

DESCRIPTION

MEMBER ATTACHMENT ROBOT

TECHNICAL FIELD

5 [0001] The present invention relates to a member attachment robot.

BACKGROUND ART

[0002] JP2017-110466A discloses a member attachment robot that
attaches a hanger bolt to an embedded member that is provided in a
10 ceiling surface.

SUMMARY OF INVENTION

[0003] In a case in which the embedded member provided in the
ceiling surface is an insert that is provided before concrete is poured, if
15 the insert is attached to a deck plate in advance, the insert may be
caused to be inclined due to flow of the concrete when the concrete is
poured over the deck plate, and in addition, if the insert is attached to
plywood forms in advance, the insert may be caused to be inclined due
to deformation of the panel. In addition, in a case in which the
20 embedded member provided in the ceiling surface is a post-construction
anchor that is attached to the ceiling surface of the concrete that has
been poured, if a hole for attaching the anchor is formed at an angle, the
anchor is attached in a inclined state.

[0004] When the embedded member is provided in the ceiling surface in such an inclined state, even if the hanger bolt is to be attached to the embedded member by using the member attachment robot as described in JP2017-110466A, a case in which the hanger bolt cannot be screwed
5 to a screw hole of the embedded member and an operation error is caused may be caused, or a case in which galling is caused in a threaded portion by forcibly screwing the hanger bolt to the screw hole of the embedded member may be caused, and thereby, it may not be able to attach the hanger bolt normally. Therefore, the operation to attach the
10 hanger bolt to the embedded member needs to be performed by a worker again, and as a result, there is a risk in that operation man-hours is increased.

[0005] An object of the present invention is to reduce man-hours in an operation for attaching a rod-shaped member to an embedded
15 member provided in a ceiling surface.

[0006] According to one aspect of the present invention, a member attachment robot for attaching a rod-shaped member having a threaded portion to an embedded member provided in a ceiling surface, the member attachment robot includes: a base carriage unit configured to
20 be movable on a floor surface; a member attachment part supported by the base carriage unit so as to be freely rotatable about a support shaft extending in parallel with the floor surface, the member attachment part being configured to hold the rod-shaped member and to perform attachment of the rod-shaped member to the embedded member; a

driving part configured to rotate the member attachment part about the support shaft; a detection unit configured to detect an inclination of the embedded member; and a controller configured to control an operation of the base carriage unit, the member attachment part, and the driving part. The controller is configured to operate the member attachment part so as to attach the rod-shaped member to the embedded member after operating at least one of the driving part and the base carriage unit such that an inclination of the rod-shaped member held by the member attachment part substantially matches the inclination of the embedded member detected by the detection unit.

BRIEF DESCRIPTION OF DRAWINGS

[0007]

FIG. 1 is a conceptual diagram showing a conceptual image of an operation performed by a member attachment robot according to an embodiment of the present invention.

FIG. 2 is a side view of the member attachment robot according to the embodiment of the present invention.

FIG. 3 is a diagram showing a part of the member attachment robot viewed from the direction indicated by an arrow A shown in FIG. 2.

FIG. 4 is a block diagram showing an entire configuration of a control system including the member attachment robot and a carrier robot.

FIG. 5 is a side view of the carrier robot that is used together with the member attachment robot.

FIG. 6 is a flow chart showing a procedure of the operation performed by the member attachment robot.

5 FIG. 7A is a diagram for explaining a method of detecting an inclination of an embedded member.

FIG. 7B is a diagram viewed from the direction indicated by an arrow B shown in FIG. 7A.

FIG. 8 is a diagram for explaining an operation of attaching a
10 rod-shaped member to the embedded member.

FIG. 9 is a flow chart showing a detail of a part of process in the flow chart shown in FIG. 5.

FIG. 10 is a diagram for explaining an operation of correcting the inclination of the rod-shaped member attached to the embedded
15 member.

FIG. 11A is a diagram for explaining a modification of the method of detecting the inclination of the embedded member.

FIG. 11B is a diagram viewed from the direction indicated by an arrow C shown in FIG. 11A.

20 FIG. 12A is a diagram for explaining a method of detecting the inclination of the embedded member in a case in which an end surface of the embedded member and a ceiling surface are substantially flush with each other.

FIG. 12B is a diagram viewed from the direction indicated by an arrow D shown in FIG. 12A.

FIG. 13A is a diagram for explaining a method of detecting the inclination of the embedded member in a case in which the end surface
5 of the embedded member is not exposed from the ceiling surface.

FIG. 13B is a diagram viewed from the direction indicated by an arrow E shown in FIG. 13A.

FIG. 14 is a diagram showing a modification of the member attachment robot according to the embodiment of the present invention.

10 FIG. 15 is a side view of another modification of the member attachment robot according to the embodiment of the present invention.

FIG. 16 is a diagram viewed from the direction indicated by an arrow F shown in FIG. 15.

FIG. 17 is a diagram showing a cross-section taken along line G-G
15 in FIG. 16, and is a diagram for explaining a structure for supplying the rod-shaped members.

FIG. 18 is a diagram for explaining a process of delivering the rod-shaped member to the member attachment part.

FIG. 19 is a diagram for explaining the process of delivering the
20 rod-shaped member to the member attachment part and is the diagram showing the process subsequent to FIG. 18.

FIG. 20 is a diagram for explaining the process of delivering the rod-shaped member to the member attachment part and is the diagram showing the process subsequent to FIG. 19.

FIG. 21 is a diagram for explaining the process of delivering the rod-shaped member to the member attachment part and is the diagram showing the process subsequent to FIG. 20.

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DESCRIPTION OF EMBODIMENTS

[0008] In the following, a member attachment robot according to an embodiment of the present invention will be described with reference to the drawings.

10 [0009] A member attachment robot 100 according to the embodiment of the present invention is an autonomous robot that does not require any operation from the outside, and as shown in FIG. 1, the member attachment robot 100 performs an operation of respectively attaching rod-shaped members 6 to embedded members 4 provided in a ceiling surface 1. FIG. 1 is an exaggerated conceptual diagram showing

15 the operation performed by the member attachment robot 100 for the clarity, and some parts may differ from the actual size and proportions.

[0010] The ceiling surface 1 shown in FIG. 1 is an undersurface of a deck plate to which concrete has been poured or an undersurface of a concrete slab from which plywood forms have been removed, and in the

20 ceiling surface 1, a plurality of embedded members 4 are provided at predetermined locations.

[0011] The embedded members 4 are each a member that is provided for attaching the rod-shaped member 6 to the ceiling surface 1, and the embedded member 4 is provided such that an internal threaded hole

(not shown), to which a threaded portion of the rod-shaped member 6 is screwed, is exposed at the ceiling surface 1. Specifically, the embedded member 4 is an insert that is provided before pouring the concrete or a post-construction anchor that is attached after the concrete has been poured.

[0012] For example, in a case in which the ceiling surface 1 is the undersurface of the deck plate, the insert may be attached at a predetermined location on the deck plate before the concrete is poured over the deck plate, and it may be used as the embedded member 4.

Alternatively, a post-construction anchor may be hammered into a hole drilled in the undersurface of the deck plate, serving as the ceiling surface 1, after the concrete poured over the deck plate has been cured and may be mechanically fixed in the hole by opened expanding portions (not shown), and it may also be used as the embedded member 4.

[0013] In addition, in a case in which the ceiling surface 1 is the undersurface of the concrete slab from which the plywood forms have been removed, the insert may be attached at a predetermined location on the plywood forms before the concrete is poured over the plywood forms, and it may be used as the embedded member 4. Alternatively, the post-construction anchor may be mechanically fixed in the hole drilled in the undersurface of the concrete slab, serving as the ceiling surface 1, after the concrete poured over the plywood forms have been cured, and it may also be used as the embedded member 4. The construction anchor, which is used as the embedded member 4, is not

limited to the one that is mechanically fixed into the hole, and may be the one that is fixed into the hole as an adhesive, etc. filled inside the hole is cured.

[0014] Each of the insert and the post-construction anchor, which is
5 used as the embedded member 4, is provided, in the design, in a state in which at least a portion thereof is embedded and fixed in the concrete and a lower end portion thereof projects out from the ceiling surface 1 by a predetermined length. With such a configuration, because the internal threaded hole formed in the embedded member 4 is exposed on
10 the side of the ceiling surface 1, it is possible to attach the rod-shaped member 6 to the ceiling surface 1 via the embedded member 4. In the above, the embedded member 4 is not limited to the insert and the post-construction anchor, and the embedded member 4 may be any member so long as the member has a configuration that at least a
15 portion thereof is embedded and fixed in the ceiling surface 1, thereby enabling attachment of the rod-shaped member 6 to the ceiling surface 1.

[0015] The rod-shaped member 6 is a continuous thread stud and is used as a hanger bolt that, for example, supports a frame member for
20 holding a ceiling panel, supports an air conditioning device or a duct for air conditioning, or supports an illuminating device. A lower end of the rod-shaped member 6 may be provided with an engagement portion (not shown) that can engage with a tightening tool, etc. when the rod-shaped member 6 is to be screwed to the embedded member 4, and such an

engagement portion includes, for example, a hexagon head or a hexagon socket head having the outer diameter that is smaller than the minor diameter of the external threaded portion.

[0016] As shown in FIG. 1, the member attachment robot 100
5 performs the operation in which the member attachment robot 100 receives the rod-shaped member 6 carried by a carrier robot 110 from the carrier robot 110 and attaches thus-received rod-shaped member 6 to the embedded member 4 provided in the ceiling surface 1 one by one. Similarly to the member attachment robot 100, the carrier robot 110 is
10 also an autonomous robot that does not require any operation from the outside. A single carrier robot 110 may be provided for every member attachment robot 100, or the single carrier robot 110 may be provided for a plurality of member attachment robots 100.

[0017] The member attachment robot 100 and the carrier robot 110
15 each has a base carriage unit 10 having the same configuration, and the member attachment robot 100 is configured by assembling a member attachment unit 20 to the base carriage unit 10, and the carrier robot 110 is configured by assembling a carrier unit 60 to the base carriage unit 10.

[0018] The member attachment robot 100 will be described first with
20 reference to FIGs. 2 to 4. FIG. 2 is a side view of the member attachment robot 100, FIG. 3 is a diagram showing a part of the member attachment robot 100 viewed from the direction indicated by an arrow A shown in FIG. 2 and mainly showing a part of the member attachment

unit 20, and FIG. 4 is a block diagram showing an entire configuration of a control system including the member attachment robot 100 and the carrier robot 110.

[0019] As shown in FIGs. 2 and 3, the member attachment robot 100
5 is provided with: the base carriage unit 10 that can move on a floor surface 2; a member attachment part 24 that holds the rod-shaped member 6 and performs attachment of the rod-shaped member 6 to the embedded member 4; a rotating motor (a driving part) 22 that rotates the member attachment part 24 about a support shaft 23; and a controller
10 50 that controls operations of the base carriage unit 10, the member attachment part 24, and the rotating motor 22. In the above, the member attachment unit 20 is configured of other mechanisms than the base carriage unit 10.

