FILLING SAND DRAIN HOLES

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ABSTRACT

A water filled sand drain hole is filled with sand by pouring the sand down through a conduit extending into the hole while water rises up from the hole outside the conduit and a portion of the rising water is directed over into the conduit to mix with and flush down the incoming sand.

14 Claims, 13 Drawing Figures
FILLING SAND DRAIN HOLES

This invention relates to the handling of pulverulent solids, and more particularly it concerns novel arrangements for improving the speed and efficiency with which such solids may be poured through a confined region.

The invention is particularly suited to the construction of sand drains where a pulverulent material such as sand is poured down through a vertical hole in the earth to fill same. In many cases, sand drain holes are filled with water at the time the sand is poured into them, this water resulting from previous drilling and/or flushing operations.

Sand drains are used to provide a rapid consolidation or settling of certain water-bearing soils in regions where heavy construction is to be undertaken. Such soils are usually high in clay content and are stratified in the sense that subsurface water in the soil may flow much more easily in the horizontal direction than in the vertical direction. In order to take advantage of this relatively free horizontal flow so as to effect rapid removal of water and settlement of the soil under the weight of heavy construction, several sand drains are provided in the vicinity of the construction site. These sand drains are holes approximately 10 to 20 inches in diameter extending down into the soil at various depths up to about 50 feet or more. The holes are filled with sand or other solid material capable of providing porosity for free fluid flow and, at the same time, capable of preventing the sides of the hole from closing in. The sand drains permit the surface release of subsurface water which flows horizontally into them from the surrounding soil.

An area is prepared for consolidation by the sand drain technique by first covering the entire surface of the area with a blanket of sand, which may, for example, be anywhere from 3 to 10 feet or more in depth. This blanket provides weight which builds up pressure in the soil to force out its water content. Also, the sand blanket serves to maintain grade level following soil consolidation and water displacement. Moreover, it permits effective drainage of surface water.

Following placement of the sand blanket, a series of sand drain holes are drilled into the earth. Often, these holes are formed by water jets or wet rotary drills; and in most cases water is used to flush particulate matter up out of the drilled hole. Thereafter, sand is poured into the hole to displace the water.

When drilling sand drain holes, it is often necessary to provide a casing extending through the upper sand blanket so that the sand from the blanket does not fall into the hole and become wasted by being flushed out with the particulate matter during the flushing operation. This casing is maintained in place until the hole is filled with sand up to the level of the blanket. The casing is then removed and the blanket is leveled off with additional sand.

In the past, a number of difficulties have been experienced in filling sand drain holes with sand or equivalent material. Often, where the sand was poured from a bucket or skip directly into the casing, the sand would produce excessive splashing and turbulence at the surface of the water in the hole and, unless the sand were poured quite slowly, a great deal of it was lost outside of the hole. Attempts were made to improve this situation by causing the sand to flow into the hole through a conduit which extended down below the level of the water in the hole. This procedure was unsuccessful, however, because the sand would “arch over” and plug up the conduit. Vibrators and hammers were employed to overcome the plugging effects. However, these did not improve the operation substantially, and until the present invention, hand shoveling of sand into a sand drain hole was the most widely employed technique.

The present invention overcomes the above-described difficulties of the prior art. With the present invention, water filled sand drain holes may be filled with sand quickly and efficiently and with minimal loss of sand. The present invention, moreover, permits rapid machine pouring of the sand as from a bucket, skip or hopper through a conduit without plugging or arching.

According to the present invention, sand or similar solid pulverulent material is poured into a sand drain hole through a conduit or passageway defining structure while water or equivalent liquid is flowed into the conduit along with the sand to prevent plugging, and at the same time to provide a water-sand mixture of greater density than the water in the sand drain hole. The incoming water-sand mixture, being heavier than the water already in the hole, displaces this water in a smooth and effective manner so that sand is not splashed out of the hole and wasted.

As illustratively embodied, the present invention provides for recirculation of a portion of the water already in the sand drain hole to mix with and flush down the incoming sand. This is accomplished by vertically partitioning or otherwise dividing the upper end of the sand drain hole into a sand inlet conduit and a water outlet conduit. The partitioning is constructed to permit a certain amount of the water from the water outlet conduit to flow over into the sand inlet conduit to mix with the sand therein and flush it down into the sand drain hole.

