

DRILLING AGITATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Korean Patent
5 Application No. 10-2020-0099125, filed on August 7, 2020,
the disclosure of which is incorporated herein by reference
in its entirety.

BACKGROUND

10 1. Technical Field

[0002] The present disclosure relates to a drilling
agitation system, and more particularly, to a drilling
agitation system that, when drilling and excavating the
composite ground with deep soil-cement mixing (DCM),
15 implements both convenient movement and adjustment of a
drilling agitation machine required for excavation,
together with efficient excavation using the drilling
agitation machine.

20 2. Related Art

[0003] A drilling agitator is typically used to drill and
excavate the composite ground with deep soil-cement mixing
(DCM). The drilling agitator is configured by combining
only components such as an auger machine, a support shaft,

an auger shaft, an agitating blade, a screw, and a drill bit. Hence, the rotational load of the auger shaft is increased during the excavation of excavation sites, which may lead to an increase in torque loss of the auger shaft
5 and thus a decrease in penetration capacity of the screw.

[0004] In particular, the drilling agitator must be moved to any point on the site to be excavated. In the movement of the drilling agitator, there is a need to perform the following series of operations: loading the drilling
10 agitator onto a separate vehicle; fixing the drilling agitator loaded on the vehicle so as not to shake; and unloading the drilling agitator from the vehicle arriving at the excavation site and installing the drilling agitator on the excavation site. For this reason, it is quite
15 inconvenient and cumbersome to install and set the drilling agitator.

[0005] Moreover, the auger shaft and the drill bit may be reduced in rotational speed due to the increase in load thereof in the process where they drill excavation sites
20 while rotating. Especially, since the auger shaft is vulnerable to shear force while rotating, there is always a possibility of the auger shaft being bent or damaged.

[0006] Meanwhile, the following patent document in the related art relates to a drilling-related technology for
25 reference.

[0007] [Patent Document 0001] Korean Patent Application No. 10-2007-0006370 (filed on January 20, 2007)

SUMMARY

5 **[0008]** Various embodiments are directed to a drilling agitation system that implements adjustment of an angle of excavation of a drilling agitator, convenient movement of the drilling agitator, and efficient excavation with the drilling agitator.

10 **[0009]** In an embodiment, there is provided a drilling agitation system that includes a drilling agitation machine configured to drill and excavate the composite ground with deep soil-cement mixing (DCM) while rotating, a frame structure connected to an adjacent one side of the drilling
15 agitation machine to support the drilling agitation machine, and a transport operation machine axially coupled to a lower end of the frame structure to easily move the drilling agitation machine, together with the frame structure, to an excavation site and to induce an operation
20 required for adjustment of the drilling agitation machine during the excavation by means of the drilling agitation machine.

[0010] The drilling agitation machine may include a triple-pipe swivel installed between an auger machine and at least
25 one auger shaft so that the triple-pipe swivel allows

inputs to be selectively supplied, according to the excavation situation on the excavation site, in an inward direction of the auger shaft, which is vertically and rotatably arranged from the auger machine and is rotated to induce the excavation of the excavation site, at least one high-speed coupler installed at each predetermined point in a longitudinal direction of the auger shaft so that the high-speed coupler reduce wear of a bushing while reducing a rotational load of the auger shaft and strengthening a shear force thereof by reducing friction shock generated during the rotation of the auger shaft, and a drilling agitator connected to a lower end of a lowermost one of the auger shafts connected through the high-speed coupler to drill the excavation site by agitating and rotating the inputs on the excavation site.

[0011] The triple-pipe swivel may include an inner ring connected to the auger shaft of the drilling agitation machine, used to excavate the seabed ground, to rotate together with the auger shaft, and an outer ring surrounding the inner ring and fixedly coupled to upper and lower covers. The inner ring may have a main through-hole formed vertically from the top to the bottom at the center thereof. The outer ring may have a first horizontal through-hole, formed horizontally from an upper portion on one side of an outer peripheral surface toward an inner

peripheral surface thereof, and a second horizontal through-hole formed horizontally from a lower portion on one side of the outer peripheral surface toward the inner peripheral surface thereof or from a lower portion on the other side of the outer peripheral surface toward the inner peripheral surface thereof.

[0012] Each of the main through-hole, the first horizontal through-hole, and the second horizontal through-hole may be selectively supplied with slurry, high-pressure water, and high-pressure air as the inputs.

[0013] The high-speed coupler may include a housing integrated with a coupling member coupled to a support shaft functioning as a central shaft between the auger shafts, covers coupled to or decoupled from both ends of the housing, and a rotor rotatably inserted into the housing and used to connect the auger shafts therebetween while rotating together with the auger shafts.

[0014] The high-speed coupler may further include a bushing integrated on an outer peripheral surface of the rotor with a predetermined gap therebetween, or a dual bushing interposed between the rotor and the housing.

[0015] The transport operation machine may be a crane. The transport operation machine may include an adjustment connecting rod hinged, at one end thereof, to an upper portion of the frame structure and hinged, at the other end

thereof, to the rear of the crane, to operate forward and backward by power provided thereto, thereby adjusting the operation required for the excavation adjustment of the drilling agitation machine. The transport operation machine may further include a cylinder connected to the adjustment connecting rod to provide the power to the adjustment connecting rod for the forward and backward operation thereof.