[0020] The base carriage unit 10 is a traveling device that is movable
15 in all directions on the floor surface 2, and the base carriage unit 10 is provided with a main body portion 11, a pair of wheels 14 that are attached to the main body portion 11, a pair of motors (not shown) that are provided so as to be able to drive the pair of wheels 14 separately, and a battery (not shown) that supplies electric power to the pair of
20 motors. As described above, by driving the pair of wheels 14 in a separate manner, the base carriage unit 10 can turn on the spot. The battery provided in the base carriage unit 10 is also used as an electric power source for supplying electric power to the member attachment unit 20.

[0021] As the configuration for turning the base carriage unit 10 on the spot, instead of employing the pair of wheels 14, for example, a configuration in which three omni-directional wheels or four mecanum wheels are provided may be employed, or alternatively, a configuration
5 in which a plurality of spherical bodies capable of rotating in the all directions that function as driving wheels in contact with the floor surface 2 may also be employed. Although it is preferable that the base carriage unit 10 can rotate on the spot from the view point of improving an operation efficiency, the base carriage unit 10 may also be a generally
10 used traveling device that is movable on the floor surface 2 back and forth and left and right so as to be able to move to a predetermined location.

[0022] In the base carriage unit 10, a column 12 that extends upward from the main body portion 11 and a carriage-side flange
15 portion 13 provided on an upper end of the column 12 are provided such that the member attachment unit 20 can be attached to the base carriage unit 10. The member attachment unit 20 is attached to the carriage-side flange portion 13 via a mount plate 21, which will be described below. Although the column 12 shown in FIG. 2 is a simple
20 columnar member, the column 12 may also have a configuration in which the column 12 can freely extend/contract in the vertical direction.

[0023] In addition, the base carriage unit 10 is provided with an information acquisition device (image acquisition part) 15 that is capable of acquiring surrounding information around the base carriage

unit 10. The information acquisition device 15 is a 360-degree or 180-degreee camera capable of acquiring an image of the surrounding of the base carriage unit 10 or an image above the base carriage unit 10. The image acquired by the information acquisition device 15 is
5 transmitted to the controller 50 and is used for specifying the self-location of the base carriage unit 10 or for detecting any obstacle. As the information acquisition device 15, instead of employing the camera, or in addition to the camera, a three-dimensional range sensor such as a laser scanner, etc. capable of detecting distances in all
10 directions, the so-called 3D-LiDAR (Light Detection and Ranging) sensor, may also be used.

[0024] As shown in FIGs. 2 and 3, the member attachment part 24 of the member attachment unit 20 that is attached to the base carriage unit 10 has: a flat-plate shaped arm plate 25 that is supported by the
15 rotating motor 22 via the support shaft 23 so as to be freely rotatable; holding parts 32 that are provided on a first flat surface 25a of the arm plate 25 so as to hold the rod-shaped member 6 along the arm plate 25; an attachment operating part 26 that performs the operation of attaching the rod-shaped member 6 held by the holding parts 32 to the
20 embedded member 4; a guide sleeve (sleeve) 45 that guides the rod-shaped member 6 held by the holding parts 32 towards the embedded member 4; and an electric cylinder 40 that is provided on a second flat surface 25b of the arm plate 25 and that can move the guide

sleeve 45 in the direction towards and in the direction away from the embedded member 4.

[0025] The holding parts 32 each has a fixed block 33 that is formed with a U-shaped groove 33a for receiving the rod-shaped member 6 and
5 a rotating block 34 that is attached to the fixed block 33 via a pin member 34a so as to be rotatable. The fixed block 33 is fixed to the arm plate 25 such that the direction in which the U-shaped groove 33a is formed extends along the longitudinal direction of the arm plate 25.

[0026] A position of the rotating block 34 can be changed by a
10 servomotor (not shown) whose operation is controlled by the controller 50 between a position at which the U-shaped groove 33a is opened and a position at which the U-shaped groove 33a is closed, in other words, between a state in which the rod-shaped member 6 can be held and a state in which the rod-shaped member 6 can be received. Specifically,
15 the position of the rotating block 34 is held at the position at which the U-shaped groove 33a is closed when the rod-shaped member 6 is to be attached to the embedded member 4 and is held at the position at which the U-shaped groove 33a is opened when the rod-shaped member 6 is to be supplied from the carrier robot 110. FIG. 3 shows a state in which
20 the rotating block 34 is set at the position at which the U-shaped groove 33a is opened.

[0027] The plurality of holding parts 32 are provided at a predetermined interval along the longitudinal direction of the arm plate 25. Although the holding parts 32 are provided at two locations in an

example shown in FIG. 3, the holding parts 32 may be provided at three or more locations.

[0028] The attachment operating part 26 has: an electric motor 27 that rotates the rod-shaped member 6 when the rod-shaped member 6 is
5 to be screwed to the embedded member 4; a socket 28 that is attached to a rotating shaft 27a of the electric motor 27; and an electrical slide 30 that moves the electric motor 27 along a rail 31 that is formed so as to extend along the longitudinal direction of the arm plate 25.

[0029] The socket 28 has a configuration in which the socket 28 can
10 cover a lower end portion of the rod-shaped member 6 and can grip an outer circumferential surface of the lower end portion of the rod-shaped member 6, for example, the socket 28 has a configuration in which a member capable of gripping the outer circumferential surface of the rod-shaped member 6 projects out radially inward as the socket 28 is
15 rotated. In the above, in a case in which the engagement portion, such as a hexagon socket head, etc., is provided on the lower end of the rod-shaped member 6, projections and depressions that can engage with the engagement portion are provided in the socket 28.

[0030] The electric motor 27 and the electrical slide 30 are controlled
20 by the controller 50 such that the rod-shaped member 6 gripped by the socket 28 is to be screwed to the embedded member 4. Specific operations of these components will be described in detail in the description of a method of attaching the rod-shaped member 6 to the embedded member 4, which will be described later.

[0031] The guide sleeve 45 is a member that is provided for reliably guiding the rod-shaped member 6 to the embedded member 4 when the rod-shaped member 6 is to be screwed to the embedded member 4, and as shown in FIG. 3, the guide sleeve 45 has a through hole 46 through which the rod-shaped member 6 held by the holding parts 32 can be inserted.

[0032] In addition, the guide sleeve 45 is divided into two members 45a and 45b at a plane extending through the center axis of the through hole 46 serving as the division surface, and the members 45a and 45b are linked via a hinge.

[0033] The first member 45a among the two members 45a and 45b is fixed to a plate 43 that is provided at a tip end of a rod portion 42 of the electric cylinder 40, which will be described later. In this configuration, the second member 45b can be displaced between a position in contact with the first member 45a and a position away from the first member 45a about the hinge by a servomotor (not shown) whose operation is controlled by the controller 50.

[0034] Specifically, when the rod-shaped member 6 is to be attached to the embedded member 4, the position of the second member 45b is held at the position in contact with the first member 45a, and when the rod-shaped member 6 is to be supplied from the carrier robot 110, the position of the second member 45b is held at the position away from the first member 45a. FIG. 3 shows a state in which the second member 45b is positioned at the position away from the first member 45a.

[0035] The through hole 46 of the guide sleeve 45 has a receiving hole 46a that can receive a part of the embedded member 4 provided in the ceiling surface 1 and a guiding hole 46b that can guide the rod-shaped member 6 towards the embedded member 4 received in the receiving hole 46a.

[0036] As shown in FIG. 3, the receiving hole 46a is formed so as to open at the opposite side from the arm plate 25 and has a shape in which its inner diameter is larger than the outer diameter of the embedded member 4 projecting out from the ceiling surface 1 and the inner diameter is gradually increased towards the opening end. The guiding hole 46b is formed so as to open at the arm plate 25 side and has a shape in which its inner diameter is smaller than the inner diameter of the receiving hole 46a, but larger than the outer diameter of the rod-shaped member 6, and the inner diameter is gradually increased towards the opening end.

[0037] In other words, an inner circumferential surface of the receiving hole 46a is formed to have a tapered shape in order to receive the embedded member 4 projecting out from the ceiling surface 1 with ease, and an inner circumferential surface of the guiding hole 46b is formed to have a tapered shape in order to guide the rod-shaped member 6 towards the receiving hole 46a side with ease. The through hole 46 is formed by joining the receiving hole 46a and the guiding hole 46b that are formed as described above.

[0038] The plurality of guide sleeves 45 having different combinations of the diameter of the receiving hole 46a and the diameter of the guiding hole 46b, but having the above-described shape are prepared in advance, and the guide sleeve 45 is appropriately exchanged
5 in accordance with kinds of the embedded member 4 and the outer diameters of the rod-shaped member 6 used at the construction site.

[0039] The electric cylinder 40 is an extendable/contractable mechanism having a cylinder portion 41 and the rod portion 42, and the electric cylinder 40 is fixed to the second flat surface 25b of the arm plate
10 25 so as to extend/contract along the longitudinal direction of the arm plate 25. The plate 43, to which the guide sleeve 45 is fixed, is provided on a tip end of the rod portion 42 that is projected from the cylinder portion 41. Therefore, by extending/contracting the electric cylinder 40, it is possible to cause the guide sleeve 45 to approach the ceiling
15 surface 1 or to move away from the ceiling surface 1.

[0040] The rotating motor 22 that rotates the member attachment part 24 having the above-described configuration about the support shaft 23 is fixed to the carriage-side flange portion 13 of the base carriage unit 10 via the mount plate 21 in a state in which the support
20 shaft 23 serving as an output shaft extends in parallel with the floor surface 2. An amount of rotation of the rotating motor 22, in other words, an inclination of the arm plate 25 is detected by a built-in angle sensor (not shown).

[0041] As described above, the member attachment part 24 is supported by the base carriage unit 10 so as to be freely rotatable about the support shaft 23 extending in parallel with the floor surface 2.

[0042] In addition to the above-described respective mechanisms,
5 the member attachment robot 100 is further provided with a distance sensor (detection unit) 51 capable of detecting the inclination of the embedded member 4 and an upper image acquisition part 52 capable of ascertaining the position of the embedded member 4.

[0043] The distance sensor 51 is a laser displacement sensor with a
10 built-in camera and is fixed to the plate 43 together with the guide sleeve 45. As described above, by providing the distance sensor 51 at the position in close proximity to the embedded member 4 and the ceiling surface 1, the distance sensor 51 functions as a distance detection unit that is capable of accurately detecting the distances to the embedded
15 member 4 and the ceiling surface 1.

[0044] The distance detected by the distance sensor 51 is transmitted to the controller 50, and as described later, it is mainly used to detect the inclination of the embedded member 4.

[0045] The upper image acquisition part 52 is a camera that is
20 provided so as to acquire an image of the ceiling surface 1 side and is fixed to the mount plate 21 together with the rotating motor 22. In order to cause the upper image acquisition part 52 to approach the embedded member 4, for example, the upper image acquisition part 52 may be fixed to the mount plate 21 via a column that is freely

extendable/contractable in the vertical direction, or the upper image acquisition part 52 may be fixed to the plate 43 together with the distance sensor 51. By causing the upper image acquisition part 52 to approach the embedded member 4 as required, it is possible to more accurately ascertain the position of the embedded member 4 by the upper image acquisition part 52.

