

Specification

Title of the invention

Device for Vibration Compaction of Sand Grounds

Technical Field

The present invention relates to a device for vibration compaction of sand grounds (hereinafter referred to as "rod compaction device", and its method is referred to as "rod compaction method"), and it particularly relates to a rod compaction device with which it is possible to maintain, during performance of a rod compaction method using a plurality of steel pile rods or H-section steels (hereinafter, both are generally referred to as mere "rods"), vertical properties of each rod and constant intervals between respective rods, and to achieve improvements in uniform and effective sand grounds.

Background Art

A conventional rod compaction device will now be explained in accordance with Figs. 16 and 17, and a general rod compaction method will further be explained in accordance with Figs. 18 and 19.

Fig. 16 is a side view showing an overall view of a conventional rod compaction device comprised of a uniaxial rod, and Fig. 17 is a front view of the

same. Generally, a rod compaction method is a method in which vibrations are transmitted to a ground via a rod using a vibro hammer to perform compaction of sand grounds. As for the applicable types of soil, since the rod compaction method is basically a vibration compaction method for sand grounds, such method is intended for sand grounds that can be easily compacted through vibration, and it is generally applied to sand grounds having a particle size of not more than 74μ and a content rate of not more than 35%.

The intended use of the rod compaction method is preventing liquefaction, increasing bearing resistance and constant reduction of settlement of loose sand grounds, and it is used for compacting foundations of various constructions such as buildings, roads and tanks and backfill portions of revetments, retaining walls or the like.

Device 1 that is used in a conventional uniaxial rod compaction method will now be explained in accordance with Figs. 16 and 17. In the drawings, the rod compaction device 1 is comprised with a crawler crane 2, wherein a mount 6 fixedly provided with a vibro hammer 4 on an upper surface thereof and an uniaxial rod 5 on a lower surface thereof is attached to a leader 3 of the crawler crane 2 in a

freely elevating manner, and wherein the uniaxial rod 5 is vertically driven and pulled out along the leader 3 into a sand ground G that is to be improved so as to transfer vibration of the vibro hammer 4 to the sand ground G via the uniaxial rod 5 to perform compaction of the sand ground G.

Next, general procedures of a rod compaction method will be explained in accordance with Figs. 18 and 19. As shown in Fig. 18(a), the uniaxial rod 5 is set on an upper surface of the sand ground G to be improved. Next, as shown in Fig. 18(b), after the uniaxial rod 5 is driven into the sand ground G through vibration of the vibro hammer 4 so as to reach a prescribed depth for improvement, and after reaching the prescribed depth for improvement as shown in Fig. 18(c), the uniaxial rod 5 is pulled out by a preliminarily calculated prescribed amount U_m and is further driven by a preliminarily calculated prescribed amount D_m as shown in Fig. 18 (d).

In this manner, upon repeating driving and pulling out actions of the uniaxial rod 5 (see Figs. 18(e) to (f)), the sand ground G to be improved is compacted by vibration of the vibro hammer 4 transferred via the uniaxial rod 5 and tamping operations when driving the uniaxial rod 5. Since

the surface layer of the sand ground G is gravitated by the compacting operations, refill sand is filled to such portion as shown in Fig. 18(g) while executing the rod compaction method such that compaction of the sand ground G is performed to achieve an improved ground.

In this respect, the prescribed amount U_m of pulling out and the prescribed amount D_m of re-driving for the uniaxial rod 5 is obtained on the basis of a void ratio N value between sands of the original sand ground G and a design value N' value of the improved ground after compaction, whereupon a total tampering length h and a bolting pitch d is determined to execute the rod compaction method. Fig. 19 shows one example in a rod tip trace pattern of a rod compaction method for an improvement depth of 10m. In this example, the prescribed amount U of pulling out is defined to be 3.0 m while the prescribed amount D of re-driving is defined to be 2.0 m to execute the rod compaction method. Further, the rod compaction method is executed in principle in that a ratio of not less than $2/3$ is re-driven with respect to the pulling out length for improvements in a depth of 2 m from the surface layer.

