pipe and the removal of residual stripping agent outside the mould by means of steam applied to the pipe.

3. A method according to claim 1 or claim 2, wherein the stripping agent has a melting point between 40° and 60°.

4. A method according to any one of claims 1 to 3, wherein the stripping agent is selected from the group consisting of wax, asphalt, pitch and mixtures of these substances.

5. A method according to any one of claims 1 to 4, wherein the stripping agent is paraffin.

6. A method according to any one of claims 1 to 5, wherein the partial curing is performed by the application of steam.

7. A method according to any one of claims 1 to 6, wherein the mould, after release of the moulding therefrom, is reused for moulding a further pipe after replenishing of the stripping agent.

8. A method according to any one of claims 1 to 7, wherein the moulding is carried out in a one-piece cylinder.



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of Hume concrete pipe with socket according to JIS (Japanese Industrial Standard). The concrete pipe with socket in this example was 600 mm in inside diameter, 50 mm in thickness, 2,430 mm in length, and 660 Kg in weight. In the same way as in Example 1, a paraffin having a melting point of 49°C was melted and applied on the interior of a cylindrical mold by spray coating, whereby a 0.15 mm-thick layer of stripping agent was formed thereon. After cooling and hardening this layer, inserting a steel cage in the mold and setting metal fittings on both ends of said mold, concrete slurry was poured therein. After conducting centrifugal molding for about 20 minutes, the mold containing the molding was left standing still for 1 hour. Subsequently, primary steam curing was effected at a temperature not exceeding 70°C for about 1.5 hour, and immediately thereafter the molding was pushed out of the mold and introduced into the steam curing chamber having a temperature of 70°C to stay therein for 20 minutes. The thus treated molding was then subjected to natural curing like in Example 1, and a strength test of the product was conducted in the same way as in Example 1 36 hours after the centrifugal molding. As a result, the product proved to have attained a strength to bear the load of 2,800 Kg per 1 mm of the length of pipe. This verifies that the present pipe is stronger by 40% than a pipe 3 days after molding by the conventional method employing a split-type mold and steam curing for about 6 hours (of which 1.5 hour at the outset is the time for leaving the molding standing still at room temperature) which showed a strength to bear the load of 2,000 Kg per 1 m of the length of pipe when subjected to the same strength test. Further, as there was residual paraffin still in the state of liquid within the mold like in the case of Example 1, the mold was rotated immediately after taking out the molding so as to spread it uniformly all over the interior of the mold, and then just the deficiency of paraffin was filled up by spraying. Besides, the paraffin attached to the exterior of the product molding taken out of the mold could be removed almost completely by subjecting said molding to secondary steam curing for 20 minutes. The thus removed paraffin was of course recovered; the gross amount of recovered paraffin was as much as about 60% of the amount of paraffin employed. This proves that the present method is very economical in stripping agent.

The composition of the concrete slurry (per 1 m³) used in the present example was as follows:

Portland cement	400 Kg	65
water	160 Kg	
sand	835 Kg	
gravel	1,027 Kg	
specific gravity of mixture	2.35	70

WHAT WE CLAIM IS:—

1. A method of manufacturing a concrete pipe in a centrifugal mould having a horizontal axis, the method comprising the steps of forming a solidified layer of a stripping agent on the interior of the mould; pouring into the mould a concrete slurry; rotating the mould to form the pipe to shape; partially curing the pipe whilst still in the mould, until it can retain its own shape, by the application of heat sufficient to melt the stripping agent; removing the pipe from the mould, and completing the curing of the pipe and the removal of residual stripping agent outside the mould by means of steam applied to the pipe.

2. A method of manufacturing a reinforced concrete pipe by subjecting concrete slurry with a steel cage buried therein to a centrifugal moulding process within a mould having a horizontal axis while rotating said mould, the method comprising forming a solidified layer of stripping agent on the interior of the mould; pouring concrete slurry into the mould; partially curing the pipe whilst in the mould, until it can retain its own shape by the application of heat sufficient to melt the stripping agent; removing the pipe from the mould, and completing the curing of the pipe and the removal of residual stripping agent outside the mould by means of steam applied to the pipe.

3. A method according to claim 1 or claim 2, wherein the stripping agent has a melting point between 40° and 60°.

4. A method according to any one of claims 1 to 3, wherein the stripping agent is selected from the group consisting of wax, asphalt, pitch and mixtures of these substances.

5. A method according to any one of claims 1 to 4, wherein the stripping agent is paraffin.

6. A method according to any one of claims 1 to 5, wherein the partial curing is performed by the application of steam.

7. A method according to any one of claims 1 to 6, wherein the mould, after release of the moulding therefrom, is reused for moulding a further pipe after replenishing of the stripping agent.

8. A method according to any one of claims 1 to 7, wherein the moulding is carried out in a one-piece cylinder.

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9. A method according to claim 1,
substantially as described with reference to
the accompanying drawings.

5 10. A pipe produced by a method
according to any one of claims 1 to 9.

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