[0046] The image acquired by the upper image acquisition part 52 is transmitted to the controller 50, and as described above, the image is mainly used to move the member attachment robot 100 below the embedded member 4 accurately. In a case in which it is possible to sufficiently ascertain the position of the embedded member 4, to which the rod-shaped member 6 will be attached, with the above-described information acquisition device 15 that is provided on the base carriage unit 10, the upper image acquisition part 52 may not be provided.

[0047] As shown in FIG. 4, the controller 50 controls operations of the base carriage unit 10, the member attachment part 24, and the rotating motor 22 on the basis of data acquired by the distance sensor 51, the upper image acquisition part 52, and the information acquisition device 15 and pre-imported data related to an operation area in a BIM (Building Information Modeling), etc. The specific control performed by the controller 50 will be described below in detail in a following description of a method of attaching the rod-shaped member 6 to the embedded member 4.

[0048] Specifically, the controller 50 is configured of a microcomputer provided with a CPU (a central processing unit), a ROM (a read-only memory), a RAM (random-access memory), and an I/O interface (an input-output interface). The RAM stores data processed
5 by the CPU, the ROM stores a control program, etc. of the CPU in advance, and the I/O interface is used for input/output of information with devices and detectors connected to the controller 50. The controller 50 may be configured of a plurality of microcomputers, and for example, the controller 50 may be provided on each of the member
10 attachment unit 20 and the base carriage unit 10.

[0049] In addition, as shown in FIG. 4, the controller 50 is provided with a communication unit 50a that performs transmission and reception of data with an external server 120 that instructs the member attachment robot 100 and the carrier robot 110 to perform the operation
15 and that monitors their operation state. The communication unit 50a may be a general wireless communication device capable of transmitting data through an Internet connection or may be a near-field wireless communication device such as BLE (Bluetooth® Low Energy) or Wi-Fi®. The communication unit 50a is also used to perform communication
20 with a controller 90 of the carrier robot 110.

[0050] Next, the carrier robot 110 that carries the rod-shaped members 6 will be described with reference to FIGs. 4 and 5. FIG. 5 is a side view of the carrier robot 110.

[0051] As shown in FIG. 5, the carrier robot 110 is provided with: the base carriage unit 10 that can move on the floor surface 2; a holding plate 70 that can hold a plurality of rod-shaped members 6; a stand portion 62 that is provided so as to retain the holding plate 70 to the base carriage unit 10; a delivery mechanism 80 that grips each of the rod-shaped members 6 held by the holding plate 70 and that delivers it to the member attachment robot 100; and the controller 90 that controls the operations of the base carriage unit 10 and the delivery mechanism 80. The carrier unit 60 is configured of the mechanism other than the base carriage unit 10.

[0052] Because the configuration of the base carriage unit 10 is the same as that of the base carriage unit 10 of the member attachment robot 100, the description thereof will be omitted.

[0053] As shown in FIG. 5, the holding plate 70 is a plate-shaped member formed to have a substantially U-shape, and has a pair of flat plate portions 72 and 73, a connecting portion 71 that connects one ends of the pair of flat plate portions 72 and 73, and a plurality of grip portions 74 that are respectively provided on the pair of flat plate portions 72 and 73.

[0054] Each of the grip portions 74 has a groove capable of gripping the rod-shaped member 6, and a portion in which the groove is provided is formed of an elastic member such as a resin or rubber. By respectively providing equal number of such grip portions 74 on the pair of flat plate portions 72 and 73, it is possible to cause the holding plate

70 to hold the plurality of rod-shaped members 6 across the pair of flat plate portions 72 and 73.

[0055] The stand portion 62 has a mount plate 64 that is attached to the carriage-side flange portion 13, a column 63 that extends upwards
5 from the mount plate 64, and hook portions 65 that are fixed to the column 63.

[0056] The hook portions 65 have shapes that can support, from the underneath, the flat plate portions 72 and 73 of the holding plate 70 that is retained on the stand portion 62. In other words, the holding plate
10 70 is provided so as to be attachable/detachable to/from the hook portions 65 of the stand portion 62.

[0057] The delivery mechanism 80 has a rail member 81 that is fixed so as to be orthogonal with respect to the column 63, a delivery portion 82 that can be moved along the rail member 81, and an electrical slide
15 (not shown) that moves the delivery portion 82 along the rail member 81.

[0058] The delivery portion 82 has a configuration that allows an operation such that one rod-shaped member 6 among the plurality of rod-shaped members 6 held by the holding plate 70 is detached from the grip portions 74 and that the thus-detached rod-shaped member 6 is
20 delivered to the member attachment robot 100.

[0059] Specifically, the delivery portion 82 is provided with: holding parts 83 that can magnetically hold the rod-shaped member 6; an actuator (not shown) that moves the holding parts 83 in the direction in which the rod-shaped member 6 is detached from the holding plate 70;

and a rotating motor (not shown) that rotates the holding parts 83, together with the actuator, in the horizontal direction about the rail member 81 side as the rotation center. Similarly to the grip portions 74 of the holding plate 70, the holding parts 83 may hold the rod-shaped member 6 by utilizing an elastic force.

[0060] As described above, the carrier robot 110 has the configuration that enables storage of the plurality of rod-shaped members 6 in a state in which they are aligned along the vertical direction and that enables delivery of the rod-shaped members 6 stored in the state in which they are aligned along the vertical direction to the member attachment robot 100 while maintaining such a state. Therefore, for example, compared with a case in which the rod-shaped members 6 are stored in the carrier robot 110 in a state in which they are aligned along the horizontal direction, movement required to deliver the rod-shaped member 6 to the member attachment robot 100 is made simpler, and at the same time, an increase in the width of the carrier robot 110 is suppressed, and thereby, it is possible to prevent the operation of the member attachment robot 100 from being inhibited by the carrier robot 110.

[0061] In addition, because the holding plate 70, which holds the plurality of rod-shaped members 6, has the configuration in which it can be attached/detached to/from the stand portion 62, it is possible to perform supply of the rod-shaped members 6 to the carrier robot 110 with ease by exchanging the holding plate 70.

[0062] In addition to the above-described respective mechanisms, the carrier robot 110 is further provided with a side image acquisition part 91 capable of ascertaining the position of the holding parts 32 of the member attachment robot 100.

5 [0063] The side image acquisition part 91 is a camera that is provided so as to be able to acquire an image of the member attachment robot 100 and is fixed to the rail member 81. The position at which the side image acquisition part 91 is to be fixed is not limited to that on the rail member 81, and the side image acquisition part 91 may be fixed to
10 any position as long as the image on the member attachment robot 100 side can be acquired, and for example, the side image acquisition part 91 may be fixed to the position on the delivery portion 82 or the stand portion 62.

[0064] The image acquired by the side image acquisition part 91 is
15 transmitted to the controller 90 of the carrier robot 110, and as described later, the image is mainly used to accurately align the delivery portion 82 of the carrier robot 110 with respect to the holding parts 32 of the member attachment robot 100.

[0065] The controller 90 of the carrier robot 110 controls the
20 operations of the base carriage unit 10 and the delivery mechanism 80 on the basis of the data acquired by the side image acquisition part 91 and the information acquisition device 15 and on the basis of the pre-imported data related to the operation area such as the BIM, etc. In addition, similarly to the controller 50 of the member attachment robot

100, the controller 90 is provided with a communication unit 90a. Because the specific configuration of the controller 90 is the same as that of the controller 50 of the member attachment robot 100, the description thereof will be omitted.

5 [0066] Next, a method of attaching the rod-shaped member 6 to the embedded member 4 provided in the ceiling surface 1 by using the member attachment robot 100 having the above-described configuration will be described with reference to FIGs. 6 to 10. FIGs. 6 and 9 are flow charts showing a procedure of the operation performed by the member
10 attachment robot 100, FIGs. 7A and 7B are diagrams for explaining a method to detect the inclination of the embedded member 4, FIG. 8 is a diagram for explaining the operation of attaching the rod-shaped member 6 to the embedded member 4, and FIG. 10 is a diagram for explaining an operation of correcting the inclination of the rod-shaped
15 member 6 attached to the embedded member 4.

[0067] First, in Step S11, the data related to the operation area is imported and stored in the controller 50 of the member attachment robot 100. Specifically, the plot data such as the BIM, etc. is acquired from the server 120 via the communication unit 50a of the controller 50,
20 and it is stored in a storage unit. The data imported in this step includes, in addition to the plot data such as the BIM, etc., the position of the embedded member 4, an order of attaching the rod-shaped member 6, and so forth.

[0068] Next, in Step S12, by using the information acquisition device 15 of the base carriage unit 10, the controller 50 acquires the surrounding information around the member attachment robot 100, for example, distances to posts and placement of the posts, and identifies the self-location of the member attachment robot 100, in other words, the coordinate of the member attachment robot 100 on the plot by collating the stored plot data such as the BIM, etc. with the acquired information. In order to specify the self-location, the controller 50 may have a function of a SLAM (Simultaneous Localization and Mapping).

10 [0069] In following Step S13, the controller 50 extracts a coordinate of the embedded member 4 to which the rod-shaped member 6 is to be attached first from the data imported in Step S11 and controls the base carriage unit 10 to move the member attachment robot 100 towards the thus-extracted coordinate of the embedded member 4. The embedded member 4 to which the rod-shaped member 6 is to be attached first may be the embedded member 4 that is at the closest distance from the location of the member attachment robot 100.

[0070] Once the movement of the member attachment robot 100 is finished, the controller 50 acquires an image of the ceiling surface 1 including the coordinate position of the embedded member 4, which becomes an operation target, by using the upper image acquisition part 52 and detects the position of the embedded member 4 from the thus-acquired image (Step S14).

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[0071] When the position of the embedded member 4 is detected from the acquired image, the process proceeds to Step S15, and when the position of the embedded member 4 is not detected, for example, when the embedded member 4 is embedded within the concrete or when the
5 embedded member 4 is covered by some obstacle, it is determined that the operation cannot be performed, and the process proceeds to Step S20.

[0072] In Step S15, the controller 50 acquires the surrounding information around the member attachment robot 100 by using the
10 information acquisition device 15 of the base carriage unit 10 and detects whether or not there is the obstacle, a step, and so forth around the member attachment robot 100 for performing an attachment operation of the rod-shaped member 6. Specifically, as described below, if the embedded member 4 is inclined, the member attachment
15 robot 100 correspondingly needs to be moved by some extent, and therefore, it is detected whether or not there is an obstacle that interferes with the movement of the member attachment robot 100 within a range of a few meters from the member attachment robot 100.

[0073] When it is determined that there is no obstacle in Step S15,
20 the process proceeds to Step S16, and when it is determined that there is the obstacle, it is determined that the operation cannot be performed, and the process proceeds to Step S20.

[0074] In following Step S16, the controller 50 detects distances to the embedded member 4 and the ceiling surface 1 by using the distance

sensor 51 and detects a degree and direction of the inclination of the embedded member 4 on the basis of the distances detected. At this time, in order to bring the distance sensor 51 as close as possible to the embedded member 4, the electric cylinder 40 is extended.

5 [0075] Here, a method of detecting the inclination of the embedded member 4 on the basis of the distances to the embedded member 4 and the ceiling surface 1 will be described with reference to FIGs. 7A and 7B.