[0016] The transport operation machine may further include a tension cable hinged, at one end thereof, to the upper portion of the frame structure, and connected, at the other end thereof, to first and second rollers for adjusting tension of the tension cable by unwinding or winding a wire, a first auxiliary adjustment connecting rod connected, at one end thereof, to one of the first and second rollers and hinged, at the other end thereof, to the cylinder providing the power for forward and backward movement in front of the transport operation machine so as to tilt, thereby adjusting and inducing the tension of the tension cable, and a second auxiliary adjustment connecting rod hinged, at one end thereof, to the first auxiliary adjustment connecting rod and hinged, at the other end thereof, to the transport operation machine, thereby complementing the tilting of the first auxiliary adjustment connecting rod and inducing auxiliary tilting.

[0017] The drilling agitator may include rhombic blades horizontally coupled to a rotary shaft and spaced apart from each other by a predetermined distance along the length of the rotary shaft to evenly agitate the inputs and
5 to reduce a torque loss of the auger shaft, an agitating blade horizontally coupled to a lower portion of the rotary shaft to simultaneously perform excavation and agitation, and a spiral screw formed at a lower end of the rotary shaft to supply the inputs introduced thereinto along with
10 the excavation to the excavation site.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. 1 is a view illustrating an entire drilling agitation system, when viewed from one direction, according
15 to an embodiment of the present disclosure.

[0019] FIG. 2 is a front view illustrating an external structure of the triple-pipe swivel of FIG. 1.

[0020] FIG. 3 is a top view illustrating an upper structure of the triple-pipe swivel of FIG. 1.

20 [0021] FIG. 4 is a cutaway view for helping understanding an internal structure of the triple-pipe swivel of FIG. 1.

[0022] FIG. 5 is an enlarged view illustrating portion A of the triple-pipe swivel of FIG. 4.

[0023] FIG. 6 is a front view illustrating any portion of
25 first and second housings 161 and 162 constituting a

housing of the high-speed coupler of FIG. 1.

[0024] FIG. 7 is a top view illustrating the first housing 161 positioned at the upper portion of the housing of the high-speed coupler of FIG. 1.

5 [0025] FIG. 8 is a cross-sectional view, illustrating the high-speed coupler, taken along line A-A of FIG. 7.

[0026] FIG. 9 is a cross-sectional view, illustrating the high-speed coupler, taken along line B-B of FIG. 8.

[0027] FIG. 10 is a longitudinal cross-sectional view of the
10 high-speed coupler including a rotor 1600 inserted and installed into the housing (first and second housings 161 and 162) thereof, in order to help understanding an internal structure of the high-speed coupler.

[0028] FIG. 11 is a longitudinal cross-sectional view and a
15 side view illustrating the rotor 1600 of FIG. 10 for helping understanding an internal structure thereof.

[0029] FIG. 12 is a detailed longitudinal cross-sectional view of one 165 of coverings 165 and 165' coupled to both ends of the housing (first and second housings 161 and 162)
20 of FIG. 10.

[0030] FIG. 13 is a detailed conceptual longitudinal cross-sectional view of an exemplary bushing 166 interposed and installed between the housing (first and second housings 161 and 162) and the rotor 1600.

25 [0031] FIG. 14 is a detailed conceptual longitudinal cross-

sectional view of another exemplary bushing 167 interposed and installed between the housing (first and second housings 161 and 162) and the rotor 1600.

5 [0032] FIG. 15 is a detailed enlarged view of portion "A" of another exemplary bushing 167 illustrated in FIG. 14.

[0033] FIG. 16 is a longitudinal cross-sectional view of a first friction shock reducing unit 168, which may be applied and installed into a gap G formed between another exemplary bushing 167 of FIG. 15 and an inner bushing 167a
10 thereof, in order to help understanding an internal structure of the first friction shock reducing unit 168.

[0034] FIG. 17 is a longitudinal cross-sectional view of a second friction shock reducing unit 169, which may be applied and installed into the gap G formed between another
15 exemplary bushing 167 of FIG. 15 and the inner bushing 167a thereof, in order to help understanding an internal structure of the second friction shock reducing unit 169.

[0035] FIG. 18 is a front view illustrating a configuration of the drilling agitator 170 of FIG. 1, when viewed from
20 one side.

[0036] FIG. 19 is a top view illustrating the drilling agitator 170 of FIG. 18.

DETAILED DESCRIPTION

25 [0037] It is noted that the drawings attached to the

specification of the present disclosure are exaggerated for clarity and convenience of description. Since the embodiments described herein are nothing but one preferred embodiment of the present disclosure and it does not cover
5 all the technical ideas of the disclosure, it should be understood that various equivalents and modifications may be made at the time of filing the present application. In addition, the scope of the present disclosure is not limited to the following embodiment, but should be
10 interpreted based on the technical spirit throughout the specification in consideration of various modifications.

[0038] As illustrated in FIG. 1, a drilling agitation system according to an embodiment of the present disclosure may include a drilling agitation machine 100 vertically formed
15 for excavation of the composite ground with deep soil-cement mixing (DCM), a frame structure 200 connected to an adjacent one side of the drilling agitation machine to support the drilling agitation machine, and a transport operation machine 300 axially coupled to the lower end of
20 the frame structure to easily move the drilling agitation machine, including the frame structure, to an excavation site on the composite ground with deep soil-cement mixing (DCM) and to induce an operation required for adjustment of the drilling agitation machine 100 during excavation by
25 means of the drilling agitation machine 100.