In this manner, since compaction effects

achieved in a general compaction method are mainly for performing compaction of the sand ground through vibration of the uniaxial rod 5, transfer of vibration by the vibro hammer 4 is limited to proximities of the uniaxial rod 5. In such a case, the diameter of the improved pole improved by compaction is small so that when it is aimed to improve a ground on an extensive scale, construction needs to be repeated at small pitches which will result in a drawback in that construction costs will be increased.

It has accordingly be suggested a rod employed in a rod compaction method wherein a rod main body made of a steel pipe and a tip block having a diameter equivalent to or larger than the outer diameter of the rod main body are apart from each other and disposed coaxially, and a tip end portion of the rod main body and the tip end block are coupled with a coupling means having a smaller rigidity than the rod main body (see, for example, Japanese Patent Laid-Open Publication No. 2005-83080 (Claim 1 and Fig. 1)).

Patent Document 1: Japanese Patent Laid-Open Publication No. 2005-83080 (Claim 1 and Fig. 1)

Disclosure of the Invention

Since the rod of the rod compaction device disclosed in claim 1 of Japanese Patent Laid-Open Publication No. 2005-83080 (Claim 1 and Fig. 1) is, after all, a uniaxial rod similar general rods, even when an improved pole is formed through compaction based on longitudinal vibration and lateral vibration of the rod as disclosed in claim 1 of Japanese Patent Laid-Open Publication No. 2005-83080 (Claim 1 and Fig. 1), its vibration width will be limited to proximities of the uniaxial rod so that this rod does not result in an effective solution of drawbacks owned by the prior art.

A technical subject to be solved is accordingly occurred to define an improvement range of the sand ground to be as large as possible, to allow simultaneous execution for reduction of repetitive operations of small pitch construction, and to enable reductions in construction costs, and it is an object of the present invention to solve such a subject.

The present invention has been suggested to achieve the above object, and the invention according to claim 1 provides a rod compaction device, the device being arranged to have a substantially box-shaped manner, and comprising a beam for mounting rods of which lower surface is fixedly attached with

a plurality of rods at constant intervals in a perpendicular manner and a vibro hammer fixedly attached to a central portion on an upper surface of the beam for mounting rods, wherein the vibro hammer is coupled to a main wire of a crawler crane such that the vibro hammer, the beam for mounting rods, and the rods can simultaneously perform vertical movements; the rod compaction device further comprising a box-shaped metallic holder maintaining the respective rods at constant intervals and allowing vertical movements of the rod, wherein the rods are fitted with play into play inserting holes of the rods provided at the holder and wherein the holder is coupled to an auxiliary wire of the crawler crane.

According to this arrangement, the plurality of rods is attached to the beam for mounting rods at constant intervals with respect to each other so that vibration of the vibro hammer will range to between the rods and outer peripheries thereof by synergic actions of the plurality of rod vibrations, therefore the vibrations are transferred to the sand ground.

Further, the rods fitted into the box-shaped metallic holder with play will always maintain the constant intervals while performing driving and pulling out actions with respect to the sand ground.

The invention according to claim 2 provides a rod compaction device, the device being arranged to have a substantially box-shaped manner, and comprising a beam for mounting rods of which lower surface is fixedly attached with a plurality of rods at constant intervals in a perpendicular manner and a vibro hammer fixedly attached to a central portion on an upper surface of the beam for mounting rods, wherein the vibro hammer is coupled to a main wire of a crawler crane such that the vibro hammer, the beam for mounting rods, and the rods can simultaneously perform vertical movements; the rod compaction device further comprising a box-shaped metallic holder maintaining the rods at constant intervals and allowing vertical movements of the rod, wherein the respective rods are fitted with play into play inserting holes of the respective rods provided in the holder, wherein a gate-shaped guide frame for guiding vertical movements of the beam for mounting rods is provided on both sides of the beam for mounting rods to stand face to face, wherein the box-shaped metallic holder is fixedly attached to proximate of lower end portions of leg portions of the gate-shaped guide frames, and wherein an upper frame of the gate-shaped guide frame is coupled to an auxiliary

wire of the crawler crane.