In its presently preferred embodiment, the present invention makes use of an outer funnel-shaped receptacle extending down to the sand drain hole and an inner pipe extending down through the center of the funnel-shaped receptacle. In some situations, the inner pipe constitutes the sand inlet conduit while the region between the pipe and the funnel-shaped receptacle constitutes the water outlet conduit. In these situations, sand is poured down through the pipe and water rises up in the funnel-shaped receptacle and overflows along its upper edge. Openings are provided through the pipe just below the level of the upper edge of the funnel-shaped receptacle and these openings admit sufficient water to permit a flushing action which washes the sand down through the pipe without plugging.

In other situations, the region between the pipe and the funnel-shaped receptacle constitutes the sand inlet conduit while the pipe itself constitutes the water outlet conduit. In these other situations, the sand is poured down into the funnel-shaped receptacle and this results in a forcing of water up through the pipe. The water which spouts up through the pipe flows down into the funnel-shaped receptacle and a portion of it mixes with the sand and flows down with it to prevent arching and plugging. The remaining portion of the water, which is
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3. quite free of suspended sand particles, spills over the side of the funnel.

The pouring of the sand into the sand drain hole, as above-described, takes place quite smoothly until the sand in the hole reaches the level of the lower end of the inner pipe. At this point sand flow will stop, thus indicating that filling is near completion. At this point the inner pipe may be removed and a predetermined amount of sand may be poured into the funnel-shaped receptacle. The funnel-shaped receptacle is then pulled up to allow the sand to flow down and complete the filling of the hole to a precise predetermined level.

Various further and more specific objects, features and advantages of the invention will appear from the description given below, taken in connection with the accompanying drawings, illustrating by way of example preferred forms of the invention.

In the drawings: formation of Figs. 1-8 are related cross-sectional elevational views illustrating successive steps in the formation of a sand drain according to the present invention;

Fig. 9 is an enlarged exploded perspective view of a self-flushing pouring assembly used in the method of Figs. 1-8;

Fig. 10 is a further perspective view illustrating the assembled pouring assembly;

Fig. 11 is an enlarged cross-sectional elevational view illustrating the operation of the pouring assembly of Figs. 9 and 10;

Fig. 12 is a perspective view of an alternate form of pouring assembly; and

Fig. 13 is a cross-sectional elevational view illustrating the operation of the pouring assembly of Fig. 12.

As indicated previously, sand drains are usually formed in water-bearing soils of the type which permits better lateral than vertical water flow. Such soils are generally high in clay composition and are known in many instances as clayey-silty soils. As shown in Fig. 1, a water-bearing soil to be drained by means of sand drains is first covered with a layer or blanket of sand 22. This blanket, which may be anywhere from a few to 10 or more feet in thickness, serves to provide continuous downward pressure to the water-bearing soil 20 to assist in squeezing water from it. At the same time the sand blanket 22 allows lateral flow of any surface water and thus permits good drainage.

Fig. 2 illustrates the formation of a sand drain hole 23 down through the blanket 22 and the water-bearing earth 20. This hole, which may extend to 30 feet or more into the water-bearing earth, is formed by water jets 24 from a wet rotary drill 26. The wet rotary drill is mounted on a hollow stem 28 and water is pumped down through the stem from an external source (not shown) to form the jets 24. At the same time the drill 26 and stem 28 are continuously rotated and slowly lowered by a surface mounted rig, also not shown. The water jets 24 cut away the soil while the rotating drill 26 produces a paddle effect to maintain the cut away particulate matter in suspension. The water flow, in addition to providing jets with effective cutting force, is also sufficient to produce an upward flow of water in the hole 23 which carries the particulate matter up to the surface thereby flushing the hole clean. Alternate means may be used to cut the hole 23, however, such means should not smudge the surface of the hole and adversely affect the lateral permeability of the soil 20 in the vicinity of the hole. Also, a water flushing action has been found to provide an excellent means for removing the cut away particulate matter without producing adverse effects on the surface of the soil. The use of water further serves to reduce the tendency for the water-bearing earth 20 to slip laterally and close in on the hole 23 prior to filling it with sand.

As shown in Fig. 2, there is provided an upper casing 30 having an inner diameter corresponding to the inner diameter of the hole (e.g., 20 inches), and this casing is sunk down through the sand blanket 22 so that its lower edge seals into the water-bearing soil 20. The casing 30 serves to hold back the sides of the sand blanket 22 as the hole 23 is being formed and filled. If this casing were not in place, the surrounding sand would spill into the hole and would become washed away and wasted during the hole drilling and flushing operation.

Upon completion of the hole drilling and flushing operation, the drill 26 and stem 28 are withdrawn and the hole 23 is left filled with water, as illustrated in Fig. 3. The hole at this point is prepared for a sand filling operation.