[0076] As shown in FIGs. 7A and 7B, by using the distance sensor 51 that is the laser displacement sensor with a built-in camera, the
10 controller 50 measures the distances to a plurality of measurement points P2 (dots shown by solid black circles in the figure) on a line that is identified as a lower end edge 5 of the embedded member 4 and measures the distances to a plurality of measurement points P1 (dots shown by open white circles in the figure) on the plane that is identified
15 as the ceiling surface 1 around the embedded member 4. In the above, it is preferable that the plurality of measurement points P1 and P2 be set at equal intervals so as to be substantially centered at an internal threaded hole 4a of the embedded member 4.

[0077] The angle formed between the center axis of the distance
20 sensor 51 and a line connecting the point with the longest distance and the point with the shortest distance among thus-measured distances to the plurality of measurement points P1 on the ceiling surface 1 is then calculated as the angle of the ceiling surface 1 (a reference tilt angle). In addition, the angle formed between the center axis of the distance sensor

51 and a line connecting the point with the longest distance and the point with the shortest distance among thus-measured distances to the plurality of measurement points P2 on the lower end edge 5 of the embedded member 4 is calculated as the angle of the lower end edge 5 of the embedded member 4 (a measured tilt angle).

[0078] A difference between the two angles calculated as described above is then calculated as the inclination of the embedded member 4 with respect to the vertical direction. The above-described calculation method is based on an assumption that the ceiling surface 1 forms a substantially horizontal plane. Therefore, in the design, in a case in which the ceiling surface 1 is tilted, upon calculation of the inclination of the embedded member 4 with respect to the vertical direction, the tilt angle of the ceiling surface 1 is taken into consideration.

[0079] In the above-described calculation method, because the point with the longest distance and the point with the shortest distance are used for the calculation, it is preferable that the number of the measurement points P1 and P2 be as many as possible, and for example, it is preferable that at least eight points be set.

[0080] In addition, as an alternative method, the plane containing the plurality of measurement points P1 of the ceiling surface 1 subjected to the measurement may be calculated as the reference plane, the plane containing the plurality of measurement points P2 on the lower end edge 5 of the embedded member 4 subjected to the measurement may be calculated as a measured plane, and the angle (an acute angle) at which

these two planes intersect may be obtained as the inclination of the embedded member 4 with respect to the vertical direction. In this alternative method, it may be possible to calculate the angle formed between the reference plane and the center axis of the distance sensor 51 as the reference tilt angle, to calculate the angle formed between the measured plane and the center axis of the distance sensor 51 as the measured tilt angle, and to calculate the difference between these two angles as the inclination of the embedded member 4 with respect to the vertical direction.

10 [0081] When the inclination of the embedded member 4 is detected as described above, the process proceeds to Step S17, and the inclination of the rod-shaped member 6, in other words, the inclination of the arm plate 25 is adjusted.

[0082] Specifically, at least one of the rotating motor 22 and the base carriage unit 10 is controlled such that the inclination of the rod-shaped member 6 held by the member attachment part 24 matches with the inclination of the embedded member 4 detected in Step S16 and such that the internal threaded hole 4a of the embedded member 4 is located on the extension of the rod-shaped member 6. In the above, the match between the inclination of the rod-shaped member 6 and the inclination of the embedded member 4 mentioned hereinabove does not mean a perfect geometrical match, but it only means an approximate match, and a deviation that falls within a range that does not hinder screwing of the rod-shaped member 6 to the embedded member 4 is acceptable.

[0083] When the inclination of the rod-shaped member 6 matches the inclination of the embedded member 4, in following Step S18, the controller 50 controls the attachment operating part 26 to screw the rod-shaped member 6 to the embedded member 4.

5 [0084] In the above, it is thought that it is an easy operation to screw the rod-shaped member 6 to the embedded member 4 if the internal threaded hole 4a of the embedded member 4 is located on the extension of the rod-shaped member 6. However, in practice, the rod-shaped member 6 that is a relatively long member may be bent due to the
10 self-weight or may be wobbled as the rod-shaped member 6 is rotated by the electric motor 27, and so, it is difficult to smoothly screw the rod-shaped member 6 to the embedded member 4.

[0085] Thus, in this embodiment, upon screwing the rod-shaped member 6 to the embedded member 4, the guide sleeve 45 for guiding
15 the rod-shaped member 6 is positioned in a vicinity of the embedded member 4 in advance.

[0086] Specifically, as shown in FIG. 8, once the adjustment of the inclination of the rod-shaped member 6 in Step S17 is completed, the controller 50 extends the electric cylinder 40 to cause the guide sleeve
20 45 to approach the embedded member 4. Because the receiving hole 46a capable of receiving the embedded member 4 is provided in the guide sleeve 45, in a case in which the embedded member 4 is projected out from the ceiling surface 1, a state in which a part of the embedded member 4 is received in the receiving hole 46a is achieved. In a case in

which the embedded member 4 is not projected out from the ceiling surface 1, the guide sleeve 45 is caused to approach the embedded member 4 such that the receiving hole 46a is positioned so as to face the embedded member 4.

5 [0087] It is successively determined whether or not the guide sleeve 45 has reached a vicinity of the embedded member 4 on the basis of the distances to the ceiling surface 1 and the embedded member 4 detected by the distance sensor 51 and the image acquired by the upper image acquisition part 52. In order to the accurately place the guide sleeve 45
10 relative to the embedded member 4, it is preferable to provide, on or around the guide sleeve 45, a proximity sensor that can detect that the embedded member 4 has approached or has been received in the receiving hole 46a of the guide sleeve 45.

[0088] When it is determined that the embedded member 4 has
15 approached or has been received in the receiving hole 46a of the guide sleeve 45 as described above, the controller 50 starts to screw the rod-shaped member 6 to the embedded member 4.

[0089] Specifically, the electrical slide 30 is first lifted along the rail 31 until the rod-shaped member 6 comes into contact with the
20 embedded member 4. When it is confirmed that the rod-shaped member 6 has come into contact with the embedded member 4 on the basis of a driving force of the electrical slide 30 or an increase in a current value in correlation with the driving force, the electric motor 27 is rotated in the screwing direction, and at the same time, the electrical

slide 30 is gradually lifted in synchronous with the screwing speed. Subsequently, it is determined that the screwing of the rod-shaped member 6 to the embedded member 4 is completed at the time point when torque of the electric motor 27 becomes equal to or higher than a
5 predetermined value, and the rotation of the electric motor 27 is stopped. At the same time as the electric motor 27 is stopped, the electrical slide 30 is then lowered towards a lower end of the rail 31 to move the electric motor 27 and the socket 28 away from the rod-shaped member 6. It may be possible to lift the electrical slide 30 while rotating
10 the electric motor 27 in the screwing direction without confirming that the rod-shaped member 6 has come into contact with the embedded member 4.

[0090] As described above, the guiding hole 46b formed to have a tapered shape so as to be able to guide the rod-shaped member 6
15 towards the receiving hole 46a is provided on the guide sleeve 45. Therefore, even if the rod-shaped member 6 is wobbled by being rotated by the electric motor 27, the tip end portion of the rod-shaped member 6 is directed towards the embedded member 4 smoothly by being guided by the guiding hole 46b. Thus, it is possible to smoothly screw the
20 rod-shaped member 6 to the embedded member 4 without causing the galling.

[0091] When the screwing of the rod-shaped member 6 to the embedded member 4 is completed, the controller 50 determines whether or not the inserted length of the rod-shaped member 6 into the

embedded member 4 is greater than a predetermined threshold value (Step S19).

[0092] The controller 50 determines that the screwing of the rod-shaped member 6 to the embedded member 4 has started and that
5 the screwing has been completed on the basis of the torque of the electric motor 27 or a current value in correlation with the torque. Specifically, when the screwing of the rod-shaped member 6 to the embedded member 4 is started, the torque of the electric motor 27 is increased by a certain degree due to a screwing resistance, and
10 therefore, when the torque of the electric motor 27 exceeds a first threshold value that is set in advance, it is determined that the screwing has been started.

[0093] On the other hand, when a state in which the rod-shaped member 6 is screwed to the entire length of the internal threaded hole 4a
15 of the embedded member 4 is achieved or when a state in which the screwing of the rod-shaped member 6 to the embedded member 4 is inhibited due to the cause of the galling or a presence of a foreign matter in the internal threaded hole 4a is caused, the torque of the electric motor 27 is increased greatly. Therefore, when the torque of the electric
20 motor 27 exceeds a second threshold value that is higher than the first threshold value, the controller 50 determines that the screwing has been completed or that the screwing has apparently been completed although the screwing has not actually been completed.

[0094] At the same time as making such determination, the controller 50 detects, as the inserted length of the rod-shaped member 6 into the embedded member 4, the distance that the electrical slide 30 has moved along the rail 31 while the level of the torque of the electric
5 motor 27 is changed from the value indicating the beginning of the screwing to the value indicating the finish of the screwing.

[0095] When the inserted length of the rod-shaped member 6 into the embedded member 4, which is detected as described above, is greater than a predetermined threshold value, for example, when it is greater
10 than 60% of the entire length of the internal threaded hole 4a of the embedded member 4, it is determined that the attachment of the rod-shaped member 6 to the embedded member 4 has been performed normally, and the process proceeds to Step S30. On the other hand, when the inserted length is equal to or smaller than a predetermined
15 threshold value, because there is a possibility that abnormality such as the galling, etc. has been caused, it is determined that the attachment of the rod-shaped member 6 to the embedded member 4 has not been performed normally, and the process proceeds to Step S20. In other words, in Step S19, it is determined whether or not the attachment of
20 the rod-shaped member 6 to the embedded member 4 has been suitably performed.

[0096] In following Step S30, a process of correcting the inclination of the rod-shaped member 6 is performed.

[0097] Unsurprisingly, the rod-shaped member 6 inserted into the inclined embedded member 4 is in an inclined state with respect to the ceiling surface 1. Thus, there is a risk in that difficulties are caused for an attachment operation of a frame member of a ceiling panel, etc. using the rod-shaped member 6 as a hanger bolt.

[0098] Thus, in this embodiment, by following a flow chart shown in FIG. 9, the inclination of the rod-shaped member 6 is corrected such that the rod-shaped member 6 becomes substantially vertical with respect to the ceiling surface 1.

[0099] In Step S31, it is first determined whether or not the correction of the inclination of the rod-shaped member 6 is required. If the inclination of the rod-shaped member 6 falls within an inclination range that does not hinder the operation that uses the rod-shaped member 6 as the hanger bolt, of course there is no need to correct the inclination.

[0100] Thus, in Step S31, when the inclination of the embedded member 4 detected in Step S16 is smaller than a predetermined threshold value, the controller 50 determines that the correction of the inclination is not required and performs a releasing operation so that the rod-shaped member 6 attached to the embedded member 4 is released from the member attachment robot 100. Specifically, a state in which the electric cylinder 40 is contracted to bring the guide sleeve 45 towards the arm plate 25 and the two members 45a and 45b forming the guide sleeve 45 are separated away from each other is achieved.

Furthermore, a state in which the held state of the rod-shaped member 6 is released by rotating the rotating blocks 34 of all of the holding parts 32 to the positions where the U-shaped grooves 33a are opened (see FIG. 3).

