

Compression Load Test On A Pile Using Reaction Anchors

Field of Invention

[001] The present invention relates to compression load testing of a pile to determine its load bearing capacity. In particular, the compression load test makes use of reaction anchor piles.

Background

[002] Fixed structures, such as buildings, bridges, offshore oil installations and so on, must be built on sturdy foundations. These foundations, in turn, must be supported by piles driven into the ground. To ascertain the designed load bearing capacity of a pile, a compression load test is conducted on each pile.

[003] Conventionally, a compression load test is conducted by stacking dead weights on a skid 30. The skid 30 is supported on blocks 32 so that the centre of the skid is substantially above a test pile 10. The load on the skid exceeds the designed load, and by jacking the skid up with jacks 26, a designed test load is exerted onto the test pile 10. FIG. 1A shows the conventional method 5 of conducting the compression load on the test pile 10. A drawback of such a static load test is that many concrete blocks 40 have to be lifted and loaded onto the skid 30 to conduct the load test and then the concrete blocks are unloaded after the load test is completed. Typically, a number of load cells 20 are used to determine the load on the test pile. This drawback is further limited by the small capacity of a crawler crane erected at the construction site; such manner of loading and unloading the concrete blocks is time consuming and is fraught with workplace safety concern.

[004] In an approach, US patent no. 6,363,776, issued to Gary Reinert, discloses the use of a pulling rod to expand anchoring plates disposed at a bottom end of a reaction anchor to increase the capacity of the reaction anchor, as shown in FIG. 1B. In US 6,363,776, loads on the reaction anchors are transferred to I-beams by means of screw threads and nuts.

[005] It can thus be seen that there exists a need for a simpler and robust manner to conduct compression load tests on piles at the construction site.

Summary

[006] The following presents a simplified summary to provide a basic understanding of the present invention. This summary is not an extensive overview of the invention, and is not intended to identify key features of the invention. Rather, it is to present some of the inventive concepts of this invention in a generalised form as a prelude to the detailed description that is to follow.

[007] The present invention seeks to provide several set-ups for conducting compression load tests on piles at a construction site. These set-ups are simple to form and to dismantle. Components of some of the set-ups are removeable and reuseable.

[008] In one embodiment, the present invention provides a compression load test for a pile using reaction anchors. The set-up comprises: a test pile; a tension member connected substantially vertically on top of each of two or more reaction anchors, wherein the two or more reaction anchors are disposed around the test pile; a plurality of transfer beams being arranged in a formation so that a middle section has a predetermined moment of inertia and rigidity, and the middle section is disposed substantially above a top of the test pile while two peripheral ends of a top transfer beam in the formation are connected to a pair of associated tension members via an aperture formed in each tension member; and one or more actuator(s) for applying a load on the test pile against the transfer beam formation or against the associated tension members.

[009] In another embodiment, the present invention provides a method for conducting compression load test on a pile using reaction anchors. The method comprises: disposing two or more reaction anchors around a test pile and connecting a tension member substantially vertically on top of each reaction anchor; arranging a plurality of transfer beams in a formation to transmit reaction loads from the two or more tension members to a top of the test pile; connecting a top beam of the transfer beams formation to the associated tension members; and applying a load above or below the transfer beam formation so that a predetermined test load is applied on the top of the test pile.

[0010] Preferably, the plurality of transfer beams is arranged in a substantially reversed triangle or reversed pyramid formation.

[0011] Preferably, each aperture is located near a top end of the associated tension member, such that the aperture is dimensioned to receive an end of the top transfer beam forming the base of the beam formation.

[0012] Preferably, when the reaction anchor is a reinforced concrete pile and the tension member is a steel beam, each tension member is connected to the associated reaction anchor via a predetermined number of reinforced steel bars being disposed around the tension member so that one end of each reinforced steel bar is welded to the tension member and the other end is embedded in concrete in the reaction anchor.

Brief Description of the Drawings

[0013] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0014] FIG. 1A illustrates a conventional method of load testing using dead weights, while FIG. 1B is an extract from US 6,363,776;

[0015] FIG. 2A illustrates a set-up for conducting compression load test on a test pile using reaction anchors according to an embodiment of the present invention; FIG. 2B-2E illustrate details of a tension member erected on an anchor pile for use in the set-up shown in FIG. 2A;

[0016] FIGs. 3A and 3B illustrate positions of the reaction anchors relative to a test pile;

[0017] FIGs. 4A and 4B illustrate the advantageous use of distributing forces on the transfer beam to maximize utility; and

[0018] FIG. 5 illustrates a set-up for conducting compression load test according to another embodiment of the present invention.

