

Method for Dynamic Load Testing

Field of the Invention

[0001] The present invention relates to dynamic load testing. In particular, the present invention relates to method to perform dynamic load testing for testing capacity of foundation piles and apparatus therefor.

Background

[0002] It is extremely important to carefully study load bearing capacity of foundation piles of a building. The load bearing capacity of foundation piles gives information on how sturdy the foundation piles can withstand loads being exerted on them, thus determining the strength of the building supported by the piles.

[0003] Static load testing and dynamic load testing are the most common methods performed to evaluate the load bearing capacity of foundation piles. In static load testing, a weight is placed on the head of the pile for a period of testing time, exerting a progressive load onto the pile. Subsequently, the amount of sinking of the pile is measured regularly over the testing time period. The static load testing is considered time consuming that it generally takes long time to perform such test and obtain a meaningful result therefrom.

[0004] Compared to static load testing, the testing period of dynamic load testing is relatively shorter. In dynamic load testing, a force load is dynamically exerted onto the pile by dropping a weight onto the pile, transmitting an impulsive and brief force to the

pile. The effect of the force to the pile is measured and the load bearing capacity of the foundation piles is thus determined.

[0005] One conventional method to perform dynamic load testing is by means of having a crane to lift a ballast/hammer with certain weight and subsequently drop the ballast/hammer onto a pile. A transducer is installed to the pile to record the impact of the weight of the ballast/hammer to the pile.

[0006] US 5,325,702 concerns a machine and a method for determining load capacity of foundation piles. The machine comprises a framework resting on a mobile undercarriage. A guide-derrick, in which there is hung a ballast or weight to exert force on foundation pile to be tested, is hinge-mounted to the framework. The ballast or weight further comprises pair of springs to slowly transmit its load impact to the foundation pile.

[0007] US 2003/0122434 discloses a dynamic load testing means for foundation piles, which comprises a magnetostrictive vibrator. The magnetostrictive vibrator is connected to the head of the pile to be tested. As an electric current is fed into the vibrators, a strain occurs therein, producing vibrations in the pile. The vibrations being transmitted to the ground around the pile are recorded, and the load bearing capacity of the pile is thus determined.

Summary

[0008] It is an object of the present invention to provide a dynamic load testing apparatus and method which is simple, economical, and yet effective for testing load bearing capacity of foundation pile.

[0009] The dynamic load testing apparatus of the present invention comprises a detachable framework mounted on the ground across the foundation pile, wherein the detachable framework has a pair of vertical supports with the top ends connected by a reversed U- shaped frame, a winch attached to the reversed U-shaped frame of the framework, a clamp capable of holding and releasing a hammer towards the foundation pile, thereby exerting impact force on the foundation pile, the clamp is hooked onto the winch, such that the clamp can be adjusted vertically to a desired height, a steel guide casing axially aligned with the foundation pile, for vertical passage of the hammer, the steel guide casing having an upper and a lower end, wherein the upper end receives the hammer and the lower end is clamped to the foundation pile, a cover placed on the top of the foundation pile for protecting the foundation pile from breaking due to the impact force from the hammer and a transducer attached to the pile below the cover for measuring and recording the impact force from the hammer on the foundation pile. To clamp the foundation pile to the lower end of the steel guide casing, a plurality of hydraulic clamps or a plurality of screwed clamps are used.

[0010] In one embodiment, the transducer attached to the pile below the cover is Pile Driving Analyser (PDA)® or CAPWAP®.

[0011] In a further embodiment of the present invention, the dynamic load testing apparatus further comprises a crane to lift and connect the hammer to the clamp. The clamp is a hydraulic clamp, whilst the winch is a hydraulic winch comprising a pulley.

[0012] In one embodiment, the hammer further comprises means for hooking the hammer to the clamp. The hammer can be a solid shape or a cylinder bucket shaped hammer with X-shaped or +-shaped bars welded to the top sidewall of the hammer

[0013] In another embodiment of the present invention, the dynamic load testing apparatus comprises means for adjusting the height of the framework.

[0014] Another aspect of the present invention provides a method for performing dynamic load testing for a foundation pile. The method comprises the steps of installing a framework on the ground, across the foundation pile, the framework having a pair of vertical supports with the top ends connected by a reversed U-shaped frame, providing means attached to the reversed U-shaped frame of the framework for holding and releasing a hammer, installing a transducer on the foundation pile, connecting the hammer to the means attached to the reversed U-shaped frame and releasing the hammer towards the foundation pile, whereby the transducer records measurements of the impact of the hammer onto the foundation pile. The means for holding and releasing the hammer comprises a hydraulic clamp hooked onto a hydraulic winch having a pulley.