5 [0101] When it is confirmed that the rod-shaped member 6 attached to the embedded member 4 is separated away from the member attachment robot 100 as the held state of the rod-shaped member 6 by the member attachment robot 100 is released through the above-described releasing operation, the process proceeds to Step S35.

10 In the above, it is detected, by the proximity sensor, etc. (not shown), whether or not the rod-shaped member 6 is separated away from the member attachment robot 100, in other words, whether or not the rod-shaped member 6 is in the U-shaped grooves 33a of the two fixed blocks 33.

15 [0102] On the other hand, when the inclination of the embedded member 4 detected in Step S16 is equal to or greater than a predetermined threshold value, the controller 50 determines that the correction of the inclination is required, and the process proceeds to Step S32.

20 [0103] In following Step S32, a moving distance D1 of the member attachment robot 100 required to correct the inclination of the rod-shaped member 6 is calculated.

[0104] As shown in FIG. 10, the correction of the inclination of the rod-shaped member 6 is performed by applying correcting load to the

rod-shaped member 6 in the direction opposite to that of the inclination and by plastically deforming the rod-shaped member 6 in the vicinity of the embedded member 4. In other words, the moving distance D1 of the member attachment robot 100 calculated in Step S32 is the distance
5 that the member attachment robot 100 is moved along the moving direction indicated by an arrow in FIG. 10 from the location at which the attachment of the rod-shaped member 6 is performed as shown in FIG. 8 to the location at which the correcting load of a predetermined level is applied to the rod-shaped member 6 as shown in FIG. 10.

10 [0105] A correlation between an extent of the applied load and an extent of the plastic deformation caused thereby with respect to the rod-shaped member 6 and a correlation between an extent of the moved distance of the member attachment robot 100 and an extent of the load thus applied to the rod-shaped member 6 are mapped in advance, and
15 stored in the controller 50. Parameters affecting the correlation includes: the inclination angle of the embedded member 4; the outer diameter, a material, a stiffness, and so forth of the rod-shaped member 6; a distance between the holding part 32 serving as the point of operation that applies the load to the rod-shaped member 6 and the
20 embedded member 4 serving as the fixed point; and so forth.

[0106] In Step S32, in order to correct the rod-shaped member 6 attached to the inclined embedded member 4 to the substantially vertical state with respect to the ceiling surface 1, the extent of the plastic deformation required for the rod-shaped member 6 and the

extent of the moving distance D1 for moving the member attachment robot 100 to achieve such a plastic deformation of the rod-shaped member 6 are obtained according to the map stored in the controller 50.

[0107] When the moving distance D1 of the member attachment

5 robot 100 is obtained as described above, it is determined whether or not the member attachment robot 100 can be moved in following Step S33.

[0108] In Step S33, the controller 50 determines, on the basis of the image around the member attachment robot 100 acquired by the information acquisition device (the image acquisition part) 15 of the base carriage unit 10, especially, on the basis of the image acquired in the direction in which the member attachment robot 100 is to be moved for correcting the inclination of the rod-shaped member 6, whether or not it is possible to apply the correcting load to the rod-shaped member 6.

[0109] When it is determined that there is no obstacles, steps, and so

15 forth on a planned moving route and that it is possible to move the member attachment robot 100, it is determined that it is possible to apply the correcting load to the rod-shaped member 6, and the process proceeds to Step S34. When it is determined that there is an obstacle, step, and so forth on the planned moving route and that it is not possible to move the member attachment robot 100, it is determined that it is not possible to apply the correcting load to the rod-shaped member 6, and the process proceeds to Step S36. In the above, in a case in which the process proceeds to Step S36, there is no subsequent operation to be performed by the member attachment robot 100 to the rod-shaped

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member 6. Therefore, in the case in which the process proceeds to Step S36, the held state of the rod-shaped member 6 by the member attachment robot 100 is released through the above-described releasing operation such that the rod-shaped member 6 attached to the embedded member 4 is released from the member attachment robot 100.

[0110] In Step S34, as shown in FIG. 10, by moving the member attachment robot 100 only by the moving distance D1 obtained in Step S32, the correction of the inclination of the rod-shaped member 6 is performed.

[0111] When the correction of the inclination of the rod-shaped member 6 is to be performed, the arm plate 25 is set at a state in which the arm plate 25 is freely rotatable about the support shaft 23, in other words, at a state in which a driving force or a brake force is not imparted from the rotating motor 22. In addition, as shown in FIG. 10, the guide sleeve 45 is set at a state in which the guide sleeve 45 is pulled towards the arm plate 25 by the contraction of the electric cylinder 40, and in which the two members 45a and 45b are separated from each other, in other words, the guide sleeve 45 is not in contact with the rod-shaped member 6. In other words, when the correction of the inclination of the rod-shaped member 6 is to be performed, the rod-shaped member 6 is held only by the holding parts 32, and the above-described correcting load is applied to the rod-shaped member 6 via the holding parts 32.

[0112] In Step S34, once the movement of the member attachment robot 100 is completed, it is confirmed whether or not the held state of

the rod-shaped member 6 by the member attachment robot 100 is released through the above-described releasing operation and the rod-shaped member 6 attached to the embedded member 4 is separated away from the member attachment robot 100. When it is confirmed
5 that the rod-shaped member 6 is separated away from the member attachment robot 100, the process proceeds to Step S35.

[0113] When the held state of the rod-shaped member 6 is released at a state shown in FIG. 10, there is a risk in that the rod-shaped member 6 vibrates largely due to its resiliency and hits the member attachment
10 robot 100 to damage the member attachment robot 100. Therefore, the release of the held state of the rod-shaped member 6 by the member attachment robot 100 is performed after the member attachment robot 100 is moved below the embedded member 4 and the inclination of the rod-shaped member 6 and the arm plate 25 becomes substantially
15 vertical with respect to the ceiling surface 1.

[0114] In Step S35, the controller 50 determines that a series of operations for attaching the rod-shaped member 6 to the predetermined embedded member 4 are completed and stores that the operation is completed.

20 [0115] On the other hand, in Step S36, the controller 50 determines that the correction of the inclination of the rod-shaped member 6 is not completed although the insertion of the rod-shaped member 6 to the predetermined embedded member 4 is completed, and the controller 50 stores that an inclination correction operation is in-completed.

[0116] Similarly, in Step S20, the controller 50 determines that the insertion of the rod-shaped member 6 to the predetermined embedded member 4 is not completed, and the controller 50 stores that the attachment operation cannot be performed or the attachment operation
5 is in-completed, together with the cause therefor. In the above, the information related to the operation stored in the controller 50 in Steps S35, S36, and S20 is transmitted to the server 120 via the communication unit 50a of the controller 50 successively.

[0117] Therefore, an operator or a site worker who monitors the
10 operation state of the member attachment robot 100 via the server 120 can easily confirm that to which of the embedded members 4, the attachment of the rod-shaped member 6 has been normally completed and can easily ascertain the cause of the failure to perform the attachment of the rod-shaped member 6 and the correction of the
15 inclination of the rod-shaped member 6.

[0118] In addition, the information related to the operation stored in the controller 50 of the member attachment robot 100 is also transmitted to a post-processing robot that performs some sort of operations to the rod-shaped member 6 attached to the embedded
20 member 4. Therefore, it is possible to allow the post-processing robot to perform the operation only for the rod-shaped members 6 that have been attached normally.

[0119] As described above, when storage of the operation state is completed in Steps S20, S35, and 36, the process proceeds to Step S21,

and the controller 50 confirms whether or not all of the planned operations have been completed.

[0120] When all of the planned operations have been completed, the process is terminated, and the member attachment robot 100 is shifted
5 to a standby state until an instruction for a next operation is received from the server 120.

[0121] On the other hand, when the planned operations have not been completed yet, the process returns to Step S13 in order to move the member attachment robot 100 to the location of the embedded member
10 4 to which subsequent rod-shaped member 6 is to be attached.

[0122] Upon returning to Step S13, the rod-shaped member 6 is supplied in Step S22.

[0123] The supply of the rod-shaped member 6 in Step S22 is performed by delivering the rod-shaped member 6 from the carrier robot
15 110 to the member attachment robot 100.

[0124] Specifically, the controller 50 of the member attachment robot 100 first confirms that the arm plate 25 is set to a vertical state relative to the floor surface 2 by the rotating motor 22, the member attachment part 24 is set to a state in which the rod-shaped member 6 can be
20 received, in other words, a state in which the second member 45b of the guide sleeve 45 is separated away from the first member 45a, and the rotating blocks 34 of all of the holding parts 32 are set to a state in which the rotating blocks 34 are rotated to positions to open the U-shaped grooves 33a.

[0125] When it is confirmed that the state in which the rod-shaped member 6 can be received is achieved, the member attachment robot 100 sends, to the carrier robot 110 via the communication unit 50a of the controller 50, a request signal that requests the delivery of the rod-shaped member 6.

[0126] In the above, in the member attachment robot 100, because the held state of the rod-shaped member 6 is released at the time point reaching Step S21, which is the upstream step of this process, the state in which the rod-shaped member 6 can be received is normally achieved.

Thus, the confirmation of whether or not the state in which the rod-shaped member 6 can be received is achieved may be omitted.

[0127] When the carrier robot 110 receives the request signal by the communication unit 90a of the controller 90, the carrier robot 110 moves to the vicinity of the member attachment robot 100 in order to deliver the rod-shaped member 6. In the above, in a case in which the single carrier robot 110 may not be provided for every member attachment robot 100 and two to three carrier robots 110 are shared between the plurality of member attachment robots 100, for example, the carrier robot 110 located in the shortest distance is moved to the vicinity of the member attachment robot 100 in response to the request signal.

[0128] The controller 90 of the carrier robot 110 detects the positions of the holding parts 32 of the member attachment robot 100, more

specifically, the positions of the U-shaped grooves 33a of the fixed blocks 33 from the image acquired by the side image acquisition part 91.

[0129] The delivery portion 82 is then moved to approach the arm plate 25 of the member attachment robot 100 such that the delivery portion 82 holding the rod-shaped member 6 is positioned between the U-shaped grooves 33a of the two fixed blocks 33 positioned in the vertical direction.

[0130] When the controller 50 of the member attachment robot 100 detects that the rod-shaped member 6 is received in the U-shaped grooves 33a of the two fixed blocks 33 with the proximity sensor (not shown), a state in which the rotating blocks 34 of all of the holding parts 32 are rotated to positions at which the U-shaped grooves 33a are closed and the second member 45b of the guide sleeve 45 is in contact with the first member 45a is achieved.

[0131] When the rod-shaped member 6 is held by the member attachment robot 100 by doing so, the controller 50 of the member attachment robot 100 sends, to the carrier robot 110, a completion signal notifying of the completion of the delivery.

[0132] When the completion signal is received, the controller 90 of the carrier robot 110 reduces the magnetic force of the holding parts 83 of the delivery portion 82 and releases the held state of the rod-shaped member 6 by the holding parts 83.

