METHOD FOR THE MANUFACTURE OF ELONGATED OBJECTS OF CONCRETE

1 Claim, 6 Drawing Figs.

ABSTRACT: The present invention relates to a method for the manufacture of concrete objects by means of a slidable moulding assembly by feeding a concrete mass down from a movable container onto a support bed and vibrating the concrete for the compression of the concrete. The invention eliminates any risk of fissures in the final object primarily by inserting a reinforcement rod into the mass along with some water through an axial bore in a sleeve guide on the container, after a majority of the compressing or compacting of the mass has occurred. A container-carried rotating screw is used for separating, by means of its threads, the concrete remaining in the container from the concrete in the object being formed.
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It is known to manufacture lengthened concrete elements by means of horizontal sliding mould casting. The concrete by this method is fed out through an opening at the lower end of a container and down to a flat bed. The container with the concrete mixture is moved slowly along the bed. Moving after or trailing behind the container there is arranged a slide having a vibrator by means of which the concrete layer, formed on the bed, is vibrated and compressed. The container and the vibration slide are moved with even speed over the bed. The vibrator on the side of the container will thus move over the concrete fed out of the container and distributed over the bed and compress the concrete. When the concrete leaves the slide with the vibrator, it is finally compressed and need thereafter no support moulds. The method requires that the resistance of the concrete, when the latter leaves the slide with the vibrator, the sufficient so that the object formed retains its shape without sagging or forming of fissures. The concrete must be dispensed from the container very evenly and carefully. Otherwise there is obtained an object having varying properties concerning resistance, tightness and dimensions. For this purpose expensive and complicated laying devices must be used. The method further requires that the concrete has such a consistency and viscosity during the vibration that the reinforcement when such is used can be completely enclosed and embedded.

From the container, the concrete must be laid out with a height of \( H_0 \) so adjusted that the final object, the beam will have a height \( H \), that is the correct one. The relation \( H/H_0 \) is inversely proportional to the relation between the volume weight of the concrete when uncompressed and when compressed, respectively. The value of the relation is about 0.5–0.69. This means in practice that if one desires to make a beam with the final height of \( H_0 = 20 \) centimeters, one has to lay out the concrete in the front of the vibration slide with a height of about 40 cm. During the vibration the concrete will be displaced vertically downwards which action, in particular when there is a question of a manufacture of rather thin beams standing on one longitudinal edge, is to be considered as an important drawback and considerably restricts the method. The concrete must on the one hand be rather loose to such an extent that it can completely flow around the reinforcement. The difficulties arise from laying out the concrete in the correct amount. These difficulties are further increased with an increasing height and/or decreasing width of the beam. The limit for the method is at present probably situated at beams with a height of about 20 centimeters and a width of about 5 centimeters. So as to assure that the reinforcement is sufficiently embedded in the concrete during the reinforcement it is, as a rule, necessary to lift the reinforcement to the same extent as the concrete is displaced downwards during the vibration. The same is true by the use of a cavity or hole mould, i.e. by the use of rods usually in the shape of tubes for forming longitudinal holes in the object formed.

The possibility of making the concrete so loose and fluid that it flows in the desired way below the slide with the vibrator is restricted by the requirement of using a rather stiff consistency necessary in order that the object formed shall retain its form after the compression and before the hardening of the concrete. From the point of view of resistance, it is advisable to use a rather stiff concrete and to a flat bed of as low as possible. Another factor limiting the method is the friction between the concrete and the sides of the sliding mould. If the height of the sides is too large in relation to the width of the object formed, the concrete will stick to the sidewalls of the mould below the slide with the vibrator, which causes undesirable formation of cavities and fissures in the final products.