[0015] In a further embodiment, a crane is used to lift and connect the hammer to the means attached to the reversed U-shaped frame.

[0016] In another embodiment of the present invention, the step of installing the framework to the ground includes excavating and leveling the ground around the foundation piles for installing the framework thereto.

[0017] In a further embodiment, the step of installing the transducer on the foundation pile includes placing a cover on the top of the foundation pile.

Brief Description of the Drawings

[0018] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0019] **Fig. 1** illustrates a crane employed for dynamic load testing according to prior art;

[0020] **Fig. 2** illustrates a diagrammatic view of an apparatus for performing dynamic pile testing according to one embodiment of the present invention;

[0021] **Fig. 3** illustrates a longitudinal sectional view taken through the hammer in accordance with one embodiment of the present invention; and

[0022] **Fig. 3A** illustrates top view of the cylinder bucket shaped hammer in accordance with one embodiment of the present invention.

Detailed Description

[0023] The following descriptions of a number of specific and alternative embodiments are provided to understand the inventive features of the present invention.

It shall be apparent to one skilled in the art, however that this invention may be practiced without such specific details. Some of the details may not be described in length so as to not obscure the invention. For ease of reference, common reference numerals will be used throughout the figures when referring to same or similar features common to the figures.

[0024] **Fig. 1** illustrates a crane **100** employed for dynamic load testing according to prior arts. The crane **100**, with a certain loading capacity, comprises a boom **101** and a pulley line **102** engaged with a pulley **103**, mounted to the outer end of the boom **101**.

[0025] Still referring to **Fig. 1**, a hammer **104** is connected to the pulley line **102**. In this embodiment, weight of the hammer **104** is smaller than the maximum loading capacity of the crane, thus single pulley **103** and pulley line **102** are sufficient to hold the weight of the hammer **104**. In a further embodiment, when the weight of the hammer **104** meets the maximum loading capacity of the crane **100**, a plurality of pulley and pulley lines are to be used to hold the hammer **104**.

[0026] The operation of the crane **100** to perform the dynamic load testing is described as follows: the boom **101** lifts the hammer **104** connected to the pulley line **102** to a certain height. Afterwards, the pulley line **102** is moved downward and concurrently, the hammer **104** is dropped down and hits the foundation pile to be tested. As the hammer **104** hits the foundation pile, it simultaneously exerts an amount of impact force to the foundation pile. The effect of the force impacted to the foundation pile is measured and analyzed.

[0027] For a dynamic load testing, an engineer will need to design a theoretical value of impact force he would like to exert to the foundation pile. The value of the impact force exerted on the foundation pile is an important factor for determining the strength of the foundation pile, and it depends largely on the weight of the hammer as well as vertical speed of the falling hammer.

[0028] The foregoing crane utilization for dynamic load testing possesses some drawbacks, especially in its testing capacity and efficiency. One problem is related to the pulley and pulley line holding the hammer. The utilization of pulley and pulley line involves some friction, such that when the hammer is dropped, the friction decelerates the vertical speed of the falling hammer, thus decrease the impact force exerted on the foundation pile. The problem is even worsen when the weight of the hammer meets the maximum loading capacity of the crane, such that a plurality of pulley and pulley lines are being used to hold the hammer. More pulleys cause more friction to the falling hammer, and thus further decelerate vertical speed of the falling hammer and decrease the impact force exerted on the foundation pile. These problems affect the outcome of the dynamic load testing.

[0029] To deal with the foregoing issues, a crane with larger weight handling capacity is typically preferable so as not to cause any unexpected problems to the dynamic load testing. Nevertheless, the cost of using a larger crane is undoubtedly higher and thereby, it is not effective.

[0030] The present invention offers advantages upon the above-mentioned problems. The present invention discloses a method for dynamic load testing, wherein a crane is

still being used, yet the method is simple and capable of overcoming the above-mentioned problems related to the utilization of the crane.

[0031] **Fig. 2** illustrates a diagrammatic view of an apparatus **200** for performing foundation pile dynamic load testing, according to one embodiment of the present invention. The foundation pile to be tested **210**, which can be a driven pile or a bored pile, is installed in the ground **220**. The cross-section of the pile **210** may be round, square, rectangular or of any other shape.