[0133] As described above, when the rod-shaped member 6 is not held by the holding parts 83 of the delivery portion 82, the rod-shaped

member 6 is lowered due to the force of gravitation while being held by the plurality of holding parts 32 of the member attachment robot 100. Because the socket 28 of the attachment operating part 26 is provided below the holding parts 32 as described, the lower end portion of the rod-shaped member 6 is received by the socket 28. Therefore, the rod-shaped member 6 held by the holding parts 32 is set to a state in which the rod-shaped member 6 can be rotated by the electric motor 27, in other words, a state in which the rod-shaped member 6 can be screwed to the embedded member 4.

[0134] When it is confirmed that the supply of the rod-shaped member 6 is completed in Step S22 as described above, the process proceeds to Step S13, the member attachment robot 100 is moved to the location of the embedded member 4 to which the subsequent rod-shaped member 6 is to be attached. The supply of the rod-shaped member 6 may also be performed after the member attachment robot 100 has been moved to the location of the embedded member 4 to which the subsequent rod-shaped member 6 is to be attached.

[0135] According to the embodiment mentioned above, the advantages described below are afforded.

[0136] In the member attachment robot 100 having the above-described configuration, the rod-shaped member 6 is attached to the embedded member 4 by the member attachment part 24 after the inclination of the rod-shaped member 6 that is held by the member

attachment part 24 is substantially matched with the inclination of the embedded member 4 detected by the distance sensor 51.

[0137] By performing the attachment of the rod-shaped member 6 to the embedded member 4 after the inclination of the rod-shaped member 6 is substantially matched with the inclination of the embedded member 4 as described above, the occurrence of the galling between the threaded portion of the rod-shaped member 6 and the threaded portion of the embedded member 4 is suppressed with reliability, and as a result, it is possible to prevent the occurrence of a situation in which the operation of attaching the rod-shaped member 6 to the embedded member 4 needs to be performed again by the site worker. Therefore, it is possible to reduce the man-hours for the operation of attaching the rod-shaped member 6 to the embedded member 4 that is provided in the ceiling surface 1.

[0138] In addition, in the member attachment robot 100 having the above-described configuration, the rod-shaped member 6 is attached to the embedded member 4 by the member attachment part 24 after causing the guide sleeve 45 to come to the vicinity of the embedded member 4.

[0139] As described above, by performing the attachment of the rod-shaped member 6 to the embedded member 4 after the guide sleeve 45 that is provided with the guiding hole 46b capable of guiding the rod-shaped member 6 towards the embedded member 4 is caused to come to vicinity of the embedded member 4, even in a case in which the

inclination of the embedded member 4 detected is deviated from the actual inclination to some extent and the inclination of the rod-shaped member 6 cannot be matched with the inclination of the embedded member 4, it is possible to screw the rod-shaped member 6 to the
5 embedded member 4 without causing the galling at the threaded portion.

[0140] In addition, in the member attachment robot 100 having the above-described configuration, the rod-shaped member 6 is supplied from the carrier robot 110 as required.

10 [0141] As described above, by automatically supplying the rod-shaped member 6 from the carrier robot 110 to the member attachment robot 100, it is possible to perform the attachment of the rod-shaped member 6 to the embedded member 4 in succession without a temporal interruption caused by the supply of the rod-shaped member
15 6. As a result, it is possible to shorten a construction period.

[0142] Following modifications are also within the scope of the present invention, and it is also possible to combine the configurations shown in the modifications with the configurations described in the above-described embodiment and to combine the configurations
20 described in the following different modifications.

[0143] In above-mentioned embodiment, the inclination of the embedded member 4 is detected on the basis of the distances to the embedded member 4 and the ceiling surface 1 measured by the distance sensor 51. Instead of this configuration, as in a modification shown in

FIGs. 11A and 11B, the inclination of the embedded member 4 may also be detected on the basis of shape of the lower end edge 5 of the embedded member 4 that is extracted from the image of the embedded member 4. In this modification, a camera 151 having a relatively high resolution is used as the detection unit instead of the distance sensor 51. FIG. 11A is a diagram showing a cross-section corresponding to that of FIG. 7A, and FIG. 11B is a diagram viewed from the direction indicated by an arrow C shown in FIG. 11A.

[0144] Specifically, in a case in which an image of the embedded member 4 that is provided at an angle is acquired by the camera 151 from below in the vertical direction as shown in FIG. 11A, the lower end edge 5 of the embedded member 4 extracted from the acquired image forms an oval shape with a major axis and a minor axis as shown in FIG. 11B. On the other hand, in a case in which the embedded member 4 is provided without inclination, the lower end edge 5 of the embedded member 4 on the acquired image forms a substantially perfect circle.

[0145] In other words, because the ratio a length L1 in the major axis direction to a length L2 in the minor axis direction shown in FIG. 11B takes a value approaching 1:1 as the inclination of the embedded member 4 becomes smaller, it is possible to obtain a degree of the inclination of the embedded member 4 on the basis of the ratio. In addition, the minor axis direction shown in FIG. 11B indicates the direction of the inclination of the embedded member 4. Therefore, also

with such a modification, it is possible to detect the inclination of the embedded member 4.

[0146] In addition, in the above-mentioned embodiment, the embedded member 4 is attached such that its lower end portion is projected out from the ceiling surface 1 by a predetermined length. The insert and the post-construction anchor, which are used as the embedded member 4, are provided, in the design, in a state in which at least a portion thereof is embedded and fixed in the concrete and the lower end portion thereof projects out from the ceiling surface 1 by a predetermined length. However, depending on its attached state, as shown in FIG. 12A, there may be a case in which the embedded member 4 projects from the ceiling surface 1 by only little amount and a lower end surface of the embedded member 4 and the ceiling surface 1 are substantially flush with each other. Especially, in a case in which the embedded member 4 is the post-construction anchor, as shown in FIG. 13A, if an insertion hole 1a formed in the ceiling surface 1 is too deep, the entire body of the embedded member 4 is inserted within the insertion hole 1a, and thereby, a state in which the embedded member 4 is not project out from the ceiling surface 1 at all may be caused.

[0147] As described above, even if a state in which the lower end portion of the embedded member 4 is projected out from the ceiling surface 1 by a predetermined length is not achieved, it is possible to detect the inclination of the embedded member 4 by using a following method.

[0148] Specifically, as shown in FIGs. 12A and 12B, in a case in which the lower end surface of the embedded member 4 and the ceiling surface 1 are substantially flush with each other, it is possible to calculate, in a similar approach to that of the above-mentioned
5 embodiment, the inclination of the embedded member 4 with respect to the vertical direction by measuring the distances to the plurality of measurement points P2 (the dots shown by the solid black circles in the figure) on the line that is identified as the lower end edge 5 of the embedded member 4 by the distance sensor 51 and by measuring the
10 distances to the plurality of measurement points P1 (the dots shown by the open white circles in the figure) on the plane that is identified as the ceiling surface 1 around the embedded member 4. FIG. 12A is a diagram showing a cross-section corresponding to that of FIG. 7A, and FIG. 12B is a diagram viewed from the direction indicated by an arrow D
15 shown in FIG. 12A.

[0149] In a case in which only a part of the lower end edge 5 of the embedded member 4 is projected out from the ceiling surface 1 and the remaining part is depressed from the ceiling surface 1, the reference plane of the ceiling surface 1 is obtained on the basis of the distances to
20 the plurality of measurement points P1 on the ceiling surface 1 measured at random, and differences are respectively calculated for the plurality of measurement points P2 on the lower end edge 5 of the embedded member 4 with respect to the reference plane. Then, the point with the greatest difference on the positive side and the point with

the greatest difference on the negative side are extracted among the plurality of measurement points P2, and on the basis of a line connecting these two points, it is possible to calculate the inclination of the embedded member 4 with respect to the vertical direction.

5 [0150] In addition, as shown in FIGs. 13A and 13B, in a case in which the embedded member 4 is not projected out at all from the ceiling surface 1, it is possible to calculate, in a similar approach to that of the above-mentioned embodiment, the inclination of the embedded member 4 with respect to the vertical direction by measuring the distances to the
10 plurality of measurement points P2 (the dots shown by the solid black circles in the figure) on the line that is identified as the lower end edge 5 of the embedded member 4 by the distance sensor 51, by measuring the distances to the plurality of measurement points P1 (the dots shown by the open white circles in the figure) on the line that is identified as an
15 opening edge of the insertion hole 1a formed in the ceiling surface 1, and by calculating the angle of the ceiling surface 1 (the reference tilt angle) on the basis of the plurality of measurement points P1 on the opening edge of the insertion hole 1a. FIG. 13A is a diagram showing a cross-section corresponding to that of FIG. 7A, and FIG. 13B is a
20 diagram viewed from the direction indicated by an arrow E shown in FIG. 13A.

[0151] When a state in which the lower end portion of the embedded member 4 is projected out from the ceiling surface 1 by a predetermined length is not achieved as shown in FIGs. 12A and 13A, because the part

of the embedded member 4 cannot be received in the receiving hole 46a provided in the guide sleeve 45 in the above-mentioned embodiment, there is a risk in that it becomes difficult to guide the rod-shaped member 6 towards the embedded member 4 via the guide sleeve 45.

5 [0152] Especially, in a case in which the embedded member 4 is the post-construction anchor that is inserted into and fixed to the insertion hole 1a formed in the ceiling surface 1, a state in which the lower end portion of the embedded member 4 is projected out from the ceiling surface 1 or a state in which the lower end portion of the embedded member 4 is not projected out from the ceiling surface 1 is caused due to
10 varied drilled depths of the insertion holes 1a and/or varied inserted amounts of the embedded members 4 into the insertion hole 1a.

[0153] Even in such a case, in order to accurately guide the rod-shaped member 6 towards the embedded member 4, as in a
15 modification shown in FIG. 14, a shape and a structure of a guide sleeve 145 (a sleeve) may be modified. FIG. 14 is a diagram showing an operation state corresponding to the operation state shown in FIG. 8 and shows a vicinity of the guide sleeve 145 in enlargement.

[0154] Similarly to the guide sleeve 45 of the above-mentioned
20 embodiment, the guide sleeve 145 shown in FIG. 14 is divided into two members 145a and 145b at a plane extending through the center axis of a through hole 146 serving as the division surface, and the members 145a and 145b are linked via hinges (not shown).

[0155] As shown in FIG. 14, the through hole 146 has an inner diameter that is larger than the outer diameter of the rod-shaped member 6 and has a shape in which the diameter is increased gradually towards the rod-shaped member 6 held by the holding parts 32. In other words, the through hole 146 of the guide sleeve 145 has only a function corresponding to the guiding hole 46b of the guide sleeve 45 of the above-mentioned embodiment, and the through hole 146 is not provided with a part corresponding to the receiving hole 46a of the guide sleeve 45 of the above-mentioned embodiment.

[0156] In addition, the guide sleeve 145 is provided with a tapered portion 147 whose outer diameter is gradually reduced towards the embedded member 4. The outer diameter of a tip end portion of the tapered portion 147 is set so as to be smaller than the outer diameter of the embedded member 4, in other words, the inner diameter of the insertion hole 1a formed in the ceiling surface 1.

[0157] Therefore, for example, as shown on the right side in FIG. 14, in a case in which the entire body of the embedded member 4 is inserted within the insertion hole 1a and the embedded member 4 is not projected out at all from the ceiling surface 1, by inserting a tip end portion of the tapered portion 147 into the insertion hole 1a, it is possible to surely guide the rod-shaped member 6 towards the embedded member 4 via the guide sleeve 145.