The sand filling operation is begun by installing a pouring assembly 32 at the upper end of the casing 30. The pouring assembly 32, which will be described in greater detail hereinafter, basically comprises an upper funnel portion 34 having a lower skirt portion 36 extending from its lower end. The lower skirt portion 36, as shown in Fig. 4, fits closely about the upper end of the casing 30. An inner pipe 38 is mounted to extend down through the center of the pouring assembly 32 to about the bottom of the casing 30. The inner pipe 38 extends slightly above the upper edge of the funnel portion 34.

Sand 40 is poured from a bucket 42 or other loading device into the funnel portion 34, but not into the inner pipe 38, so that it flows down into the annular space between the inner pipe 38 and the casing 30. The sand mixes with the water in this space to produce a composite having a higher density than the relatively pure water within the pipe 38. As a result of this density difference, the composite moves downward through the annular space and displaces water up through the inner pipe 38. This water spouts up over the top of the inner pipe 38, as illustrated by arrows 44 in Fig. 5. A part of this spouted water mixes with incoming sand 40 from the bucket 42 and flushes it down through the funnel portion 34 and into the annular space between the inner pipe 38 and the casing 30. This prevents arching or plugging situations where the sand clogs the passageway through which it is poured. The self-flushing action of the water forced up through the inner pipe 38 serves to maintain a smooth free flow of sand down into the hole 23.

As the downwardly moving sand reaches the bottom of the casing 30, the downward velocity of the composite sand-water mixture decreases due to the fact that the hole 23 below the casing 30 has a greater cross-section than the annular space through which the mixture initially flowed. The sand 40 then settles, by virtue of its higher density, down to the bottom of the hole 23, as illustrated at 46.

While a portion of the water which spouts up through the inner pipe 38 is used to flush incoming sand down
through the pouring assembly, a further portion spills over the side of the funnel portion 34, as indicated by the arrows 48. Because of the large cross-section of the funnel portion 34 at its upper edge, the water movements are relatively slow and the incoming sand is therefore not carried over the edge of the pouring assembly 32. It will be seen that the inner pipe 38 constitutes a partition which divides the interior of the pouring assembly 32 into an inner water outlet conduit (within the pipe 38) and an outer sand inlet conduit (between the pipe 38 and the casing 30).

Eventually, the settled sand 46 in the hole 23 reaches the level of the inner pipe 38, as illustrated in FIG. 6. At this point, fluid communication from within the pipe 38 to the annular space outside it is interrupted; and water then ceases to spout up through the inner pipe. This provides an automatic indication of the degree to which the hole 23 has been filled; and it becomes possible to take steps to stop the sand flow before too much has been poured.

At this point, the inner pipe 38 may be removed; or, if desired, it may be left in place. A premeasured amount of sand is then slowly poured into the funnel portion 34. This premeasured amount corresponds to that necessary to fill the hole 23 from a depth corresponding to the bottom of the inner pipe 38. When this additional sand has been poured into the funnel portion 34, the entire pouring assembly 32 is lifted together with the casing 30 by means of a surface mounted rig. This produces a completed sand drain 50, as shown in FIG. 8.

The construction of the pouring assembly 32 is shown in greater detail in FIGS. 9–11. As can be seen in FIG. 9, the funnel portion 34 is of circular cross-section and is provided with a horizontal inwardly extending flange lip 52 about its upper edge. The funnel also could be square in cross-section. A pair of crossbars 54 extend in parallel fashion across the upper edge of the funnel portion 34 to provide support for the inner pipe 38. A pair of transverse members 56 extend between the crossbars 54 near the center thereof to define a central opening 58 for maintaining proper positioning of the inner pipe. The inner pipe itself is provided with a pair of outwardly extending lugs 60 which, as shown in FIG. 10, rest on the crossbars 54 in assembly. This arrangement permits adequate support for the inner pipe 38, while at the same time allowing full and free sand and water flow and ready removal of the inner pipe 38 for completion of the sand filling operation.

A pair of diametrically positioned rings 61 extend from the upper edge of the funnel portion to permit lifting of the pouring assembly 30 by means of hooks from a rig (not shown).

As can be seen in FIG. 11, the entire upwardly spouting water flow from the inner pipe 38 spills over into the funnel portion 34. However, because of the large cross-section of this region of the funnel portion, large volume rates can be accommodated with minimal linear flow velocities. Thus, the conditions near the top of the funnel portion are relatively quiescent and the sand entering the pouring assembly can settle down toward the space between the inner pipe 38 and the casing 30 without being splashed over the edge of the assembly. The flange lip 52 about the upper edge of the assembly is effective in ensuring that no sand is lost over the side, although excess water may readily spill over.