[0039] The drilling agitation machine 100 may include a triple-pipe swivel 120 installed between an auger machine 110 and a plurality of auger shafts 140 and 150 so that the triple-pipe swivel 120 may allow inputs (slurry, high-
5 pressure water, and high-pressure air) to be selectively supplied, according to the excavation situation on the excavation site, in the inward direction of the auger shafts 140 and 150 which are vertically and rotatably arranged, e.g., in two rows from the auger machine 110, and
10 are rotated to induce the excavation of the excavation site.

[0040] In addition, the drilling agitation machine 100 may include a high-speed coupler 160 installed at each predetermined point in the longitudinal direction of the auger shafts 140 and 150, for example, which are arranged
15 vertically in two rows, so that the high-speed coupler 160 can reduce the rotational loads of the auger shafts 140 and 150 by reducing the friction shock generated during the rotation of the auger shafts 140 and 150. The high-speed coupler 160 can be strongly resistant to the shear force
20 generated during the rotation of the auger shafts 140 and 150 and can reduce the wear of a bushing.

[0041] Furthermore, the drilling agitation machine 100 may include a drilling agitator 170 connected to the lower end of the lowermost one(s) of the plurality of auger shafts
25 140 and 150 connected through the high-speed couplers 160

to drill an excavation site by agitating and rotating inputs (slurry, high-pressure air, and high-pressure water) on the excavation site.

[0042] Although the auger shafts 140 and 150 are arranged, 5 for example, in two rows in the drawing, they may be arranged in two or more rows or two or less rows so as to be suitable for the conditions of design and the environment for excavation work. The auger shafts 140 and 150 may be rotated about a support shaft 130 which is 10 vertically installed at the center therebetween. Since the plurality of auger shafts 140 and 150 need to have a long-connected structure, they may be connected to each other through the high-speed couplers 160 installed at predetermined points.

15 **[0043]** As illustrated in FIGS. 1 and 2 to 4, the triple-pipe swivel 120 may include an inner ring 122 connected to the auger shafts 140 and 150 of the drilling agitation machine 100 to rotate together with the auger shafts 140 and 150 for use in the excavation of the composite ground with deep 20 soil-cement mixing (DCM), and an outer ring 123 surrounding the inner ring 122 and fixedly coupled to upper and lower covers 123 and 124.

[0044] In the triple-pipe swivel 120, the inner ring 122 may include a main through-hole 120H1 formed vertically from 25 the top to the bottom at the center thereof. In addition,

the outer ring 121 may include a first horizontal through-hole 120H2, which is formed horizontally from an upper point on one side of the outer peripheral surface toward the inner peripheral surface thereof, and a second
5 horizontal through-hole 120H3 which is formed horizontally from a lower portion on one side of the outer peripheral surface toward the inner peripheral surface thereof or from a lower portion on the other side of the outer peripheral surface toward the inner peripheral surface thereof.

10 **[0045]** The individual main through-hole 120H1 and first and second horizontal through-holes 120H2 and 120H3 may function to supply selective one(s) or all of the inputs, such as slurry, high-pressure water, and high-pressure air, to the excavation site through the auger shafts 140 and 150
15 and through the drilling agitator 170 to be described in detail later.

[0046] As illustrated in FIG. 1, the high-speed coupler 160 connects the auger shafts 140 and 150 therebetween. As illustrated in FIGS. 6 to 11, the high-speed coupler 160
20 may include first and second housings 161 and 162 constituting a housing integrated with coupling members 164 and 163, covers 165 and 165' coupled to or decoupled from both ends of the first and second housings 161 and 162, and a rotor 1600, as illustrated in FIG. 10, rotatably inserted
25 into the first and second housings 161 and 162 and used to

connect the auger shafts 140 and 150 therebetween while rotating together with the auger shafts.

[0047] Of course, the high-speed coupler 160 may further include a bushing 166, as illustrated in FIG. 13, integrated on the outer peripheral surface of the rotor 1600 with a predetermined gap therebetween, or a dual bushing 167, as illustrated in FIGS. 14 and 15, interposed between the rotor 1600 and the housing (first and second housings 161 and 162).

[0048] As illustrated in FIGS. 1, 18, and 19, the drilling agitator 170 may include, for example, a plurality of blades 172 and agitating blades 173, and a screw 174 on a rotary shaft 171 formed vertically.

[0049] The blades 172 are coupled to the rotary shaft 171 and are spaced apart from each other by a predetermined distance along the length of the rotary shaft 171. Each of the blades 172 extends horizontally and has a rhombic shape as a whole.

[0050] That is, since the blade 172 extends horizontally in a rhombic shape, it may help to reduce the torque losses of the above-mentioned auger shafts, by virtue of the reduction in friction area in contact with the excavation site during the rotation thereof, while functioning to evenly agitate inputs.

[0051] The agitating blades 173 are coupled to the lower

portion of the rotary shaft 171. Each of the agitating blades 173 extends horizontally and has individual drill bits 173a coupled thereto. Thus, the agitating blade 173 may perform excavation while agitating inputs.

5 **[0052]** The screw 174 is coupled to the lower end of the rotary shaft 171 and has a spiral shape. In addition, the screw 174 may have individual drill bits (not shown) coupled thereto to perform excavation while selectively supplying inputs to the excavation site through discharge
10 passages formed in the drill bits. Accordingly, it may be expected that the screw 174 will have an increased penetration capacity through a combination of the individual drill bits and the discharge passages therein in the excavation process of the excavation site.

15 **[0053]** Moreover, since the blades 172 and the agitating blades 173 are coupled to the rotary shaft 171 through round flanges thereof, they can contribute to reducing the rotational load of the rotary shaft 171 and at the same time to minimizing the torque losses of the auger shafts.