According to this arrangement, in addition to the actions achieved by the above-described invention according to claim 1, both sides of the beam for mounting rods to which the vibro hammer and the rods are mounted will be guided by the gate-shaped guide frame so that the respective rods will continuously maintain verticality by the gate-shaped guide frame even if verticality maintaining properties of the holder should be lacking while performing driving and pulling out operations of the rod so as to enable execution of driving and pulling out operations with respect to the sand ground.

The invention according to claim 3 provides a rod compaction device, the device being arranged to have a substantially box-shaped manner, and comprising a beam for mounting rods of which lower surface is fixedly attached with a plurality of rods at constant intervals in a perpendicular manner and a vibro hammer fixedly attached to a central portion on an upper surface of the beam for mounting rods, wherein the vibro hammer is coupled to a main wire of a crawler crane such that the vibro hammer, the beam for mounting rods, and the rod can simultaneously perform vertical movements; the rod compaction

device further comprising a box-shaped metallic holder maintaining the respective rods at constant intervals and allowing vertical movements of the rods, wherein the respective rods are fitted with play into play inserting holes of the respective rods provided in the holder, wherein the holder is arranged to be freely attachable/detachable with respect to an upper machinery of the crawler crane via an arm, and wherein the metallic holder is coupled to an auxiliary wire of the crawler crane.

According to this arrangement, in addition to the actions achieved by the above-described invention according to claim 1, even if the holder does not have a weight sufficient for maintaining vertical driving and pulling out of the rod, the arrangement position of the holder will be fixed at a predetermined position since the holder is coupled to an upper machinery of the crawler crane via an arm, therefore directions of driving and pulling out of the respective rods with respect to the sand ground will continuously be maintained in a perpendicular manner.

The invention according to claim 4 provides a rod compaction device, the device being arranged to have a substantially box-shaped manner, and

comprising a beam for mounting rods of which lower surface is fixedly attached with a plurality of rods at constant intervals in a perpendicular manner and a vibro hammer fixedly attached to a central portion on an upper surface of the beam for mounting rods, wherein the vibro hammer is coupled to a main wire of a crawler crane such that the vibro hammer, the beam for mounting rods, and the rods can simultaneously perform vertical movements; rod compaction device further comprising a box-shaped metallic holder maintaining the respective rods at constant intervals and allowing vertical movements of the rod, wherein the respective rods are fitted with play into play inserting holes of the respective rods provided in the holder, wherein the holder is couple to an auxiliary wire of a crawler crane and wherein a vibro tamper is mounted to a central portion on an upper surface of the holder.

According to this arrangement, in addition to the actions achieved by the above-described invention according to claim 1, as the vibro tamper on the holder is mounted, the surface layer of the sand ground will be compacted by shaking movements of the vibro tamper after performing the rod compaction method.

The invention according to claim 5 provides a rod compaction device wherein the holder is arranged to maintain the direction of vertical movements of the rod in a perpendicular manner by its own weight.

According to this arrangement, since the holder employed in the inventions according to claim 1 or 4 has a weight sufficient for enabling the rods to be driven into or pulled out from the sand ground in a perpendicular manner, the respective rods will be driven and pulled out in a continuously perpendicular manner to execute the rod compaction method.

In the invention according to claim 1, the plurality of rods is attached to the lower surface of the beam for mounting rods at constant intervals, respectively, the compaction area with respect to the sand ground by the rod compaction method will be increased, and since the respective rods are fitted with play into play inserting holes formed in a box-shaped metallic holder at constant intervals so as to assure driving and pulling out operations of the rods into and from the sand ground while maintaining the constant intervals between the rods, the constant intervals between the rods during driving and pulling out operations will be continuously maintained. In this manner, no

deflection will be caused by bending moments occurring when the rods are driven into or pulled out from the sand ground, and it will be possible to accurately perform the rod compaction method by use of a plurality of uniaxial rods.