Proposals have been made to overcome said drawbacks and to render possible the manufacture, by means of sliding moulding, of lengthened concrete objects of considerable height, e.g. 90–100 cm. and with a minimum thickness of about 4–5 cm. According to one proposal the side surfaces of the concrete layer formed on the bed are vibrated directly below the container filled by the concrete mass so that the concrete mixture is fed from the latter to compensate for volume of concrete required for the compression obtained by means of the vibration in lateral direction of the concrete layer formed below the container. It is possible by means of this method to compress directly under the container the concrete layer to about 80–90 percent and perhaps even more which thus means that the concrete layer may at the place where the upper surface of the layer is stripped, be laid with a height \( H_0 \) which is only by 20–30 cm. shorter than the height \( H \) of the final element. Thus, the subsequent slide with the vibrator has only to compress the concrete layer in vertical direction by about 10–5 percent or less while the final compression in lateral direction is carried out by means of the sidewalls of the mould below the vibration slide. The concrete mass is fed or flows down from the container not only to fill the interspace between the sidewalls of the sliding mould but also to compensate for the compression obtained by means of these walls. During the vibration only from above of elements shaped as beams, it is not possible to obtain any similar compression effect. First there is obtained independently of the height of the element a homogenous compression of the element in the direction of its height. Responsive to a compression only from above, the element will be completely compressed at the lower portion. Otherwise a higher water-cement ratio must be used in order to obtain a sufficient compression. One can operate with concrete having a rather low water-cement ratio, i.e. the weight relation between the water and the cement in the concrete mixture. The water-cement ratio may as a rule be kept as low as about 0.27–0.35 for a cement content of about 300–350 kg/m.\(^3\), which gives a cement content of about 100–120 l/m.\(^3\). Due to this rather low water-cement ratio there is obtained a product with a rather high resistance. Another advantage in this rather dry concrete is to be seen in the prevention of a sticking between the side surfaces of the formed object and the sides of the mould. The strong vibration makes it possible to use a low cement proportion.

However, because the concrete is, when it is stressed and compressed below the slide mould will have a rather firm consistency, it becomes rather difficult for the vibration slide to strip the concrete mass at the upper border of the concrete object. It has resulted in the same bursts and the fissures which extend deeply down into the concrete object. An important object of the present invention is to overcome this drawback. According to the invention the concrete layer below the container is separated from the concrete mass remaining in the container by means of the threads of a rotating screw which extends in the longitudinal direction of the slide mould and is brought along by the latter during the advancement. The screw is driven in such direction a way that the concrete mass is fed rearwards, i.e. in opposite direction to the direction of advancement of the slide mould preferably in such a way that the screw is driven rearwards a little faster than the slide mould is advanced. Thus, there is obtained a certain compression of the concrete mass in the upper layer before the vibration slide carries out the vertical vibration. The risk for the formation of fissures in the object formed is practically eliminated by means of the rearwards feeding by the screw.

According to a further embodiment of the invention the reinforcement iron or rod extending in the longitudinal direction which generally is arranged at the upper border of the concrete object being formed, is inserted through an axial bore in the screw during the advancement of the slide mould. The reinforcement iron will then leave the bore in the screw at the rear end of the same, i.e. at the concrete object formed where the concrete mass already has been compressed to about 80 percent. By means of the remaining compression of 20 percent of the concrete mass—this compression being performed essentially by means of a vibration in lateral direction by the sidewalls of the mould below the vibration
The advantage in feeding the reinforcement rod through the screw does not reside solely in a correct final position. If the upper border reinforcement rod is placed into the container, the reinforcement rod will be pressed downwards by the descending concrete. In case the reinforcement is not suspended by bows or by being tensioned, it will eventually slide down to the bottom. On the other hand, if the reinforcement rod is lifted (as above), it is pressed down by the concrete to such an extend that it reounds when the finished beam leaves the machine. However, this formation of very dangerous horizontal fissures in the beam. Also, the feeding does not have to be carried out by means of a special tube.

The main point is that the feeding proper takes place after the container when the main compression already has been carried out.

However, during vibration the concrete mass and the reinforcement iron will vibrate independently of each other to a certain extend and this is true for a vibration by means of the mould walls in a lateral direction as well as the vibration by the vibrating slide in a vertical direction, this vibration having a rearwardly directed reaction force. This causes a risk that the iron will tear up a longitudinally extending cavity in the concrete mass in which case the result of course, will be a considerably reduced effectiveness of the reinforcement iron in the concrete object. To this end, according to a further aspect of the invention water is fed around the reinforcement iron into the bore within the screw at the front end of the same. The screw is inclined slightly rearwards and the water thus flows from the bore at the rear end of the screw. Thus, the continuous concrete mass is here softened to such an extend that it will well embed the reinforcement iron such that the strength of the final concrete element is considerably increased.