20 **[0054]** As such, according to the combination of the rhombic blades 172, the agitating blades 173, and the screw 174, it is possible to increase a penetration capacity for the excavation site as a whole and construct improved DCM products with high quality through even mixing of inputs.

25 **[0055]** Meanwhile, the triple-pipe swivel 120 and the high-

speed coupler 160 will be described in more detail later, and the transport operation machine 300 will first be described.

[0056] As illustrated in FIG. 1, the transport operation machine 300 may be, for example, a forklift, which is a type of crane, and may be axially coupled to the lower end of the frame structure 200 connected to the adjacent one side of the drilling agitation machine 100.

[0057] That is, the crane as the transport operation machine 300 may be axially coupled to the lower end of the frame structure 200 so that the frame structure 200 is mounted to the front of the crane. Due to the mounting of the frame structure 200 in the crane as the transport operation machine 300, the crane can conveniently move the drilling agitation machine 100, including the frame structure 200, to a selected excavation site. Of course, it is also possible to conveniently move the drilling agitation machine 100 as well as the frame structure 200 to a changed excavation site even if there is an unexpected sudden change in excavation site at the site for excavation work.

[0058] The crane as the transport operation machine 300 may include an adjustment connecting rod 310 configured to adjust the operation required for the excavation adjustment of the drilling agitation machine 100, a tension cable 325 for tension, and first and second auxiliary adjustment

connecting rods 320 and 321 configured to adjust the tension of the tension cable and to accessorily adjust the operation of the drilling agitation machine 100.

[0059] As illustrated in FIG. 1, the adjustment connecting rod 310 may be hinged, at one end thereof, to the upper portion of the frame structure 200 and may be hinged, at the other end thereof, to the rear of the crane, to operate forward and backward by power provided thereto, thereby adjusting the operation required for the excavation adjustment of the drilling agitation machine 100.

[0060] Here, the operation required for the excavation adjustment of the drilling agitation machine 100 refers to a series of overall motions of the drilling agitation machine 100 such that the drilling agitation machine 100 is accurately positioned on the excavation site, and the series of overall motions may also include an angular motion.

[0061] In order to provide power to the adjustment connecting rod 310 for forward and backward operation thereof, a cylinder 311 may be further connected to the adjustment connecting rod 310. Preferably, the rod end of the cylinder 311 is hinged to the rear of the crane so that the angle of rotation of the frame structure 200 is adjustable, with the consequence that it is possible to adjust the operation of the drilling agitation machine 100

connected to the frame structure 200.

[0062] As illustrated in FIG. 1, the tension cable 325 is hinged, at one end thereof, to the upper portion of the frame structure 200, and is connected, at the other end thereof, to first and second rollers 330 and 331 for adjusting the tension of the tension cable 325 by unwinding or winding a wire 340.

[0063] The first auxiliary adjustment connecting rod 320, which is connected, at one end thereof, to one of the first and second rollers 330 and 331, preferably, to the second roller 331 in the drawing, may be hinged, at the other end thereof, to the front of the crane. At the same time, one end of a separate cylinder that is able to rotate and tilt the first auxiliary adjustment connecting rod 320 may be hinged to the first auxiliary adjustment connecting rod 320 and the other end thereof may be hinged to the crane.

[0064] The second auxiliary adjustment connecting rod 321 may be hinged, at one end thereof, to the first auxiliary adjustment connecting rod 320 and may be hinged, at the other end thereof, to the crane as the transport operation machine, thereby complementing the tilting of the first auxiliary adjustment connecting rod 320 and stably inducing auxiliary tilting.

[0065] The first and second auxiliary adjustment connecting rods 320 and 321 may perform auxiliary adjustment by

complementing the angle of rotation of the frame structure 200 while adjusting the tension of the tension cable 325.

[0066] In the triple-pipe swivel 120 included in the drilling agitation machine 100, a socket adapter 125 is coupled to any portion of the outer periphery of the outer ring 121. The socket adapter 125 may be used to couple the triple-pipe swivel 120, which is connected to the support shaft and the auger shafts, to a stabilizer or a multi-auger machine.

[0067] As illustrated in FIGS. 4 and 5, intervening O-rings 126 may be interposed at regular intervals in a vertical direction between the outer ring 121 and the inner ring 122. Bearings 127 may be interposed between the outer and inner rings 121 and 122 and the upper cover 123 and between the outer and inner rings 121 and 122 and the lower cover 124, respectively.

[0068] In addition, bearing O-rings 127a may be interposed between the inner ring 122 and the upper cover 123 and between the inner ring 122 and the lower cover 124, respectively, thereby sealing the gaps therebetween in an airtight manner.

[0069] Since the intervening O-rings 126 are configured to airtightly seal the gap between the outer ring 121 and the inner ring 122, the inflow of seawater therebetween can be blocked. Since the bearing O-rings 127a seal the gap

between the upper side end of the inner ring 122 and the upper cover 123 and the gap between the lower side end of the inner ring 122 and the lower cover 124 in an airtight manner, the inflow of seawater toward the bearing 0-rings 127a can be blocked.

[0070] The lower end of the triple-pipe swivel 120 is a portion that is connected to the upper end of the uppermost one(s) of the plurality of auger shafts 140 and 150. Accordingly, a lower O-ring 128 and a connecting O-ring 129 may be arranged at a predetermined distance on the lower end of the inner ring 122. Since the lower O-ring 128 and the connecting O-ring 129 seal the connection portion with the auger shaft in an airtight manner, the inflow of seawater can be fundamentally blocked. A long bolt 122a may be inserted into and fastened to the inner ring 122 as illustrated in FIG. 4.