The alternate pouring assembly shown in FIGS. 12 and 13 also comprises an upper funnel portion 62 and a lower skirt portion 64. The funnel portion 62 has flat sides and is square in cross-section. However, a round funnel could be used. The skirt portion 64, however, is cylindrical and, as shown in FIG. 13, fits closely over the casing 30. The upper edge of the funnel portion is provided with an inwardly extending flange lip 66 and lifting rings 68, as in the preceding embodiment.

An inner pipe 70 is supported from rings 72 by chains 73 extending from brackets 75 at opposite edges of the funnel portion 62 to extend centrally down through the funnel and skirt portions 62 and 64. In the present arrangement, the inner pipe 70 is larger in diameter in relation to the casing 30 than the internal pipe 38 of the preceding embodiment. Thus, whereas the inner pipe 38 of the preceding embodiment has a diameter of about 6 inches in a 20 inch diameter casing, the inner pipe 70 in the present embodiment has a diameter of about 14 inches for a 20 inch diameter casing.

The inner pipe 70 is formed with a pair of diametrically opposed holes 74, each about 2 inches in diameter, near its upper end. As can be seen in FIG. 13, the pipe 70 is positioned such that the holes 74 are located just below the upper edge of the funnel portion 62.

In using the alternate pouring assembly of FIGS. 12 and 13, sand 76 is poured down into the inner pipe 70 from a bucket spout 78 or similar source, as shown in FIG. 13. The sand mixes with the water in the pipe and the resulting sand-water mixture, being heavier than the water in the annular space between the inner pipe 70 and the casing 30, moves down and forces water up through the annular space and into the funnel region. This upwardly flowing water is substantially free of sand; and as it moves into the larger cross-sectional region of the funnel portion 62, its velocity decreases, thus permitting settlement of any sand particles which may have been carried up into the funnel region.

A portion of the water in the funnel region enters the inner pipe 70 through the holes 74 and washes down the incoming sand 76, thereby preventing arching or plugging. As sand continues to be poured into the inner pipe 70, water will continue to rise up into the funnel portion 62 of the pouring assembly; and a portion of this water will spill over the upper edge of the pouring assembly while a remaining portion will enter through the holes 74 to flush down the incoming sand. This operation will continue until, as explained in conjunction with the preceding embodiment, the poured sand fills the sand drain hole to the bottom of the inner pipe 70 and stops the water recirculation. At this point, the inner pipe is removed and the pouring assembly is charged with a premeasured amount of sand. The pouring assembly is then lifted, along with the casing 30, and the preselected sand charge is left in place to fill the hole. In this embodiment, the inner pipe 70 constitutes a partition which divides the interior of the pouring assembly into an inner sand inlet conduit (within the pipe 70) and an outer water outlet conduit (between the pipe 70 and the casing 30).

A feature of this method is that the large diameter inner pipe can be charged with the correct amount of
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sand to fill the sand drain to its proper level. It is not necessary to premeasure the amount of sand needed to finish the drain. For example, the volume contained within 2 lineal feet of 14 inch diameter inner pipe will fill 1 lineal foot of 20 inch diameter pipe. This inner pipe diameter and length are matched to the sand drain inside diameter. When the water circulation stops and the sand is up to the bottom of the inner pipe we charge the inner pipe with the exact amount of sand to fill the drain. The inner pipe may be provided with footage indication marks so that the drain can be filled to different cut off elevations.

It will be appreciated that with each embodiment described, there is provided an automatic recirculation of water which mixes with incoming sand and flushes it down into the sand drain hole while permitting the displacement of substantially sand-free water up out of the hole as the hole is being filled.

Having described the invention with particularity with reference to the preferred embodiment of the same, and having referred to some of the possible modifications thereof, it will be obvious to those skilled in the art, after understanding the invention, that other changes and modifications may be made therein without departing from the spirit and scope of the invention; and the appended claims are intended to cover such changes and modifications as are within the scope of the invention.

