ABSTRACT OF THE DISCLOSURE

A combined vibratory pile driver and extractor has a yoke assembly connected to a hoisting cable and a body assembly attached to a pile. The pile is subjected to vibrations generated by the rotation of eccentric weights mounted on the body. When the weight of the mechanism rests on the pile, the pile is driven into the ground. With the cable exciting an upward pull on the yoke, a driven pile can be extracted from the ground. To prevent impacts between yoke and body when pile driving and to suppress cable vibrations when pile extracting, the yoke is connected to the body by two separate sets of spring means. The first set has a defined stiffness that is sufficient to resist the inertial tendency of the yoke to separate from the body when driving a pile, but not sufficient to prevent separation of yoke and body by a distance greater than the maximum amplitude of the vibrations of the body when extracting a pile in response to minimum upward pull of the cable on the yoke. The second set of spring means has substantially greater stiffness than the first to suppress cable vibrations when substantially upward pull of the cable is required to extract a pile.

This invention relates to a resilient yoke mounting for use with a combination vibratory pile driver and extractor of the type in which revolving eccentric weights create an up and down motion that is imparted to a pile, either for driving or extracting it. The mechanism includes a body assembly that can be attached to the pile and vibrated by synchronized rotation of eccentric weights mounted on the body. To the top of the body assembly is connected a yoke assembly, and to that is attached a hoisting cable for manipulating the driver-extractor mechanism and for applying an upward pulling force thereto for extracting a pile from the ground. The yoke and body assemblies can be rigidly connected together, however, because the hoisting cable would then be subjected, during pile extracting, to severe vibrations that would not only whip and strain the cable itself but also possibly damage the hoisting machinery. Accordingly, it has been customary to connect the body and yoke assemblies by resilient spring means.

Such spring means must be stiff enough to hold the yoke tightly against the body, or more usually against a resilient pad or cushion disposed between the yoke and body, during pile driving operations when the weight of the driver-extractor substantially rests on the pile and is effective, together with the vibrations imparted to the pile, to force the pile into the ground. During this operation, there is a tendency for the yoke, because of its own inertia, to separate from the body at the end of each upward vibratory movement. If the springs are not stiff enough to restrain the yoke from doing so, then yoke and body will either bang against each other or against the resilient pad between them, to the damage of the engaging parts.

On the other hand, during the extracting operation, the cable not only supports the entire weight of the driver-vibrator but also applies an additional upward pulling force to help extract the pile from the ground. If the spring means joining yoke and body are too stiff, then vibrations will be transmitted directly to the cable and ultimately to the hoisting apparatus, causing undesirable wear on those elements. Moreover, if the spring means are of some intermediate stiffness that will permit some slight separation between yoke and body during pile extracting, but a separation that is less than the maximum amplitude of the vibrations, then yoke and body will again bang each other, or the resilient pad between them. In other words, when extracting piles, the spring means should not be so stiff as to prevent the upward pull of the cable from separating the yoke and body by an amount greater than the maximum amplitude of the vibrations generated by the revolving eccentric weights.

Herein, these seemingly irreconcilable conditions of spring stiffness were met by tightening the spring means to increase their stiffness before the beginning of each pile driving operation and by loosening them again to reduce their stiffness before the beginning of each extracting operation. Since there are multiple spring means connecting the yoke and body, considerable time is lost in adjusting them between the different operations. In fact, the loss of time becomes intolerable when the apparatus is used in conjunction with vibratory pile driving in which it is otherwise most qualified, that is in probing unknown soil conditions in which a brief period of pile extracting precedes a period of pile extracting that in turn followed by relocating the pile and renewed pile driving.

It is accordingly among the objects of the present invention to provide a resilient mounting between the yoke and body assemblies of a combined vibratory pile driver and extractor that will provide sufficient spring stiffness to prevent substantial separation of yoke and body during pile driving operations and, without requiring any adjustment, will provide sufficient spring resilience to permit separation of those elements by an amount greater than the maximum amplitude of the vibrations of the driver-extractor during pile extraction operations.

Other objects of the invention will be apparent from the following description of a preferred embodiment in connection with the attached drawings, in which:

FIG. 1 is a front elevation of a combined vibratory pile driver and extractor, with some parts broken away to provide a fragmentary view of the resilient mounting of this invention; and

FIG. 2 is a fragmentary side-elevation, partly in section, of a portion of the resilient mounting shown in FIG. 1.

Referring to the drawings, FIG. 1 shows a generally conventional combined pile driver and extractor, having a body assembly I and rigidly attached thereto a head 2 adapted to grip the upper end of a pile (not shown) and to subject it to periodic vibrations for driving it into the ground or for extracting it from the ground. On the body assembly are mounted a plurality of eccentric weights 3 which revolve in opposite directions in phased synchronization on horizontal shafts 4 to generate resultant vibrations in an up and down direction, those in other directions canceling out. Motors 6 for rotating the eccentric weights through suitable drives are supported in side cases 7, which are pivotally and resiliently suspended on either side of the body assembly. A spring box 8 of rectangular cross section forms the upper part of the body assembly. An abutment member 9 is rigidly connected to the top 10 of this box.