[0071] As illustrated in FIGS. 3 to 5, the outer ring 121 is configured to surround the inner ring 122, and the respective upper and lower covers 123 and 124 may be, for example, bolted to the upper and lower ends of the outer ring 121.

[0072] Thus, the outer ring 121 may be fixedly fastened to the upper and lower covers 123 and 124, while the inner ring 122 positioned inside the outer ring 121 may be rotated.

[0073] In particular, the inner ring 122 may have the main through-hole 120H1 vertically formed at the center thereof. The outer ring 121 surrounding the inner ring 122 may have the first horizontal through-hole 120H2, which is formed
5 horizontally from the upper point on one side of the outer peripheral surface toward the inner peripheral surface thereof, and the second horizontal through-hole 120H3, which is formed horizontally from the lower point on the other side of the outer peripheral surface toward the inner
10 peripheral surface thereof.

[0074] Of course, the first horizontal through-hole 120H2 may be formed at a position above the second horizontal through-hole 120H3, and the first horizontal through-hole 120H2 and the second horizontal through-hole 120H3 may be
15 spaced vertically from each other on the outer peripheral surface of the outer ring 121. However, depending on the conditions of design, the first horizontal through-hole 120H2 and the second horizontal through-hole 120H3 are spaced vertically from each other on the outer peripheral
20 surface of the outer ring 121, and for example, when the first horizontal through-hole 120H2 is formed at the upper point on one side of the outer peripheral surface of the outer ring 121, the second horizontal through-hole 120H3 may be formed at the lower point on the other side of the
25 outer peripheral surface of the outer ring 121.

[0075] On the other hand, at predetermined portions spaced outward of the inner ring 122 from the main through-hole 120H1 formed at the center of the inner ring 122, a first auxiliary through-hole 120H2a and a second auxiliary through-hole 120H3a may be formed vertically from the top to the bottom of the inner ring 122, similarly to the main through-hole 120H1.

[0076] The respective first and second auxiliary through-holes 120H2a and 120H3a formed in the inner ring 122 may match and communicate with the first and second horizontal through-holes 120H2 and 120H3 of the outer ring 121 fixed during the rotation of the inner ring 122. Such a communication structure makes it possible to selectively supply inputs (e.g., slurry, high-pressure water, and high-pressure air) and further to prevent twisting of cables connected for the supply of the inputs (slurry, high-pressure water, and high-pressure air).

[0077] That is, the twisting of the cables connected to the first and second horizontal through-holes 120H2 and 120H3 formed in the outer ring 121 is prevented since the first and second auxiliary through-holes 120H2a and 120H3a formed in the inner ring 122, rotated within the fixed outer ring 121, match and communicate with the first and second horizontal through-holes 120H2 and 120H3 for supply of inputs (slurry, high-pressure water, and high-pressure air).

[0078] Furthermore, the triple-pipe swivel 120 allows inputs (slurry, high-pressure water, high-pressure air) to be individually supplied according to the condition of excavation of the seabed ground, thereby preventing the
5 inputs from being supplied at one time through a single supply line formed in an existing swivel. Therefore, the durability of lines for inputs can be improved, and the quality of improved products to be constructed in the future can be enhanced as it is possible to individually or
10 selectively supply these inputs.

[0079] In other words, in some cases, only slurry may be required to be supplied to the excavation site of the excavation work due to the variable excavation situations. In this case, if high-pressure water and high-pressure air
15 as well as slurry are supplied to the excavation site through the single supply line of the existing swivel, the portions of the improved products to be constructed in the future, which do not require high-pressure water and high-pressure air, may be decreased in hardness or may be
20 defective such as non-uniformity due to the high-pressure water and high-pressure air already supplied thereto, which in turn results in a deterioration in quality of the improved products. However, the triple-pipe swivel of the present disclosure can achieve selective or individual
25 supply of inputs so as to actively cope with the variable

excavation situations, so that the quality of the improved DCM products to be constructed can be enhanced.

5 [0080] The coupling members 163 and 164 may be coupled, at the bottoms thereof, to the bed or support shaft 130 of the drilling agitation machine 100. The coupling member 164 may have a plate shape. The coupling member 163 may be integrated with the coupling member 164 while protruding therefrom and may be integrated with the first and second housings 161 and 162 constituting the housing while
10 supporting the first and second housings 161 and 162.

[0081] The first and second housings 161 and 162 may each have a semicircular shape, and may be combined with each other to form a cylindrical structure for insertion and installation of the rotor 1600 as illustrated in FIG. 10.

15 [0082] As illustrated in FIG. 10, the respective coverings 165 and 165' may be fastened to both ends of the first and second housings 161 and 162 with fasteners 165aa according to the combination of the first and second housings 161 and 162. The fasteners 165aa may be, for example, bolts.

20 [0083] The rotor 1600, which is rotatably inserted and installed into the first and second housings 161 and 162, may have a plurality of through-holes formed therein to partition the inside of the rotor 1600. For example, as illustrated in FIGS. 10 and 11, the rotor 1600 may include
25 a first through-hole 1610 formed at the center thereof, a

second through-hole 1620 formed at one side thereof, namely, at the upper portion thereof in the drawing and spaced apart from the first through-hole by a predetermined distance, and a third through-hole 1630 formed at the other side thereof, namely, at the lower portion thereof in the drawing and spaced apart from the first through-hole by a predetermined distance.