[0032] Referring to **Fig. 2**, the apparatus **200** comprises a framework **201** mounted on the ground **220**. The framework **201** is a detachable framework that is easily assembled and disassembled. The framework **201** comprises a pair of vertical supports **201A**, with the top ends connected by a reversed U-shaped frame **201B**. The framework **201** also has means for adjusting its height to a desired level. The apparatus further comprises a cover **206** placed on the top of the pile **210**. The cover **206** can be made of metal plates or wooden plates. Below the cover **206**, recording means, such as transducer **208**, is attached to the pile **210**.

[0033] Still referring to **Fig. 2**, there is a winch, preferably a hydraulic winch **202** comprising a pulley **202A**, attached to the reversed U-shaped frame **201B** of the framework **201**. To the pulley **202A** of the hydraulic winch **202**, a hydraulic clamp **203** is attached. The hydraulic clamp **203** is capable of holding a hammer **204** and releasing the hammer **204** towards the foundation pile **210**. As the hydraulic clamp **203** is attached to the pulley **202A** of the hydraulic winch **202**, the hammer **204**, which

attached to the hydraulic clamp **203**, can therefore be raised upwardly or downwardly to a desired height.

[0034] The apparatus **200** is also equipped with a metal guide casing **205**. The metal guide **205** casing comprises a vertical track with an upper end **205A** and a lower end **205B**, wherein the upper end **205A** receives the hammer **204**, and the lower end **205B** clamped to the pile **210**. The metal guide **205** functions as vertical passage for the hammer **204**, so that the hammer **204** falls perpendicularly with respect to the ground and hits precisely at the cover **206**. In one embodiment of the present invention, it is preferable that the metal guide casing **205** is made of steel.

[0035] During the test, the metal guide casing **205** is clamped to the pile **210** using a plurality of hydraulic clamps **211** to securely engage the metal guide casing to the pile **210**. It is highly desired that the metal guide casing **205** is axially engaged to the pile **210**. In another embodiment, the plurality of hydraulic clamps **211** are interchangeable with a plurality of screwed clamps.

[0036] **Fig. 3** illustrates a longitudinal sectional view taken through the hammer **204** in accordance with one embodiment of the present invention. The hammer **204** of this embodiment is in shape of cylinder bucket. The interior of the hammer **204** is filled with heavy materials **300**.

[0037] **Fig. 3A** illustrates top view of the cylinder bucket shaped hammer **204** in accordance with one embodiment of the present invention. At the top of the cylinder bucket shaped hammer **204**, X-shaped bars or +-shaped bars **301** are welded to the

sidewall of the hammer **204**. On the bars **301**, there is provided means **302** for hooking the hammer **204** to the hydraulic clamp of the apparatus **200**.

[0038] It is to be understood that the cylinder bucket shape of the hammer **204** is merely an example, not a limitation. Hammer of any shape and design, such as solid shapes, might be used in the apparatus **200** of the present invention, as long as weight of the hammer is acceptable.

[0039] According to one embodiment of the present invention, the operation of the apparatus **200** according to the invention is as follows.

[0040] For testing the load capacity of the foundation pile **210**, the ground **220** in which the pile **210** is installed is excavated up and leveled to a certain depth from the ground level **220**. It is preferable that the depth is 1.5 meters. The excavation makes the head of the pile **210** exposed, and as such the cover **206** is then placed on top of the pile **210** to protect the pile **210** from breaking due to the impact force from the hammer **204**. After the cover **206** is covering the head of the pile **210**, the transducers **208** for measurement purposes are then installed below the cover **206**.

[0041] In one embodiment, Pile Driving Analyser (PDA®) or CAPWAP® is used as the transducer.

[0042] Subsequently, the framework **201** having the hydraulic clamp **203** and the hydraulic winch **202** comprising the pulley **202A**, is placed in the ground level **220** across the pile **210**, and yet is aligned with reference to the pile **210**. To ensure that the

hydraulic winch **202** and hydraulic clamp **203** of the apparatus **200** are vertically aligned with the foundation pile **210**, a plumb line is employed accordingly.

[0043] The steel guide casing **205** is then engaged to the pile **210**, with its lower end clamped to the pile **210** using a plurality of hydraulic clamps **211**. It is desired that the steel guide casing **205** is axially aligned with the pile **210**. The plurality of hydraulic clamps **211** are interchangeable with a plurality of screwed clamps.