In the invention according to claim 2, a gate-shaped guide frame is provided such that both sides of the beam for mounting rods of the invention according to claim 1 are guided to perform vertical movements, and since a lower portion of the gate-shaped guide frame is fixedly attached to the holder and coupled to an auxiliary wire of a crawler crane, the respective rods can, in addition to the effects of the invention according to claim 1, perform vertical movements while being apart from each other at constant intervals in a perpendicular manner so that compaction of the sand ground on the basis of mutual actions of vibrations of the rods can be achieved at an even higher accuracy.

In the invention according to claim 3, the holder is mounted to an upper machinery of the crawler crane via an arm, the position of the holder can be fixed so that it does not accidentally swing. In this manner, the rod compaction method can be accurately performed while continuously maintaining the

specified intervals between mutual rods and their verticality during driving and pulling out operations of the rods with respect to the sand ground.

In the invention according to claim 4, a vibro tamper is mounted to a central portion on an upper surface of the holder so that the vibro tamper is operated for performing simultaneously tampering of the surface layer after execution of the rod compaction method. In this manner, since tampering can be performed after the rod compaction, positional setting and moving time can be saved so that the time for completion and the costs involved in the assembly/dismantling can be more reduced than the tampering by use of machines separately. In performing tampering, the respective rods will function as a gate-shaped guide frame for the tamper so that lateral shift, which might cause trouble in performing tampering, can be prevented, and it is accordingly possible to perform effective compaction by tampering.

In the invention according to claim 5, the holder of the invention according to claim 1 is arranged to have a weight sufficient for holding vertical movements of the respective rods in a perpendicular

manner, the respective rods will be apart from each other at specified intervals, and driving and pulling out operations can be accurately performed in a perpendicular direction with respect to the sand ground even if the gate-shaped guide frame of the invention according to claim 2 is not provided, and it is possible to obtain, in addition to the effects of the invention according to claim 1, a favorable sand ground of even higher accuracy on an extensive scale and in a simultaneous manner.

Brief Explanation of the Drawings

Fig. 1 is a side view showing an overall view of a first embodiment of the present invention.

Fig. 2 is a front view showing a condition in which a rod compaction portion of the first embodiment of the present invention is set on a sand ground.

Fig. 3 is a front view showing a condition in which the rods are intruded from the condition of Fig. 2 into the sand ground up to a prescribed depth.

Fig. 4 is a side view showing an over all view of a second embodiment of the present invention.

Fig. 5 is a plain view of a catch hawk employed in the second embodiment.

Fig. 6 is a side view showing an overall view of a third embodiment of the present invention.

Fig. 7(a) is a plain view of a keeper used in the third embodiment, and Fig. 7(b) is a side view of (a).

Fig. 8 is a side view showing an overall view of a fourth embodiment of tamper combined use type of the present invention.

Fig. 9 is a side view showing a condition in which the fourth embodiment of tamper combined use type of Fig. 8 is set onto the sand ground.

Fig. 10 is a plain view showing a condition in which a vibro tamper used in the embodiments of Figs. 8 and 9 is set.

Fig. 11 is a side view showing steps for executing the rod compaction method using the present invention wherein a condition of preparing bolting is shown.

Fig. 12 is a side view in which rods are intruded from the condition of Fig. 11 into the sand ground up to a prescribed depth.

Fig. 13 is a side view showing a condition in which the rods are pulled out by a prescribed amount from the condition of Fig. 12.

Fig. 14 is a side view showing a condition in which the rods are re-driven by a prescribed amount from the condition of Fig. 13.

Fig. 15 is a side view showing a condition in which vibro hammering for compacting the surface layer portion is performed from the condition of Fig. 14.

Fig. 16 is a side view showing a conventional device used in a rod compaction method.

Fig. 17 is a front view of Fig. 16.

Figs. 18(a), 18(b), 18(c), 18(d), 18(e), 18(f) and 18(g) are explanatory views showing steps of a general rod compacting method.

Fig. 19 is an explanatory view showing one example of rod tip trace patterns of a general rod compaction method.