[0084] The first to third through-holes 1610 to 1630 of the rotor 1600 may function as supply/movement passages for inputs including slurry, high-pressure water (water jet), and high-pressure air. The inputs may be selectively supplied through the through-holes to excavation sites during the construction of the composite ground with deep soil-cement mixing (DCM).

[0085] Meanwhile, since the coverings 165 and 165' may have the same configuration, only the configuration of the covering 165 will be described as an example. The covering 165 may have a plurality of first and second bearing grooves 165a and 165b formed along the inner diameter thereof at a predetermined distance as illustrated in FIGS. 10 and 12. The covering 165 may have fastening holes 165c formed above the first and second bearing grooves 165a and 165b.

[0086] Of course, the above-mentioned first and second bearing grooves 165a and 165b and fastening holes 165c may

be formed in the same manner in the covering 165'. The fastening holes 165c are holes required for insertion and fastening of the above-mentioned fasteners 165aa, and the coverings 165 and 165' may be firmly coupled to both ends
5 of the housing (first and second housings 161 and 162) through the insertion and fastening of the fasteners 165aa.

[0087] The plurality of first and second bearing grooves 165a and 165b are grooves, for example, required for insertion and installation of respective ball bearings.

10 The insertion and installation of the ball bearings provides a flexible rotational force for the rod, namely, the rotor 1600, rotated toward any excavation site, thereby helping to improve the rotational speed of the rotor 1600 by reducing the rotational friction thereof.

15 **[0088]** The exemplary bushing 166 applied to the high-speed coupler 160, as illustrated in FIGS. 10 and 13, is integrated with the outer diameter of the rotor 1600 and is engaged, namely, latched between the coverings 165 and 165' coupled to both ends of the first and second housings 161
20 and 162. Therefore, in spite of an increase in the amount of rotation of the rotor 1600, which is the rod rotated toward the excavation site, the bushing 166 can be slightly worn.

[0089] Furthermore, the bushing 166 may have friction
25 dispersion holes 166a formed along the peripheral length

thereof at a predetermined distance and penetrating from the inner diameter to the outer diameter thereof. In particular, each of the friction dispersion holes 166a has a large-small hole structure in which it has a larger diameter at the inner diameter of the bushing 166 than at the outer diameter of the bushing 166.

[0090] In other words, the friction dispersion hole 166a is a large-small hole formed to have a diameter that gradually decreases from the inner diameter toward the outer diameter of the bushing 166.

[0091] The friction dispersion holes 166a can disperse frictional resistance generated during the rotation of the rotor (rod) 1600. To this end, the friction dispersion holes 166a may each have a large-small hole structure in which the diameter thereof decreases from the inner diameter toward the outer diameter of the bushing 166, thereby increasing the dispersion of frictional resistance and thus reducing the rotational load of the rotor 1600.

[0092] Since the bushing 166 is integrated with the outer peripheral surface of the rotor 1600, the bushing 166 serving to guide the rotor (rod) can be slightly worn. In addition, since there is no rotational clearance between the bushing 166 and the rotor (rod) 1600 despite the increase in the amount of rotation of the rotor 1600, it is possible to prevent the rotor 1600 from being bent or

damaged due to the decrease in the shear force that may be applied thereto. Furthermore, the threshold of the amount of rotation of the rotor (rod) 1600 can reach a value of 50 to 60 RPM, which is much higher than the threshold of 30 RPM that may be implemented in a rotor applied to an existing coupler.

[0093] Meanwhile, another exemplary bushing 167 applied to the high-speed coupler of the present disclosure, as illustrated in FIGS. 14 and 15, may be configured as a dual bushing, which is coupled to the fasteners 165aa coupled to both ends of the housing (first and second housings 161 and 162) and includes an inner bushing 167a therein.

[0094] This another exemplary bushing 167 may further include a gap G, as illustrated in FIG. 15, from the inner bushing 167a, and reinforcement tips 167b integrated at both ends of the inner bushing 167a.

[0095] Moreover, a first friction shock reducing unit 168 as an example may be inserted into the gap G as illustrated in FIG. 16. On the other hand, as illustrated in FIG. 17, a second friction shock reducing unit 169 may be further inserted into the gap G according to the conditions of design and the environment for use.

[0096] The first friction shock reducing unit 168 may be composed of a tapered roller bearing 168A inserted into the gap G as illustrated in FIG. 16. The tapered roller

bearing 168A has a structure that is suitable for maximum reduction of loads generated during the rotation of the rotor (rod) 1600.

[0097] That is, the loads may include all of a radial load,
5 an axial load, a composite load, and other loads considered in the process of rotating the rotor (rod) 1600, and these loads can be reduced to the maximum through the tapered roller bearing 168A during the rotation of the rotor (rod) 1600. As such, through the reduction in the rotational
10 load of the rotor 1600, it is possible to reduce the loads of the auger shafts 140 and 150 directly connected to the rotor 1600 and to reduce the damage to the auger shafts 140 and 150 due to the shear force occurring in the auger shafts 140 and 150.

15 **[0098]** The tapered roller bearing 168A may include a spherical bearing 168c installed at the center of the gap G and roller bearings 168a and 168b installed on the left and right sides of the spherical bearing. The roller bearings 168a and 168b may have curved contact surfaces 168a1 and
20 168b1 formed on the respective portions thereof in contact with the left and right sides of the spherical bearing 168c, and the curved contact surfaces 168a1 and 168b1 are suitable to surround and enclose portions of the left and right sides of the spherical bearing 168c.