The method makes it possible to manufacture grooved or channel-shaped concrete elements, having two parallel and rather high sidewalls by means the improved slide moulding as described and which sidewalls are formed continuously on a rather thin concrete layer formed shortly thereafter, said thin concrete layer being possibly laid out on a bed (e.g. according to the method described in our copending Swedish Pat. application No. 1467/63.)

The adjunction to a machine for carrying into effect the method set forth hereinabove, said machine comprising a stand movable over a bed and having one or several containers for holding a concrete mixture, said containers having at their lower ends discharge openings for the concrete mixture and sidewalls extending ahead of and behind the container for forming the side surfaces of the concrete layer formed on the bed. At least one of said sidewalks is adapted to be vibrated in a lateral direction and includes a device for a vertical vibration of the upper surface of the concrete layer formed. A main feature of the invention is that at the bottom of the container there is rotated a screw extending in the displacement direction of the container, said screw being adapted, during the slide moulding, by means of its threads to separate the concrete mass remaining in the container from the laterally vibrated concrete object already formed.

Further features of the invention will be obvious from the following description with reference to the accompanying diagrammatical drawings, In the drawings:

FIG. 1 shows a vertical longitudinal section through a machine according to the invention.

FIG. 2 shows an enlarged scale a vertical longitudinal section a screw mounted for rotation in the machine.

FIG. 3 is a partly longitudinally sectioned side elevation of a slide mould assembly for the manufacture of grooved concrete elements.

FIG. 4 is a view from above of the assembly of FIG. 3.

FIG. 5 shows on an enlarged scale a vertical section on line V—V in FIG. 3, and

FIG. 6 shows on an even more enlarged scale a similar vertical cross section through the left-hand part of the aggregate according to FIG. 5.

The moulding machine shown in FIGS. 1-3 comprises a container 1 with an opening 2 at its lower end for the discharge of the concrete mixture 3 in the container. The container 1 stand 4 (see FIG. 1) is arranged on wheels 5 for the displacement of the machine on a flat bed 6. For the forming of the concrete layer or the sides of the concrete object 7 there are used parallel sidewalks 8 which extend in the forward direction as well as in the rearward direction beyond the container 1 (see FIG. 1). The machine is further provided with a slide 9 for forming the upper surface 10 of the object 7. The slide 9 is provided with a vibrator 11 for the compression of the concrete layer 7 in vertical direction. By means of springing means 12 the slide 9 is suspended on the stand 4 such that it can perform a vibration in a vertical plane. Reference letter 13 denotes a stripper at the rear edge of the opening 2 at the container 1. The rear end of the slide 9 is provided with a somewhat resilient steel plate 14 which prevents the concrete layer from forming a transverse bulge, a so-called pressure bulge at the rear end of the slide.

At least one mould wall 8, preferably the inner one (according to FIG. 6 the right hand one) is provided with a vibrator 15 and is by means of spring means 16 suspended in the stand 4 in such a way that it can vibrate in a horizontal plane. The vibrators 11 and 5 are arranged in such a way that an obliquely rearward force is applied against the upper surface and side surfaces 17 of the concrete layer 7 formed. To prevent an occurrence of a transverse bulge on the side surfaces 17, due to the vibrations of the sidewalks 8, the walls 8 at their lower ends are provided with their resilient steel plate 18, (FIG. 4). The plates 14 and 18 cause, due to the vibration, also a certain so-called steel grinding of the concrete object 7.

The advancement of the machine along the bed 6 is carried out by means of an electric motor 19 via a chain 20 to the running wheels 5.

A rearwards and downwards inclining screw 23 is mounted for rotation in the opening 2 with one end 21 supported in a bearing 22, and the screw 23 extending in the longitudinal direction of the stand 4. The screw is driven by an electric motor 24 via a pair of caged wheels 25 and 26. Axially extending in the screw is a bore 27 through which a reinforcement iron 28 can be removed. Above a receptacle 29, debouching at the front end of the bore 27 of the screw 23, there is arranged a jet nozzle 31 connected to a pressure water conduit 30, for feeding water via the bore 27 to the concrete mass at the farthest end 32 of the screw 23.