Best Mode for Carrying Out the Invention

The object of increasing the area of improvement for a sand ground by a rod compaction method as much as possible, of reducing repetitive operations of small pitch construction through simultaneous operation, and enabling reductions in construction costs has been solved by providing a rod compaction device, the device being arranged to have a substantially box-shaped manner, and comprising a beam for mounting rods which lower surface is fixedly attached with a plurality of rods at constant

intervals in a perpendicular manner and a vibro hammer fixedly attached to a central portion on an upper surface of the beam for mounting rods, wherein the vibro hammer is coupled to a main wire of a crawler crane such that the vibro hammer, the beam for mounting rods, and the rods can simultaneously perform vertical movements; the rod compaction device further comprising a box-shaped metallic holder maintaining the respective rods at constant intervals and allowing vertical movements of the rod, wherein the respective rods are fitted with play into play inserting holes of the rods provided at the holder and wherein the holder is coupled to an auxiliary wire of the crawler crane.

Embodiments of the present invention will now be explained in detail in accordance with Figs. 1 to 15. Fig. 1 is a side view showing a first embodiment of the present invention, Fig. 2 is a front view thereof, and Fig. 3 is a side view of main portions. In the drawings, 10 denotes a crawler crane used in the rod compaction method, wherein the crawler crane 10 is comprised of a base carrier 11, an upper machinery 12 mounted on the base carrier 11 on a freely turning manner, and a boom 13 pivotally attached to a front portion (right end portion of Fig. 1) of the

upper machinery 12 in a freely elevating manner. The boom 13 is coupled with a main wire 14 and an auxiliary wire 15 at respective jacks (not shown).

The embodiment as shown in Figs. 1 to 3 is arranged in that a vibro hammer 17 is fixedly coupled onto a beam 16 for mounting rods formed in a substantially planar rectangular-shaped manner, wherein two rods 18, 18 are respectively fixedly coupled to a lower surface thereof at a specified interval with respect to each other. In other words, by disposing the rods 18, 18 proximate of both end portions of the beam 16 for mounting rods, the respective rods 18, 18 can be fixedly coupled to the beam 16 for mounting rods at a specified interval with respect to each other. The rods 18 are comprised of steel pipe rods or of H-section steel.

The respective rods 18, 18 of the present invention are shaped in a block-like shape such that the rods 18, 18 maintain a specified interval with respect to each other and such that driving and pulling out operations can be performed in perpendicular directions when the respective rods 18, 18 are driven into or pulled out from a sand ground G to be improved by the rod compaction method, and a substantially rectangular-shaped holder 19 is

provided in which there are bored play inserting holes 19a, 19a for the respective rods 18, 18 proximate of both end portions of the holder 19, wherein by above-described fitting corresponding respective rods 18, 18 into the play inserting holes 19a, 19a with play, the respective rods 18, 18 will be driven into and pulled out in vertical directions while maintaining a specified interval with respect to each other.

In this respect, according to the present embodiment, the number of rods 18 is not limited to two, but it is also possible to form the holder 19 to be of substantially square-shaped manner wherein four rods 18, 18, 18, 18 are fixedly attached to proximities of four corners of the holder 19, whereby rod compaction can be performed on a more extensive scale.

In this manner, the holder 19 is arranged in that the rods 18, 18 are fitted therein with play, and in that at least both end portions are fixedly attached to proximities of lower end portions of two opposing leg portions 20a, 20a of a gate-shaped guide frame 20 to be formed uniformly with the gate-shaped guide frame 20. In this respect, lower end portions 20b, 20b of the leg portions 20a, 20a are formed to project

from the lower surface of the holder 19. An upper frame 20c of the gate-shaped guide frame 20 is coupled to the auxiliary wire 15 while the vibro hammer 17 is coupled to the main wire 14 such that they can be individually moved in a perpendicular manner.