25 **[0099]** As such, the tapered roller bearing 168A including

the spherical bearing 168c, the roller bearings 168a and 168b, and the curved contact surfaces 168a1 and 168b1 may be suitable to actively cope with various loads (radial load, axial load, composite load, and other loads) generated during the rotation of the rotor 1600, thereby reducing the loads to the maximum. Consequently, the bushing 167 can be slightly worn, the rotational speeds of the rotor 1600 and auger shafts 140 and 150 can be increased, and the shear forces of the rotor 1600 and auger shafts 140 and 150 can be strengthened.

[00100] On the other hand, as illustrated in FIG. 17, the second friction shock reducing unit 169 may be further inserted into the gap G according to the conditions of design and the environment for use.

[00101] The second friction shock reducing unit 169 may be composed of a banded ball bearing 169A inserted into the gap G as illustrated in FIG. 17. The banded ball bearing 169A also has a structure that is suitable for maximum reduction of loads generated during the rotation of the rotor (rod) 1600.

[00102] That is, the loads may include all of a radial load, an axial load, a composite load, and other loads considered in the process of rotating the rotor (rod) 1600, and these loads can be reduced to the maximum through the banded ball bearing 169A during the rotation of the rotor (rod) 1600.

[00103] The banded ball bearing 169A may include a band 169c inserted and installed into the gap G and a zigzag leaf spring 169a formed inside the band 169c. The banded ball bearing 169A may further include ball bearings 169b
5 rotatably installed at regular intervals in the longitudinal direction of the leaf spring 169a. The band 169c may have a hollow 169c1 therein, which is suitable to install the zigzag leaf spring 169a and to make it easy to absorb the friction shock transmitted to the ball bearings
10 169b while enabling the rotation of the ball bearings 169b.

[00104] As such, the banded ball bearing 169A including the leaf spring 169a, the ball bearings 169b, and the band 169c in the form of the hollow 169c1 may be suitable to actively cope with various loads (radial load, axial load, composite
15 load, and other loads) generated during the rotation of the rotor 1600, thereby reducing the loads by absorbing the loads to the maximum. Consequently, the bushing 167 can be slightly worn, the rotational speeds of the rotor 1600 and auger shafts 140 and 150 can be increased, and the shear
20 forces of the rotor 1600 and auger shafts 140 and 150 can be strengthened.

[00105] Meanwhile, the drilling agitator 170, which is coupled to the lower ends of the lowermost auger shafts 140 and 150 of the plurality of auger shafts 140 and 150 as
25 illustrated in FIG. 1, excavates the composite ground with

deep soil-cement mixing (DCM) while rotating as illustrated in FIGS. 18 and 19. The drilling agitator 170 may include the rhombic blades 172 horizontally coupled to the rotary shaft 171 and spaced apart from each other by a
5 predetermined distance along the length of the rotary shaft 171 to evenly mix slurry during excavation, the agitating blades 173 coupled to the lower portion of the rotary shaft 171, and the screw 174 including the individual drill bits to effectively excavate the composite ground while
10 discharging inputs such as slurry, high-pressure water, and high-pressure air.

[00106] In the process where the drilling agitator 170 excavates the composite ground with deep soil-cement mixing (DCM), the operation of the frame structure 200 is
15 controlled by the transport operation machine 300, the high-speed coupler 160 rotates at high speed, the frictional resistance is reduced, and the input (high-pressure water, high-pressure air and slurry) are selectively supplied through the triple-pipe swivel 120.
20 Therefore, it is possible to effectively excavate the composite ground and to increase a penetration capacity.

[00107] In particular, the amount of cement used for deep soil-cement mixing (DCM) can be significantly reduced. For example, the amount of cement in the input can be reduced
25 by more than 30% to 150 kg/m³ compared to the existing 250

kg/m³.

[00108] The efficiency of excavation of the composite ground can be achieved when comprehensively satisfying all the points that the operation of the drilling agitation machine
5 needs to be adjusted such that the drilling agitation machine is accurately positioned at the excavation site, the load of the rotating auger shaft needs to be reduced, the shear force needs to be reinforced, the inputs need to be selectively supplied according to the topography of the
10 excavation site, and the like. The efficiency of excavation of the composite ground refers to the improvement of the overall progress of excavation that can be performed well without any abnormalities from the start of excavation to the progress and completion of the
15 excavation, and also implies the effect of constructing improved DCM products with high quality.

[00109] As apparent from the above description, the drilling agitation system according to the present disclosure includes the drilling agitation machine including the
20 triple-pipe swivel and the high-speed coupler, the frame structure configured to support the drilling agitation machine, and the transport operation machine axially coupled to the lower end of the frame structure. In particular, it is possible to minimize the torque losses of
25 the auger shafts through the rhombic blades to reduce the

rotational loads of the auger shafts and to increase a penetration capacity through the spiral screw bits.

[00110] In addition, the transport operation machine of the drilling agitation system according to the present disclosure can ensure that the drilling agitation machine is conveniently moved to a changed excavation site even if there is an unexpected sudden change in excavation site on the composite ground with deep soil-cement mixing (DCM) at the site for excavation work. Thus, it is possible to actively cope with the unexpected sudden change in excavation site.

[00111] Furthermore, the drilling agitation system according to the present disclosure may adjust the drilling agitation machine about the frame structure by means of the transport operation machine in the process of excavating the composite ground with deep soil-cement mixing (DCM). Therefore, it is possible to easily and accurately adjust the excavation point of the drilling agitator for the excavation site.