What is claimed is:

1. A method of forming a sand drain in the earth, said method comprising the steps of forming an elongated hole down into the earth from the surface of the earth and filling said hole with water, dividing the upper end of said hole into two adjacent longitudinally extending conduits which are separated by a partition wall, pouring sand down into one of said conduits to mix with water therein and to form a composite sand-water mixture which is of greater density than the water in said hole thereby to force water upwardly out of said hole through the other conduit and directing one portion of the upwardly flowing water to pass directly across to the other side of said partition wall and back down into the hole via said one conduit to mix with the sand being poured therein and directing the remaining portion of the upwardly flowing water out and away from the hole.

2. A method of forming a sand drain in the earth comprising the steps of forming an elongated hole down into the earth and filling said hole with water, providing a tubular casing in said hole, extending an inner pipe down into said casing to divide the upper region of same into two adjacent longitudinally extending conduits separated from each other by a partition wall formed by said inner pipe, pouring sand down into one of said conduits so that water rises in the other conduit, directing the rising water such that at least one portion thereof spills over across to the other side of said partition wall and back down into the hole via said one conduit to mix with and flush down the poured sand, and such that the remaining portion of the upwardly flowing water is directed out and away from the hole, continuing said pouring of sand to fill said hole and thereafter removing said casing and pipe.

3. A method according to claim 2 wherein said sand is poured into the space between said inner pipe and said casing so that said one portion of said rising water spouts up from said inner pipe and falls back into said space while said one remaining portion of said water overflows over the upper edge of said casing.

4. A method according to claim 2 wherein said sand is poured into said inner pipe and said one portion of the water rising in the space between said inner pipe and said casing is directed through openings in said inner pipe back into the pipe.

5. A method of consolidating water bearing earth comprising the steps of applying a sand blanket on the surface of said earth, forming a hole down through the blanket and inserting a casing through the hole in said sand blanket to prevent sand from spilling into said hole, said casing having a funnel like configuration at its upper end, causing said hole to be filled with water, inserting an inner pipe down into said casing to form two downwardly extending adjacent passageways leading down into said hole, pouring sand down one of said passageways so that water rises in the other passageway, directing the rising water so that a portion of it spills into said one passageway to mix with and flush down the sand being poured, continuing the pouring of sand until the upward rise of water in said other passageway stops, removing said inner pipe, adding additional sand to said casing in an amount corresponding to the volume of said hole from the upper surface of said sand blanket to the bottom of said inner pipe, removing said casing and allowing said sand to settle into the upper region of said hole to fill same.

6. A method of filling a water filled sand drain hole with sand, said method comprising the steps of inserting a partition down into the upper end of said hole to divide same into two longitudinally extending conduits, pouring sand down into one of said conduits to mix with water therein and to form a composite sand-water mixture which is of greater density than the water in said hole so that water rises up out from the other conduit and directing the rising water so that one portion of it spills over an edge of said partition and back down to said hole via said one conduit to mix with and flush down the sand being poured and so that the remaining portion of the rising water is directed out away from said hole.

7. A method according to claim 6 wherein said pouring of sand is continued until water ceases to rise in said other conduit, then adding a predetermined amount of sand into said one conduit and withdrawing said partition.

8. A method according to claim 7 wherein said predetermined amount of sand is equal to the volume of said hole above the bottom of said partition.

9. A method according to claim 6 wherein the flow velocity of the rising water is retarded at the upper end of a first of said conduits to prevent appreciable carryover of sand from said first conduit.

10. Apparatus for filling sand drain holes, said apparatus comprising an outer pipe, means for sealing the lower edge of said outer pipe to the wall of a water filled sand drain hole to be filled with sand, a funnel like structure extending upwardly from the upper end of said outer pipe, the internal cross-section of the funnel like structure increasing in an upward direction, an inner pipe extending down through said outer pipe, the lower end of said inner pipe being opened below said.
funnel like structure whereby sand poured into one of the pipes will force water up through the other pipe and whereby the upwardly displaced water undergoes a reduction in flow velocity in the funnel like structure so that an effective separation of sand from water takes place prior to overflow of water from said funnel like structure, means establishing liquid communication between the upper end of said inner pipe and an upper region of said funnel like structure whereby a portion of the upwardly displaced water will flow into and flush down through said one pipe.

11. Apparatus according to claim 10 wherein said funnel like structure is formed with an inwardly extending flange like lip about its upper edge.

12. Apparatus according to claim 10 and including means on the upper edge of said funnel like structure for supporting said inner pipe.

13. Apparatus according to claim 12 wherein said means for supporting said inner pipe is constructed to permit said inner pipe to be pulled up out of said funnel like structure.

14. Apparatus according to claim 10, wherein said means establishing liquid communication comprises openings in the sides of said inner pipe immediately below the upper edge of said funnel like structure.