Further, both edge portions of the beam 16 for mounting rods are engaged at both leg portions 20a, 20a of the gate-shaped guide frame 20 so that the beam 16 for mounting rods is guided by the gate-shaped frame 20 to be vertically movable in a perpendicular manner. In this manner, the rod compaction portion A of this embodiment is formed.

When setting the rod compaction portion A on a sand ground G to be improved, the rod compaction portion A is first disposed at the target point by the crawler crane 10 as shown in Fig. 1, and the lower end portions 20b, 20b of the gate-shaped guide frame 20 are then entered into the ground surface layer portion as shown in Fig. 2 such that the gate-shaped guide frame 20 is fixed on the sand ground G in a perpendicular manner, whereupon the beam 16 for mounting rods can perform vertical movement in perpendicular directions while being guided by the gate-shaped guide frame 20 by actions of the main wire 14 as shown in Fig. 3. At this time, the gate-shaped

guide frame 20 is suspended by the auxiliary wire 15 of the crawler crane 10 for preventing concurrent descending thereof accompanying the intrusion of the rods 18, 18 into the sand ground G.

In this respect, while construction using a rod compaction method is also explained in the prior art, construction using the rod compaction method according to the present invention will be explained later in accordance with Figs. 11 to 16.

Figs. 4 to 5 show a second embodiment, wherein Fig. 4 is a side view and Fig. 5 is a plain view of a catch hawk 21. The catch hawk 21 is arranged similar to the holder 19 so as to fit the rods 18 therein with play for maintaining specified intervals between the rods 18. The present embodiment differs from the embodiment as shown in Figs. 1 to 3 in that the catch hawk 21 employs four rods 18, 18, 18, 18, in that it comprises play inserting holes 19a, 19a, 19a, 19a for the respective rods 18, 18, 18, 18 for maintaining specified intervals between the four rods 18, 18, 18, 18, in that no gate-shaped guide frame 20 is provided, and in that the rod compaction portion B of the present embodiment is arranged by coupling a rear end portion of the catch hawk 21 that corresponds to the holder

19 of the first embodiment to the upper machinery 12 of the crawler crane 10 via an arm 22.

When the rod compaction portion B is placed on to a sand ground to be improved, the rods 18, 18, 18, 18 are arranged to perform vertical movements in a perpendicular manner while maintaining specified intervals with respect to each other similar to the above-described embodiment since the position of the catch hawk 21 is fixed.

Figs. 6 and 7 further show a third embodiment of the present invention, wherein Fig. 6 is a side view thereof, Fig. 7(a) a plain view of a keeper 23 corresponding to the holder 19 and the catch hawk 21, and Fig. 7(b) is a side view thereof.

The present embodiment differs from the first and second embodiments in that it does not comprise the gate-shaped guide frame 20, and in that the keeper 23 is not coupled to the upper machinery 12 of the crawler crane 10 by the arm 22. Accordingly, the keeper 23 of a rod compaction portion C according to the third embodiment is comprised by a metallic heavy item having a substantially square shape, wherein play inserting holes 19a, 19a, 19a, 19a for the rods 18, 18, 18, 18 are provided proximate of four corners such that the rods 18, 18, 18, 18 are respectively

fitted therein with play. The rods 18, 18, 18, 18 fitted into the keeper 23 with play will maintain specified intervals between each other by the own weight of the keeper 23, and the keeper is comprised as a heavy item having a weight sufficient for allowing vertical movements of the rods in a perpendicular manner.

As described above, the keeper 23 is comprised of a metallic heavy item formed to have a substantially square shape, and while an intermediate portion thereof is formed in a girder-shaped manner, it is not limited to such an arrangement. Further, pipes 23a, 23a, 23a, 23a forming the respective play inserting holes for the rods 18, 18, 18, 18 are fixedly formed proximate of four corners of the keeper 23, wherein the respective rods 18, 18, 18, 18 corresponding to the pipes 23a, 23a, 23a, 23a are fitted therein with play, respectively, and the respective rods 18, 18, 18, 18 are arranged to perform vertical movements in a perpendicular manner while maintaining specified distances via the pipes 23a, 23a, 23a, 23a.