[00112] Moreover, the drilling agitation system according to the present disclosure can increase the number of revolutions per minute through the combination of the triple-pipe swivel, the high-sped coupler, and the drilling agitator, and can achieve a reduction in construction time, a reduction in maintenance cost, a reduction in

construction cost, and a significant reduction in the amount of cement used for deep soil-cement mixing (DCM) by simultaneously utilizing high-pressure air and high-pressure water (water jet).

5 **[00113]** While various embodiments have been described above, it will be understood to those skilled in the art that the embodiments described are by way of example only. Accordingly, the disclosure described herein should not be limited based on the described embodiments.

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WHAT IS CLAIMED IS:

1. A drilling agitation system comprising:

a drilling agitation machine configured to drill and
5 excavate the composite ground with deep soil-cement mixing
(DCM) while rotating, the drilling agitation machine
comprises:

a plurality of auger shafts and a support shaft
installed between the plurality of auger shafts;

10 a triple-pipe swivel installed between an auger
machine and the plurality of auger shafts, the triple-
pipe swivel adapted to allow inputs to be selectively
supplied, according to the excavation situation on the
excavation site, in an inward direction of the auger
15 shaft, which is vertically and rotatably arranged from
the auger machine and is rotated to induce the
excavation of the excavation site;

a plurality of high-speed couplers installed at
predetermined points in a longitudinal direction of
20 the auger shafts such that the high-speed couplers
reduce wear of a bushing while reducing a rotational
load of the auger shafts and strengthening a shear
force thereof by reducing friction shock generated
during the rotation of the auger shafts; and

a drilling agitator connected to a lower end of
a lowermost one of the auger shafts connected through
a lowermost high-speed coupler to drill the
excavation site by agitating and rotating the inputs
5 on the excavation site;

a frame structure connected to an adjacent one side of
the drilling agitation machine to support the drilling
agitation machine; and

a transport operation machine axially coupled to a
10 lower end of the frame structure to easily move the
drilling agitation machine, together with the frame
structure, to an excavation site on the composite ground
with deep soil-cement mixing (DCM) and to induce an
operation required for adjustment of the drilling agitation
15 machine during the excavation by means of the drilling
agitation machine.

2. The drilling agitation system according to claim
20 1, wherein:

the triple-pipe swivel comprises an inner ring
connected to the auger shafts of the drilling agitation
machine, used to excavate the seabed ground, to rotate
together with the auger shafts, and an outer ring

surrounding the inner ring and fixedly coupled to upper and lower covers;

the inner ring has a main through-hole formed vertically from the top to the bottom at the center thereof; and

the outer ring has a first horizontal through-hole, formed horizontally from an upper portion on one side of an outer peripheral surface toward an inner peripheral surface thereof, and a second horizontal through-hole formed horizontally from a lower portion on one side of the outer peripheral surface toward the inner peripheral surface thereof or from a lower portion on the other side of the outer peripheral surface toward the inner peripheral surface thereof.

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3. The drilling agitation system according to claim 2, wherein each of the main through-hole, the first horizontal through-hole, and the second horizontal through-hole is selectively supplied with slurry, high-pressure water, and high-pressure air as the inputs.

20

4. The drilling agitation system according to claim 1, wherein the high-speed coupler comprises:

a housing integrated with a coupling member coupled to

the support shaft;

covers coupled to or decoupled from both ends of the housing; and

a rotor rotatably inserted into the housing and used
5 to connect the auger shafts therebetween while rotating together with the auger shafts.

5. The drilling agitation system according to claim
4, wherein the high-speed coupler further comprises a
10 bushing integrated on an outer peripheral surface of the rotor with a predetermined gap therebetween, or a dual bushing interposed between the rotor and the housing.

6. The drilling agitation system according to claim
15 1, wherein:

the transport operation machine is a crane;

the transport operation machine comprises an
adjustment connecting rod hinged, at one end thereof, to an
upper portion of the frame structure and hinged, at the
20 other end thereof, to the rear of the crane, to operate forward and backward by power provided thereto, thereby adjusting the operation required for the excavation adjustment of the drilling agitation machine; and

the transport operation machine further comprises a

cylinder connected to the adjustment connecting rod to provide the power to the adjustment connecting rod for the forward and backward operation thereof.

5 7. The drilling agitation system according to claim 6, wherein the transport operation machine further comprises:

 a tension cable hinged, at one end thereof, to the upper portion of the frame structure, and connected, at the
10 other end thereof, to first and second rollers for adjusting tension of the tension cable by unwinding or winding a wire;

 a first auxiliary adjustment connecting rod connected, at one end thereof, to one of the first and second rollers
15 and hinged, at the other end thereof, to the cylinder providing the power for forward and backward movement in front of the transport operation machine so as to tilt, thereby adjusting and inducing the tension of the tension cable; and

20 a second auxiliary adjustment connecting rod hinged, at one end thereof, to the first auxiliary adjustment connecting rod and hinged, at the other end thereof, to the transport operation machine, thereby complementing the tilting of the first auxiliary adjustment connecting rod

and inducing auxiliary tilting.

8. The drilling agitation system according to claim 1, wherein the drilling agitator comprises:

5 rhombic blades horizontally coupled to a rotary shaft and spaced apart from each other by a predetermined distance along the length of the rotary shaft to evenly agitate the inputs and to reduce a torque loss of the auger shafts;

10 an agitating blade horizontally coupled to a lower portion of the rotary shaft to simultaneously perform excavation and agitation; and

a spiral screw formed at a lower end of the rotary shaft to supply the inputs introduced thereinto along with
15 the excavation to the excavation site.