[0158] In addition, the tip end portion of the tapered portion 147 is provided with a suction part 148 that allows the tip end portion of the tapered portion 147 to suck to the embedded member 4.

[0159] The suction part 148 has a structure that allows switching
5 between a sucked state and a non-sucked state. In the sucked state, a tip end surface of the tapered portion 147 is sucked to the lower end surface of the embedded member 4 by negative pressure generated by a vacuum pump (not shown), and in the non-sucked state, the suction of the tip end surface of the tapered portion 147 to the lower end surface of
10 the embedded member 4 is released as the supply of the negative pressure is shut off. In the above, suction force generated at the suction part 148 is not limited to that caused by the negative pressure, and for example, if the embedded member 4 is made of metal, the suction force may be generated by electromagnetic force. In this case,
15 by turning the electromagnetic force ON and OFF, the sucked state and the non-sucked state are switched.

[0160] As described above, by providing the suction part 148 on the guide sleeve 145, for example, as shown on the left side in FIG. 14, even in a case in which the lower end portion of the embedded member 4 cannot be received in the receiving hole 46a of the guide sleeve 45 of the
20 above-mentioned embodiment, and in addition, in which the tip end portion of the tapered portion 147 as described above cannot be inserted into the insertion hole 1a, such as when the embedded member 4 is projected from the ceiling surface 1 by little amount, and the lower end

surface of the embedded member 4 and the ceiling surface 1 are substantially flush with each other, it is possible to reliably guide the rod-shaped member 6 towards the embedded member 4 via the guide sleeve 145 by sucking the tip end surface of the tapered portion 147 to the lower end surface of the embedded member 4 by the suction part 148.

[0161] In addition, in the above-mentioned embodiment, in the member attachment robot 100, the rod-shaped member 6 is supplied from the carrier robot 110. Instead of this configuration, the member attachment robot 100 may be provided with a holding part that can hold the plurality of rod-shaped members 6 and may have a configuration that allows self-supply of the rod-shaped member 6 to the member attachment part 24. Specifically, the member attachment robot 100 may be provided with a supply mechanism 200 that can supply the rod-shaped members 6 to the member attachment part 24 as in a modification shown in FIGs. 15 to 21. FIG. 15 is a side view of the member attachment robot 100 that is provided with the supply mechanism 200, FIG. 16 is a top view viewed from the direction indicated by an arrow F shown in FIG. 15, and FIG. 17 is a diagram schematically showing a cross-section taken along line G-G in FIG. 16. In addition, FIGs. 18 to 21 are diagrams for explaining process of delivering the rod-shaped members 6 to the member attachment part 24. Although FIGs. 18 to 20 are diagrams viewed from the same

eyepoint as FIG. 16, the extending direction of the rod-shaped member 6 coincides with the left-right direction in FIGs. 18 to 20.

[0162] The supply mechanism 200 has a feeder 210 that stores a plurality of rod-shaped members 6 and that can feed the rod-shaped members 6 one by one, a delivery device 230 that grasps the rod-shaped member 6 fed from the feeder 210 and delivers the rod-shaped member 6 to the above-described member attachment part 24, and a slide device 220 that slides the rod-shaped member 6 that has been fed from the feeder 210 to the position at which the rod-shaped member 6 is grasped by the delivery device 230.

[0163] As shown in FIG. 15, the feeder 210 is arranged at a position relatively close to the column 12 that is provided on the base carriage unit 10, and as shown in FIG. 17, the feeder 210 has a storage part 211 that stores a plurality of rod-shaped members 6 and a dispenser mechanism 212 that dispenses the rod-shaped members 6 stored in the storage part 211 one by one from a lower part of the storage part 211.

[0164] A storage space 211a that can store the plurality of rod-shaped members 6 such that the longitudinal direction extends in the substantially horizontal direction is formed in the storage part 211. The storage space 211a opens at an upper part and the lower part, and an opening portion 211c that is opened and closed by the dispenser mechanism 212 is formed at the lower part.

[0165] In addition, as shown in FIG. 15, the storage part 211 is formed with a supply opening 211b that opens at a side surface thereof

such that the supply of the rod-shaped members 6 to the storage space 211a can be conducted by the site worker with ease. By forming the supply opening 211b at the side surface of the storage part 211 as described above, for example, the site worker can once store the plurality of rod-shaped members 6 supplied in lots into a supply container (not shown), and then, supply the plurality of rod-shaped members 6 at one time from the supply container to the storage space 211a through the supply opening 211b. The supply of the rod-shaped members 6 by the site worker is performed when the member attachment robot 100, which has self-determined that the supply of the rod-shaped members 6 is required, returned to a backyard, etc. from the operation area or when the member attachment robot 100 being operated in the operation area requested the supply of the rod-shaped members 6, for example.

[0166] The dispenser mechanism 212 has: feeding plates 213 that can open and close the opening portion 211c of the storage part 211 by being rotated about support pins 214; partition plates 215 that are provided so as to be able to move up and down in the vertical direction through slits 213b respectively formed in the feeding plates 213; an electric actuator (not shown) that can switch the positions of the feeding plates 213 between the position at which the opening portion 211c is opened and the position at which the opening portion 211c is closed; and an electric actuator (not shown) that can switch the positions of the partition plates 215 between the position at which upper edges of the

partition plates 215 are projected out from the respective feeding plates 213 and the position at which the upper edges of the partition plates 215 are not projected out from the respective feeding plates 213.

[0167] On each of the feeding plates 213, a projection 213a is formed so as to project upwards on the opposite side from the support pin 214, with the slit 213b being located therebetween, in order to prevent the rod-shaped member 6 from falling off.

[0168] As shown in FIG. 16, a plurality of feeding plates 213 are provided along the longitudinal direction of the storage part 211, in other words, along the longitudinal direction of the rod-shaped members 6, and the feeding plates 213 are configured so as to be moved in a cooperative manner with each other. The partition plates 215 are not necessarily formed for all of the feeding plates 213, and at least one partition plate 215 may be formed. In a case in which a plurality of partition plates 215 are provided, the respective partition plates 215 are configured so as to be moved in a cooperative manner with each other.

[0169] The operation of the dispenser mechanism 212 configured as described above will be described with reference to FIG. 17.

[0170] As the feeding plates 213 are moved in the direction indicated by an arrow H shown in FIG. 17(a), the opening portion 211c is opened, and the rod-shaped member 6 in the storage space 211a slides on an upper surfaces of the feeding plates 213 from the opening portion 211c by its own weight. The movement of the sliding rod-shaped member 6

is restricted by the projections 213a respectively formed on the feeding plates 213.

[0171] As the partition plates 215 move in the direction indicated by an arrow J shown in FIG. 17(b) in a state in which the rod-shaped member 6 has slid out on the upper surfaces of the feeding plates 213, the partition plates 215 squeeze into a gap between the adjacent rod-shaped members 6, and thereby, a state in which only a single rod-shaped member 6 is held between the projections 213a of the feeding plates 213 and the partition plates 215 is achieved.

[0172] From this state, the feeding plates 213 are rotated in the direction in which the opening portion 211c is closed, and as a result, the single rod-shaped member 6 is left on the feeding plates 213. By doing so, it is possible to dispense the rod-shaped members 6 one by one from the lower part of the storage part 211 by the dispenser mechanism 212.

[0173] The slide device 220 is an electric slider 221 that can cause a movable part 222 to reciprocate in the longitudinal direction of the storage part 211, in other words, in the longitudinal direction of the rod-shaped members 6, and the slide device 220 is arranged, together with the feeder 210, on the upper surface of the main body portion 11 of the base carriage unit 10.

[0174] The movable part 222 is attached with an abutting plate 223 that is brought into contact with an end surface of the rod-shaped member 6, and as shown in FIG. 17(a), a tip end of the abutting plate

223 is formed to have a hook shape so as to be able to enter a gap between the projections 213a of the feeding plates 213 and the storage part 211.

[0175] As described above, the slide device 220 has the configuration in which the rod-shaped member 6, which has been dispensed by the dispenser mechanism 212 onto the feeding plates 213 from the storage part 211, can be slid in the axial direction of the rod-shaped member 6.

[0176] As shown in FIGs. 15 and 16, the delivery device 230 has: a grasping mechanism 235 that can grasp the rod-shaped member 6; an electric cylinder 231 that can change a position of the grasping mechanism 235 in the horizontal direction; a rotation mechanism 240 that can rotate the grasping mechanism 235 in a vertical plane about the extension/contraction center axis C1 of the electric cylinder 231; and a slider mechanism 244 that can change a height of the grasping mechanism 235 in the vertical direction.

[0177] The grasping mechanism 235 has a pair of grasping parts 237 and a support member 236 on both ends of which the grasping parts 237 are attached, and the grasping mechanism 235 is attached to the rotation mechanism 240 via the support member 236.

[0178] The grasping parts 237 form a so-called parallel opening/closing gripper that is configured of a pair of movable parts 238 that are arranged so as to opposed to each other and an electric actuator (not shown) that can move the pair of movable parts 238 such that they are approached with each other and separated away from each other.

[0179] The electric cylinder 231 has a cylinder portion 232 and a rod portion 233 projecting out from the cylinder portion 232, and the electric cylinder 231 is operated so as to be extended and contracted along the extension/contraction center axis C1. The grasping mechanism 235 is
5 attached to a tip end of the rod portion 233 via the rotation mechanism 240.

[0180] The rotation mechanism 240 is a mechanism that rotates the grasping mechanism 235 by an electric cylinder (not shown) or an electric motor (not shown) about the extension/contraction center axis
10 C1 of the electric cylinder 231 in the vertical plane, and the rotation mechanism 240 has a structure in which a position of the grasping mechanism 235 can be switched between a first position at which the longitudinal direction of the support member 236 extends in the substantially horizontal direction and a second position at which the
15 longitudinal direction of the support member 236 extends in the substantially vertical direction.

[0181] The slider mechanism 244 is an electric slider 245 that can cause a movable part 246 to reciprocate in the vertical direction, and the electric slider 245 is provided so as to be erected on the upper surface of
20 the main body portion 11 of the base carriage unit 10. The electric slider 245 is provided at the position that does not interfere with the movement of the arm plate 25.

[0182] Because the cylinder portion 232 of the electric cylinder 231 is fixed to the movable part 246 of the slider mechanism 244, by changing

the height of the movable part 246 in the vertical direction, it is possible to change the height of the electric cylinder 231, in other words, the height of the grasping mechanism 235 in the vertical direction.

[0183] Operations of the respective parts of the supply mechanism
5 200 are controlled by the controller 50 that controls the operation of the member attachment robot 100. A controller may be provided separately from the controller 50.

[0184] Next, a process of delivering the rod-shaped member 6 to the member attachment part 24 by the supply mechanism 200 having the
10 above-described configuration will be described with main reference to FIGs. 18 to 21.

[0185] As described above, as the rod-shaped member 6 is dispensed by the dispenser mechanism 212 from the lower part of the storage part 211, as shown in FIG. 18, a state in which the single rod-shaped
15 member 6 is supported by the plurality of feeding plates 213 is achieved.