A yoke assembly 11 is resiliently supported by the spring means of this invention on the body abutment member 9. The lower part of the yoke forms a spring housing that includes front and back plates 12, side plates 13, and an abutment member 14 at the bottom of the housing. Preferably, a resilient pad 16 is disposed between the abutments 9 and 14. The upper part of the yoke is
provided with pin means 17, to which is attached a cable 18 for lifting the driver-extractor and for applying an additional upward pull thereon when extracting piles from the ground.

The yoke and body assemblies are held in vertical alignment with each other and are resiliently interconnected by a plurality of spaced parallel rods 21 slidably extending through holes in the body and yoke abutment members 9 and 14, and in the pad 16; and by an upper set 22 of compression coil springs and a lower set 23 of similar springs, each set surrounding the rods 21 and held thereon by spring guide and retainer plates 24 slidably mounted on the rods and by nuts 26 threaded on the ends of the rods. By adjusting the nuts, the stiffness of both sets of springs can be varied within desired limits.

In the embodiment shown in the drawings, the upper springs 22 contained within the spring housing of the yoke assembly have a stiffness approximately one half that of the lower springs 23 in the spring box on the body assembly. If desired, the location of these sets of springs could be reversed.

The stiffness of the upper (i.e., weaker) springs 22 is such that they will hold the abutment members 9 and 14 tightly against each other, or against the resilient pad 16, when driving a pile. During such operation, there is either no tension on the hoisting cable 18 or only such slight tension as may be initially required to support the driver-extractor and its connected pile. In other words, the only substantial force tending to separate the yoke and body assemblies under pile driving conditions is the upward force resulting from the inertia of the yoke assembly, which tends to continue moving upwardly at the end of each upward cycle of vibration and thereby to move away from the body assembly that is positively urged downwardly by the inertial impulses of the revolving eccentric weights. It is this separating force that the upper set of springs 22 is designed to overcome. Because of the much greater stiffness of lower springs 23, under the conditions just stated the deformation of springs 23 is slight and the operative resilient connection between the yoke and body assemblies is substantially limited to the upper springs 22.

Springs 22 are soft enough, however, to assure that the normal minimal upward pull of the cable required for extracting piles from the ground will separate the yoke and body abutments from each other, or one of them from the resilient pad 16, by an amount greater than the maximum amplitude of the vibrations imparted to the body assembly by the rotating weights. Such normal minimal upward pull will, of course, vary with soil conditions, the shape and size of the pile, and the depth to which the pile was previously driven. A broad range of such variables can be accommodated by the occasional tightening or loosening of nuts 26 on the ends of the rods to adjust the stiffness of both sets of springs.

Since an even greater upward pull may be exerted by the cable under less favorable conditions of pile extraction, means are provided for positively limiting the compression of the upper spring means 22 and for transferring the larger pulling forces of the cable to the stiffer lower set of springs 23 housed in the body assembly. Such means for limiting the compression of the upper springs 22 may include cylindrical skirts 31 welded to the underside of the upper spring plate 24 and extending downwardly around the outer coil of each spring 22 in the upper set of springs (there being four springs in that set as shown in the drawings, one for each of the four rods 21). These skirts extend downwardly far enough to strike the upper surface of yoke abutment member 14 when the springs have been compressed to the extent necessary to provide the desired separation between the yoke and body abutment members and before the coils of the upper springs 22 have completely bottomed.

It is among the advantages of the present invention that a combined vibratory pile driver and extractor, in which the yoke is resiliently connected to the body as herein described, can be used for alternately driving and extracting piles under most conditions met in actual practice without intervening adjustments of spring stiffness to assure retention of the yoke on the body during pile driving operations and the adequate separation of the elements during pile extracting operations. As a result, the potentialities of this type of equipment can be made more fully realized, without the inconvenience, delay, and expense of readjusting the spring stiffness with each and every change in operations as required by conventional yoke mountings.

What is claimed is:

1. A combined vibratory pile driver and extractor that includes a body assembly the lower part of which is adapted to be connected to the upper end of a pile and to subject the pile to vibrations generated by rotating eccentric weights on the body and the upper part of which is provided with a first abutment member, and that also includes a yoke assembly the upper part of which is adapted to be attached to a hoisting cable and the lower part of which is provided with a second abutment member, the improvement comprising means for resiliently interconnecting the two abutment members to reduce substantially impacting engagements between them and to suppress or reduce vibrations transmitted to the cable, said means including: a plurality of spaced parallel rods slidably passing through both abutment members, retaining members, and the adequate separation of the rods, first spring means resiliently spacing one end of each rod from one of the abutment members and second spring means resiliently spacing the other end of each rod from the other abutment member, the first spring means having a defined stiffness substantially less than that of the second spring means, such stiffness being sufficient to prevent substantial inertial separation of the two abutment members when the vibratory mechanism is driving a pile but not sufficient to prevent separation of the two abutment members by a distance greater than the maximum amplitude of said vibrations when the vibratory mechanism is extracting a pile in response to an upward pull exerted on the yoke by the cable.

2. Apparatus according to claim 1 that also includes a pad of resilient material between the two abutment members.

3. Apparatus according to claim 1, in which the retaining means on at least one end of each rod includes means threadably received thereon for adjusting the stiffness of the retained spring means.

4. Apparatus according to claim 1 that also includes means for positively limiting the deformation of the first spring means to a predetermined load and for transferring loads in excess of that amount to the second spring means.

5. Apparatus according to claim 4, in which said limiting means include rigid spacer elements disposed parallel to the axes of the spring means.

References Cited

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