When the machine is displaced in the direction of the arrow 33 according to FIG. 1, the rather dry concrete mixture (the water-cement ratio is e.g. 0.27—0.30) is fed or slides through the opening 2 down into the bed wherein 6, horizontally or vertically bent reinforcement iron 34 and 35 are laid on said bed 6. The space between the sidewalks 8 of the machine is filled with concrete mass from the container 1. Due to the vibration, an intense compression of the concrete slab is obtained in the lateral direction and a new mass continuously flows down and out of the container to compensate for the concrete mass used up by means of the compression of the same.

Below the stripper 13, where the concrete object 7 has the height H₀, the object is assumed to have been compressed already to 90 percent. Further compression of the concrete object 7 is carried out by means of the sidewalks 8 below the slide 9.

This compression in lateral direction is assumed to be carried out to an additional 5 percent. Thus, this means that the height and width dimensions of the cross section of the concrete object below the stripper 13 has to be reduced, by means of compression, by only about 10 percent or less. The final object will be the very firm and the height homogenous. For this reason this is considerable and the width rather small. The mass already intensely compressed below the container 1 is separated from the remaining concrete mass 3 in the container by means of the threads on the screw 23 which is driven at
such a speed that the concrete mass by means of the screw threads is displaced in forward direction (in the direction of the arrow 33). At the same time a reinforcement iron 28 is moved through the bore 27 within the screw 23 into the mould. As no further notable compression of the concrete object 7 occurs in vertical direction by the slide 9, the reinforcement iron 28 will assume the correct distance relative to its upper surface 10, said distance 36 being determined by the inclination of the screw 2 and the level of the outlet. It might for this reason be advisable to make the bearing 22 for the screw 23 adjustable in such a way that the desired inclination of the screw 2 is easily assured.

Due to the water addition through the jet 31 to the concrete mass at the rear end 32 of the screw 23, there is obtained the desired higher water-cement ratio the mass about the reinforcement iron 28.

In FIGS. 3-6 there is illustrated the manufacture of a grooved or channel-shaped object 37 (FIGS. 5-6) made of concrete. This object 37, a grooved beam, has a bottom slab portion 38 and sidewall portions 39 extending upwards from the same. The bottom portion 38 is first manufactured on the bed 6 and may preferably be produced by a slide mould machine 40 (FIG. 3 to the right) which has been described more in detail in my copending Swedish Patent application No. 1467/65. At the displacement of the machine 40 in the direction of the arrow 41 in FIG. 3, the rather dry concrete mixture 42, which in this case may have a water-cement ratio as low as about 0.25-0.27, flows through the opening 43 in the container 44 down on the bed 6, a downwards inclining slope 45 of the concrete mixture then being formed below the front border 46 of the opening. Water is sprayed onto this slope 45 from jets 47 as evenly as possible. A part of the water then flows down to the bed 6 where thus the water-cement ratio in the layer 48 will be as high. Thus upper surface of the concrete layer is automatically smoothed by the stripper 49. The front border 46 is situated on a lower level than the stripper 49. The concrete layer is compressed by the aid of the slide 50 of the machine 40 thereby that the vibrator 51 of the slide is vibrated whereby there is obtained the desired density of the concrete. A continuance of the compression in the layer 48 is pressed upwards such that there is obtained a certain equalizing of the water content in the layer as a whole. The water content at the upper surface, however, never will be as high as to incur any risk that the slide 50 will become stuck to the layer, thereby assuring that the final bottom slab 38 will have a smooth, firm layer at the upper surface. The bottom slab will be very firm and there is no risk whatsoever that it be deformed when the sidewalls 51 of the machine have moved beyond it.

As shown in FIG. 6 the opposed longitudinal sides of the bottom slab 38 each provided with an upwardly projecting portion 53 form, as shown in detail in FIG. 6, a guide for the walls 6 of the succeeding slide mould machine 54, to follow, as shown in FIG. 3.