Figs. 8 to 10 further show a fourth embodiment of the present invention, wherein Figs. 8 and 9 are side views thereof, and Fig. 10 is a plain view showing

a condition in which a vibro tamper 24 is mounted to a central portion of the keeper 23.

As described above, the rod compaction portion D of the present embodiment differs from the rod compaction portion C of the third embodiment in that a vibro tamper 24 is fixedly coupled to a central portion of the keeper 23 in the rod compaction portion C of the third embodiment, and in that it is further coupled to an auxiliary wire 15 of the crawler crane 10, while the remaining arrangements are identical to those of the rod compaction portion C of the third embodiment.

Steps of the rod compaction method using the present invention will now be explained in accordance with Figs. 11 to 15. In this respect, while steps of rod compaction using the rod compaction portion A of the first embodiment employing the gate-shaped guide frame 20 will here be explained from among the rod compaction portions A, B, C and D as shown in each of the first to fourth embodiments, the steps will be common to all of the rod compaction portions B, C and D of the other embodiments so that steps of the rod compaction method using these rod compaction portions B, C and D will be omitted here.

A. Preparations of Bolting (Fig. 11)

The rod compaction portion A is guided to a sand ground G to be improved by the crawler crane 10 and set. For the setting, the gate-shaped guide frame 20 is first descended by driving the crawler crane 10 to drive lower end portions 20b, 20b of both leg portions 20a, 20a of the gate-shaped guide frame 20 into the surface layer portion of the sand ground G in a perpendicular manner so as to fix the position of the holder 19. In this respect, since the catch hawk 21 is fixed to the upper machinery 12 of the crawler crane 10 via the arm 22 instead of the gate-shaped guide frame in case of the second embodiment, the position of the set catch hawk 21 will be fixed. In case of the third and fourth embodiments, the set position of the keeper 23 is fixed by the own weight of the keeper 23.

In this manner, when the lower end portions 20b, 20b of both leg portions 20a, 20a of the gate-shaped guide frame 20 of the rod compaction portion A of the first embodiment are intruded into and fixed within the sand ground G, the gate-shaped guide frame 20 is suspended to such an extent with which concurrent descending can be prevented when winding the auxiliary wire 15 of the crawler crane 10 and intruding the rods 18.

B. Intrusion of Rods (Fig. 12)

The vibro hammer 17 is actuated to intrude the rods 18 up to a prescribed depth. Accompanying the intrusion of the rods 18, the sand ground G will settle such that refill sand P, P... is input to the point of settling using a tractor shovel 26.

C. Pulling of Rods (Fig. 13)

The rods 18 are pulled out by a prescribed amount U_m of pulling while maintaining the vibro hammer 17 in operation. Also during this time, the sand ground G is gradually compacted by vibration transmitted to the rods 18 by actuation of the vibro hammer 17.

D. Re-driving (Fig. 14)

The rods 18 are re-driven up to the prescribed re-driving amount D_m while maintaining the vibro hammer 17 in operation. At this time, the sand ground G is tampered with the tip end portions of the rods 18 while the sand ground G is compacted by synergetic actions with the vibration of the rods 18.

Since the surface layer of the sand ground G is settled accompanying the re-driving, rod pulling out and re-driving processes are repeated while filling the refill sand P, P... to the settled portion using the tractor shovel 26, and compacting of the sand ground G is performed until the prescribed ground

(levee crown) is reached.

E. Vibro Tampering (Fig. 15)

Since the compaction by the rod compaction method tends to be insufficient at portions of approximately 2 m from the surface layer, the rods 18 are detached and replaced by a tampering plate 25, or vibro tampering is performed using the vibro tamper 24 while leaving the bottom surface of the beam 16 for mounting rods for performing compaction for 2 m of the surface layer so that compaction of the sand ground G is performed from the prescribed depth up to the surface layer.

In this respect, the present invention can be variously altered unless departing from the spirit of the present invention, and it can be well understood that the present invention also covers those alterations.