[0186] In the above, because the rod-shaped members 6 can be freely moved to a certain degree in the axial direction in the storage part 211, if the rod-shaped member 6 is grasped by the grasping parts 237 of the grasping mechanism 235 in the state shown in FIG. 18, the rod-shaped
20 member 6 is grasped at different positions every time. Therefore, when the rod-shaped member 6 is to be delivered to the member attachment part 24, it is required to perform different fine adjustment each time.

[0187] Thus, in this modification, as shown in FIG. 19, before the rod-shaped member 6 is grasped by the grasping parts 237, the

rod-shaped member 6 is slid to a predetermined position by the slide device 220. Specifically, when it is confirmed that the rod-shaped member 6 has been dispensed by the dispenser mechanism 212, the slide device 220 moves the movable part 222 by a preset distance
5 towards the grasping mechanism 235.

[0188] While the movable part 222 is moved towards the grasping mechanism 235 as described above, the abutting plate 223 is brought into contact with the end surface of the rod-shaped member 6. Therefore, the rod-shaped member 6 is slid together with the abutting
10 plate 223 and the movable part 222, and as a result, the rod-shaped member 6 that has been slid is positioned at the same position each time.

[0189] When the sliding of the rod-shaped member 6 by the slide device 220 is completed, as shown in FIG. 20, the electric cylinder 231 is
15 extended by a predetermined distance such that the grasping mechanism 235 approaches the rod-shaped member 6. After the electric cylinder 231 is extended, the rod-shaped member 6 is grasped by the grasping parts 237. The positions for providing the feeding plates 213 are set in advance to positions that avoid the positions at
20 which the grasping parts 237 grasp the rod-shaped member 6. Therefore, each of the grasping parts 237 can grasp the rod-shaped member 6 at positions between the feeding plates 213.

[0190] When it is confirmed that the rod-shaped member 6 is grasped by the grasping mechanism 235, the slider mechanism 244 moves the movable part 246 upwards by a preset distance.

[0191] Once the upward movement of the grasping mechanism 235 grasping the rod-shaped member 6 is completed, subsequently, the position of the grasping mechanism 235 is changed by the rotation mechanism 240 from the first position at which the longitudinal direction of the support member 236 extends in the substantially horizontal direction to the second position at which the longitudinal direction of the support member 236 extends in the substantially vertical direction. The direction in which the grasping mechanism 235 is rotated by the rotation mechanism 240 is the same every time, and in the example shown in FIGs. 20 and 21, the grasping mechanism 235 is rotated such that the grasping part 237 that grasps the part closer to the end portion of the rod-shaped member 6 of the pair of grasping parts 237 is positioned at the lower side at the second position.

[0192] Once the grasping mechanism 235 reaches the second position, as shown in FIG. 21, the electric cylinder 231 is extended until the rod-shaped member 6 grasped by the grasping mechanism 235 enters the U-shaped grooves 33a formed in the fixed blocks 33 of the holding parts 32.

[0193] When it is confirmed that the rod-shaped member 6 has entered the U-shaped grooves 33a, the slider mechanism 244 then moves the movable part 246 downwards slightly. A moved amount of

the movable part 246 in the above is set in accordance with the length of the rod-shaped member 6 to be inserted into the socket 28 attached to the rotating shaft 27a of the electric motor 27 (see FIG. 3).

[0194] When it is confirmed that the positions of the rotating blocks
5 34 are set at the positions where the U-shaped grooves 33a are closed and the rod-shaped member 6 is held by the holding parts 32, the grasped state of the rod-shaped member 6 by the grasping mechanism 235 is released. Subsequently, in order to move the grasping mechanism 235 away from the member attachment unit 20, the electric
10 cylinder 231 is contracted.

[0195] After the electric cylinder 231 is contracted, the position of the grasping mechanism 235 is switched by the rotation mechanism 240 from the second position to the first position. After the position of the grasping mechanism 235 is switched, the slider mechanism 244 moves
15 the movable part 246 downwards to the position shown in FIG. 15. By doing so, as shown in FIG. 15, the supply mechanism 200 is in a state in which the rod-shaped member 6 can be delivered.

[0196] Through the processes described above, the rod-shaped members 6 are successively delivered to the member attachment part 24
20 by the supply mechanism 200.

[0197] The processes from the dispensing of the rod-shaped member 6 from the lower part of the storage part 211 by the dispenser mechanism 212 to the grasping of the thus-dispensed rod-shaped member 6 by the grasping mechanism 235 are performed while the

member attachment robot 100 is performing the operation of attaching the rod-shaped member 6 to the embedded member 4 as described above. Therefore, it is possible to promptly supply the rod-shaped members 6 to the member attachment robot 100 that has finished the
5 operation of attaching the rod-shaped member 6. Instead of mounting the supply mechanism 200 on the member attachment robot 100, the above-described carrier robot 110 may be provided with a mechanism equivalent to the above-described supply mechanism 200.

[0198] In addition, in the above-mentioned embodiment, the
10 correction of the inclination of the rod-shaped member 6 is performed only by moving the member attachment robot 100. Instead of this configuration, the correction of the inclination of the rod-shaped member 6 may also be performed by, in addition to moving the member attachment robot 100, actively rotating the arm plate 25 by the rotating
15 motor 22, or the correction may also be performed only by rotating the arm plate 25 by the rotating motor 22 without moving the member attachment robot 100.

[0199] In addition, in the above-mentioned embodiment, the member attachment robot 100 recognizes the self-location on the basis of the
20 surrounding information acquired by the information acquisition device 15 of the base carriage unit 10. The member attachment robot 100 may also be provided with a gyroscope sensor, a geomagnetic sensor, and an acceleration sensor in addition to the information acquisition device 15 in order to improve recognition accuracy of the self-location.

[0200] In addition, in the above-mentioned embodiment, the rod-shaped member 6 is attached to the embedded member 4 by being screwed thereto. Instead of this configuration, the rod-shaped member 6 may be attached to the embedded member 4 by being fitted thereto.

5 In this case, the electric motor 27 is not required.

[0201] In addition, in the above-mentioned embodiment, although the rod-shaped member 6 is not attached with a hanger and a positioning nut of the hanger, the rod-shaped member 6 may be attached with the hanger and the positioning nut of the hanger in advance. In addition, it may be possible to separately deploy a member attachment robot that can attach the hanger and the positioning nut of the hanger to the rod-shaped member 6 that has been attached to the embedded member 4.

[0202] Although the embodiments of the present invention have been described in the above, the above-mentioned embodiments merely illustrate a part of application examples of the present invention, and the technical scope of the present invention is not intended to be limited to the specific configurations of the above-described embodiments.

CLAIMS

1. A member attachment robot for attaching a rod-shaped member having a threaded portion to an embedded member provided in a ceiling surface, the member attachment robot comprising:
- 5 a base carriage unit configured to be movable on a floor surface;
- a member attachment part supported by the base carriage unit so as to be freely rotatable about a support shaft extending in parallel with the floor surface, the member attachment part being configured to hold
- 10 the rod-shaped member and to perform attachment of the rod-shaped member to the embedded member;
- a driving part configured to rotate the member attachment part about the support shaft;
- a detection unit configured to detect an inclination of the embedded
- 15 member; and
- a controller configured to control an operation of the base carriage unit, the member attachment part, and the driving part; wherein
- the detection unit is a distance detection unit capable of detecting distances to the embedded member and the ceiling surface, and
- 20 the controller is configured to
- calculate a reference tilt angle from the distances to the ceiling surface detected by the distance detection unit,
- calculate a measured tilt angle from the distances to the embedded member detected by the distance detection unit,

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compute a difference between the reference tilt angle and the measured tilt angle as the inclination of the embedded member, and

operate the member attachment part so as to attach the rod-shaped member to the embedded member after operating at least
5 one of the driving part and the base carriage unit such that an inclination of the rod-shaped member held by the member attachment part substantially matches the inclination of the embedded member.

2. A member attachment robot for attaching a rod-shaped
10 member having a threaded portion to an embedded member provided in a ceiling surface, the member attachment robot comprising:

a base carriage unit configured to be movable on a floor surface;

a member attachment part supported by the base carriage unit so as to be freely rotatable about a support shaft extending in parallel with
15 the floor surface, the member attachment part being configured to hold the rod-shaped member and to perform attachment of the rod-shaped member to the embedded member;

a driving part configured to rotate the member attachment part about the support shaft;

20 a detection unit configured to detect an inclination of the embedded member; and

a controller configured to control an operation of the base carriage unit, the member attachment part, and the driving part; wherein

the member attachment part has: a holding part configured to hold the rod-shaped member; and an attachment operating part configured to perform an operation of attaching the rod-shaped member held by the holding part to the embedded member, and

5 the controller is configured to

operate the member attachment part so as to attach the rod-shaped member to the embedded member after operating at least one of the driving part and the base carriage unit such that an inclination of the rod-shaped member held by the member attachment
10 part substantially matches the inclination of the embedded member detected by the detection unit, and

operate, after operating the attachment operating part so as to attach the rod-shaped member to the embedded member, at least one of the driving part and the base carriage unit such that a correcting load
15 for correcting the rod-shaped member so as to be substantially vertical with respect to the ceiling surface is applied to the rod-shaped member via the holding part.

3. A member attachment robot for attaching a rod-shaped
20 member having a threaded portion to an embedded member provided in a ceiling surface, the member attachment robot comprising:

a base carriage unit configured to be movable on a floor surface;

a member attachment part supported by the base carriage unit so as to be freely rotatable about a support shaft extending in parallel with

the floor surface, the member attachment part being configured to hold the rod-shaped member and to perform attachment of the rod-shaped member to the embedded member;

5 a driving part configured to rotate the member attachment part about the support shaft;

a detection unit configured to detect an inclination of the embedded member; and

a controller configured to control an operation of the base carriage unit, the member attachment part, and the driving part; wherein

10 the member attachment part further has a sleeve capable of guiding the rod-shaped member towards the embedded member, and

the controller is configured to

operate the member attachment part so as to attach the rod-shaped member to the embedded member after operating at least
15 one of the driving part and the base carriage unit such that an inclination of the rod-shaped member held by the member attachment part substantially matches the inclination of the embedded member detected by the detection unit and determining that the sleeve has reached a vicinity of the embedded member.

20

4. The member attachment robot according to claim 1 or 3, wherein the member attachment part has: a holding part configured to hold the rod-shaped member; and an attachment operating part

configured to perform an operation of attaching the rod-shaped member held by the holding part to the embedded member, and

the controller is configured to operate, after operating the attachment operating part so as to attach the rod-shaped member to the
5 embedded member, at least one of the driving part and the base carriage unit such that a correcting load for correcting the rod-shaped member so as to be substantially vertical with respect to the ceiling surface is applied to the rod-shaped member via the holding part.

10 5. The member attachment robot according to claim 2, further comprising an image acquisition part configured to acquire an image around the member attachment robot, wherein

the controller is configured to determine whether or not the correcting load can be applied to the rod-shaped member based on the
15 image acquired by the image acquisition part.

6. The member attachment robot according to any one of claims 1 to 3 and 5, wherein the controller is configured to determine whether or not the attachment of the rod-shaped member has been suitably
20 performed based on an inserted length of the rod-shaped member into the embedded member.