Immediately upon the compression of the layer 48 there are laid two layers of concrete by means of containers I carried at some distance from each other by a common stand 55, said layers being vibrated by the sidewalls 8 and the slides 9 in the way described in the foregoing with reference to FIGS. 1 and 2. Thus, it is possible, by means of the assembly shown in FIGS. 1 and 2, to manufacture, by means of slide mould casting, reinforced grooved or channel-shaped beams having a rather thin bottom slab or web portion and rather thin opposed high walls 39. This beam will, in spite of the rather small material consumption, have a very high resistance and supporting ability.

Also, the machine 54 for the forming of the objects 7 and the walls 39, respectively, may be provided with jets 47 (not shown) connected to a water conduit for spraying water onto the slope 56 of the concrete mass 3 flowing out of the container 1 of the machine 54. In such a case there is obtained an enrichment of water in the concrete mass near the upper surface of the slab 38 formed, i.e. on the upper surface of the upward longitudinal portions 53 of the bottom slab. At the subsequent vibration and compression of the concrete mass by means of the sidewalls 8 and the slides 9 there is obtained an equalizing of the water content in the concrete object formed.

In those cases where the edgewise arranged concrete walls 39 are to be provided with a reinforcement at the lower border, it is advantageous by such a water spraying of the concrete mass 3 at the front end of the machine that a good embedding of the concrete mass is ensured around the reinforcement iron during the subsequent vibration.

The invention has been described in the aforesaid for purposes of illustration only and it is not intended to be limited by this description or otherwise except as defined in the appended claims. Thus, the slide mould machines 40 and 54 may be constructively modified in many ways within the scope of the inventive idea. The machines 40 and 54 may be alternatively moved, instead of on running wheels 5 or carried along longitudinal beams or rails mounted in the ceiling of the room where the slide moulding is carried out. The assembly according to the invention may be used for the manufacture of beams having L- or T-shaped cross section instead of being grooved or U-shaped, and in such a case one single longitudinal wall 39 is cast on the bottom slab 38.

In case there should be desired or needed, at the upper border of the walls 39, two reinforcement iron parallel to each other, it might be advisable to dispose, in the opening 2 of the container 1, two of the rotatable screws 23 having the axial bore 27. The reinforcement iron may be provided, instead of through a bore in the screw or instead of using any screws, by being inserted through or guided down into the mould by means of a number of several plain tubes; inclining obliquely downwards and rearwards, and water may be fed to the mouth of said tubes.

The problem in connection with the stripping of the concrete mass without incurring formation of fissures in the object formed—the beam—is even more pronounced if the beam has a thin web and the latter by means of a neck continues in a broader portion extending along the upper portion of the beam where the pressure zone proper is situated. In such a case the retaining forces will be smaller during the formation than the ones tending to push the concrete mass in a forward direction for the reason that the pressure zone is broader than the web. To ensure that the material in the web in this case is sufficiently compressed and at the same time to prevent the concrete mass from being stuck in the neck, i.e. in the passage from the broader part and the narrower part of the beam, the neck must be brought to incline rearwards and downwards under the slide 9 as shown in FIG. 1. Due to the use of a feeding screw 23 and the rearward inclination of the part of the mould formed by the neck, there is obtained a beam without fissures.

What we claim is:

1. A method for the manufacture of elongated and in particular rather thin and edgewise arranged reinforced objects made from a fluid concrete mixture by means of a slidable moulding assembly comprising: feeding a fluid but relatively stiff concrete mass from a continuously advancing container (1) down from above generally vertically onto a bed below said container; laterally supporting and initially forming said mass while mainly and initially compressing it in a lateral direction into a relatively rigid layer having generally mutually parallel longitudinal borders, supplementing compressing and smoothing the upper surface of said layer by means of a subsequent compression in vertical direction while still laterally supporting same; and inserting a reinforcement iron (28) at the upper border of the object through an axial bore (27) in a sleeve guide (23) carried by and during the advancement of said container (1); said iron being fed longitudinally from above the level of the final upper surface of the object being moulded and the iron inserting occurs after the initial main compressing to preclude by said subsequent compacting an
improper positioning of said reinforcing element at an undesired lower level; and introducing water through said bore (27) for increasing the water-cement ration of the relatively stiff concrete mass in the area adjacent said iron in the moulded object to thereby facilitate a compacting of said concrete mass around the reinforcing iron and maintaining a much stronger and lower concrete-water ratio in the remaining mass of the formed object.