Industrial Applicability

The device for vibration compaction of sand grounds of the present invention is intended for use for sand grounds that can be compacted by longitudinal and lateral vibration, is mainly applicable to vibration compaction of sand grounds having a particle size of not more than 74μ and a content rate of not more than 35%, and is used for compaction of

foundations of various constructions such as
buildings, roads and tanks and backfill portions of
revetments or retaining walls.

What is claimed is:

1. A device for vibration compaction of sand grounds, the device being arranged to have a substantially box-shaped manner, and comprising a beam for mounting rods which lower surface is fixedly attached with a plurality of rods at constant intervals in a perpendicular manner and a vibro hammer fixedly attached to a central portion on an upper surface of the beam for mounting rods, wherein the vibro hammer is coupled to a main wire of a crawler crane such that the vibro hammer, the beam for mounting rods, and the rods can simultaneously perform vertical movements; the rod compaction device further comprising a box-shaped metallic holder maintaining the respective rods at constant intervals and allowing vertical movements of the rod, wherein the respective rods are fitted with play into play inserting holes of the respective rods provided at the holder and wherein the holder is coupled to an auxiliary wire of the crawler crane.

2. A device for vibration compaction of sand grounds, the device being arranged to have a substantially box-shaped manner, and comprising a beam for mounting rods of which lower surface is fixedly attached with a plurality of rods at constant

intervals in a perpendicular manner and a vibro hammer fixedly attached to a central portion on an upper surface of the beam for mounting rods, wherein the vibro hammer is coupled to a main wire of a crawler crane such that the vibro hammer, the beam for mounting rods, and the rods can simultaneously perform vertical movements; the rod compaction device further comprising a box-shaped metallic holder maintaining the respective rods at constant intervals and allowing vertical movements of the rod, wherein the respective rods are fitted with play into play inserting holes of the respective rods provided at the holder, wherein a gate-shaped guide frame for guiding vertical movements of the beam for mounting rods is provided on both sides of the beam for mounting rods to stand face to face, wherein the box-shaped metallic holder is fixedly attached to proximities of lower end portions of leg portions of the gate-shaped guide frames, and wherein an upper frame of the gate-shaped guide frame is coupled to an auxiliary wire of the crawler crane.

3. A device for vibration compaction of sand grounds, the device being arranged to have a substantially box-shaped manner, and comprising a beam for mounting rods of which lower surface is

fixedly attached with a plurality of rods at constant intervals in a perpendicular manner and a vibro hammer fixedly attached to a central portion on an upper surface of the beam for mounting rods, wherein the vibro hammer is coupled to a main wire of a crawler crane such that the vibro hammer, the beam for mounting rods, and the rods can simultaneously perform vertical movements; the rod compaction device further comprising a box-shaped metallic holder maintaining the rods at constant intervals and allowing vertical movements respective of the rod, wherein the rods are fitted with play into play inserting holes of the respective rods provided at the holder, wherein the holder is arranged to be freely attachable/detachable with respect to an upper machinery of the crawler crane via an arm, and wherein the metallic holder is coupled to an auxiliary wire of the crawler crane.

4. A device for vibration compaction of sand grounds, the device being arranged to have a substantially box-shaped manner, and comprising a beam for mounting rods of which lower surface is fixedly attached with a plurality of rods at constant intervals in a perpendicular manner and a vibro hammer fixedly attached to a central portion on an upper

surface of the beam for mounting rods, wherein the vibro hammer is coupled to a main wire of a crawler crane such that the vibro hammer, the beam for mounting rods, and the rods can simultaneously perform vertical movements; rod compaction device further comprising a box-shaped metallic holder maintaining the respective rods at constant intervals and allowing vertical movements of the rod, wherein the respective rods are fitted with play into play inserting holes of the respective rods provided at the holder, wherein the holder is couple to an auxiliary wire of a crawler crane and wherein a vibro tamper is mounted to a central portion on an upper surface of the holder.

5. The device for vibration compaction of sand grounds according to claim 1 or 4, wherein the holder is arranged to maintain the direction of vertical movements to be perpendicular by its own weight.