[0044] Following installation of the framework **201**, a crane is used to lift the hammer **204**, and connect the hammer **204** to the hydraulic clamp **203**. Subsequently, the pulley **202A** will raise the hammer **204** to a predetermined height to begin the dynamic load testing. From the predetermined height, the hydraulic clamp **203** will be commanded to release the hammer **204**, letting the hammer **204** to fall freely, exerting impact force on the pile **210**. The impact force from the hammer **204** will not break the foundation pile **210** as the hammer **204** is protected by the cover **206**. Simultaneously, the effect of the impact force on the pile **210** is recorded by the transducer **208** and is analyzed afterwards. During the test, the crane is holding to the reversed U-shape frame **201B**, and after the dynamic load testing is done, the crane helps to dismantle the apparatus **200**. This configuration enhances the safety feature of the dynamic load testing of the present invention.

[0045] The apparatus **200** provides a simple and better method to perform a dynamic load testing. The apparatus **200** has an enhanced stability and safety feature, and yet it is simple and economical to utilize the apparatus **200** to perform a dynamic load testing

on a foundation pile. The apparatus **200** of the present invention also adds value to role of any given crane used during the dynamic load testing. The apparatus **200** is able to maximize utilization of the given crane, especially the loading capacity of the crane, for the dynamic load testing.

[0046] The above description illustrates various embodiments of the present invention along with examples of how aspects of the present invention may be implemented. While specific embodiments have been described and illustrated it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the present invention. The above examples, embodiments, instructions semantics, and drawings should not be deemed to be the only embodiments, and are presented to illustrate the flexibility and advantages of the present invention as defined by the following claims:

Claims

1. An apparatus for performing dynamic load testing for a foundation pile, the apparatus comprising:

a detachable framework mounted on the ground across the foundation pile, wherein the detachable framework has a pair of vertical supports with the top ends connected by a reversed U- shaped frame;

a winch attached to the reversed U-shaped frame of the framework;

a clamp capable of holding and releasing a hammer towards the foundation pile, whereby the hammer falls freely, hits the foundation pile and exerts impact force on the foundation pile, the clamp is hooked onto the winch, such that the clamp can be adjusted vertically to a desired height;

a steel guide casing axially aligned with the foundation pile, for vertical passage of the hammer, the steel guide casing having an upper and a lower end, wherein the upper end receives the hammer and the lower end is clamped to the foundation pile;

a cover placed on the top of the foundation pile for protecting the foundation pile from breaking due to the impact force from the hammer; and

a transducer attached to the pile below the cover for measuring and recording the impact force from the hammer on the foundation pile.

2. The apparatus of claim 1, further comprising a crane to lift and connect the hammer to the clamp.
3. The apparatus of claim 2, wherein the clamp is a hydraulic clamp.
4. The apparatus of claim 3, wherein the winch is a hydraulic winch.
5. The apparatus of claim 4, wherein the hydraulic winch further comprises a pulley.
6. The apparatus of claim 4, wherein the hammer further comprising means for hooking the hammer to the clamp.
7. The apparatus of claim 6, further comprising means for adjusting the height of the framework.
8. The apparatus of claim 7, wherein the lower end of the steel guide casing is clamped to the foundation pile by using a plurality of hydraulic clamps or a plurality of screwed clamps.
9. The apparatus of claim 8, wherein the hammer is a solid shape.
10. The apparatus of claim 8, wherein the hammer is a cylinder bucket shaped hammer with X-shaped or +-shaped bars welded to the top sidewall of the hammer.
11. The apparatus of claim 9 or 10, wherein the transducer is Pile Driving Analyser (PDA)® or CAPWAP®.

12. A method for performing dynamic load testing for a foundation pile, the method comprising the steps of:

installing a framework on the ground, across the foundation pile, the framework having a pair of vertical supports with the top ends connected by a reversed U-shaped frame;

providing means attached to the reversed U-shaped frame of the framework for holding and releasing a hammer;

installing a transducer on the foundation pile;

connecting the hammer to the means attached to the reversed U-shaped frame;
and

releasing the hammer towards the foundation pile, whereby the transducer records measurements of the impact of the hammer onto the foundation pile.

13. The method of claim 12, wherein a crane is used to lift and connect the hammer to the means attached to the reversed U-shaped frame.

14. The method of claim 13, wherein installing the framework to the ground includes excavating and leveling the ground around the foundation piles for installing the framework thereto.

15. The method of claim 13 or 14, wherein installing the transducer on the foundation pile includes placing a cover on the top of the foundation pile.

16. The method of claim 15, wherein the means for holding and releasing the hammer comprises a hydraulic clamp and a hydraulic winch comprising a pulley, wherein the hydraulic clamp is attached to the pulley of the hydraulic winch.