Detailed Description

[0019] One or more specific and alternative embodiments of the present invention will now be described with reference to the attached drawings. It shall be apparent to one skilled in the art, however, that this invention may be practised without such specific details. Some of the details may not be described at length so as not to obscure the invention. For ease of reference, common reference numerals or series of numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0020] FIG. 2A shows a setup 100 for conducting a compression load test on a test pile 110 using reaction anchors 120. As shown in FIG. 2A, two or four reaction anchors 120 are driven into or formed in the ground around the test pile 110 and vertical tension members 130 are connected to the top of the reaction anchors. A number of hydraulic jacks 26 or load actuators are disposed between a top of the test pile 110 and the load cells 20, and a series of load transfer beams 150a-150e are laid on top of the load cells in a reversed triangle or pyramid formation, with the ends of the top transfer beam 150e being received in apertures 132 formed near the top end of the associated tension members 130. For simplicity of illustration, only 5 layers of transfer beams 150 are shown in FIG. 2A. Depending on the diameter of the test pile 110 and the distances between the test piles 110 and reaction anchors 120, the numbers of layers of transfer beams 150 vary according to the force distributions on the transfer beams, the required strength and rigidity. To give the reader an idea on the magnitude of the setup and test load, the test and anchor piles are substantially 2 and 1.8 m in diameter respectively and the required test load is substantially 6400 tonnes or more.

[0021] Typically, the test piles 110 are round, and the reaction anchors 120 (variously known as reaction piles or anchor piles) are smaller or equal in diameter to the test pile. The distance between the centres of the reaction anchors 120 and the test pile 110 is usually 3 times the diameter of the test pile or a minimum of 2 m. FIGs. 3A and 3B show the relative positions between the test and reaction anchors. Such test and anchor piles

may be reinforced concrete bored piles. Other types of piles may be used, for example, precast concrete piles, I- or H-beams, pipes or caissons, and so on.

[0022] In practice, a plate 22 is disposed between the top of the test pile 110 and the hydraulic jacks 26. The plate 22 is rigid and is used as a datum for mounting dial gauges and scale rulers when determining movement of the test pile 110 during testing. Load cells 20 come in a range of capacities; usually load cells of the same capacity are used together and the number of load cells 20 may not correspond with the number of hydraulic jacks 26. When the numbers of load cells 20 and hydraulic jacks 26 do not correspond, another plate 24 is disposed between the hydraulic jacks 26 and the load cells 20. As illustrated in FIG. 2A, the reversed triangle or pyramid formation of the transfer beams 150a-150e provides a predetermined moment of inertia near the centre of the formation so that the beam formation can transfer a predetermined test load from the hydraulic jacks to the reaction anchors 120 safely and rigidly. By stacking the transfer beams in a formation, the forces on each transfer beam can be uniformly distributed or linearly spaced apart, depending on the required strength and rigidity. Schematically, the distributed loadings on the top beam 150e are shown in FIGs. 4A and 4B. In this way, the strength of each transfer beam 150a-150e can be maximized, and this allows optimum use of the transfer beams to transmit the designed test load to the reaction anchors 120. These transfer beams 150 may be made from I-beams, H-beams or fabricated box-beams with the required strength and rigidity.

[0023] As shown in FIG. 2A, the apertures 132 in the tension members 130 are larger in size than the ends of the top transfer beam 150e. The apertures 132 being bigger thus makes it easier for the workmen to setup the transfer beam formation and connect the top beam to the associated tension member 130. In practice, gaps between an upper surface of the top transfer beam 150e and a bearing plate 134 in the aperture 132 are not of the same distances, and shim plates may be disposed into some of these gaps so that the gaps are substantially the same distances. The gap distance must also be within both the stroke lengths of the hydraulic jacks 26 and movement of the test pile 110. Alternatively, before the load test commences, the gaps are taken up by using wedges between the shim plates. Also as shown in FIG. 2A, web plates 136 are provided above to the bearing plate 134 to give sufficient strength and rigidity to the bearing plate 134.

[0024] FIGs. 2B and 2C show views of the tension member 130 being erected on the reaction anchor 120. As shown in FIGs. 2B and 2C, the tension member 130 is made up of two I- or H-beams 130a so that the aperture 132 is formed through their web members. Location of the bearing plate 134 and web plates 136 are now more clearly shown in FIGs. 2B and 2C. FIG. 2D is a section through the web plates and bearing plate 134 showing lengths of fillet weld 138 additively add up to withstand half or a quarter of the test load that is, the tension load, taken up by each tension member 130. In addition, in FIG. 2B, shear plates 152 are provided at the ends of the top transfer beam 150e to withstand the concentrated bearing load. In another embodiment, the tension member 130 can be made up of one I- or H-beam, for example, with additional web members to ensure tensile stress is more uniformly distributed.

[0025] In FIG. 2B, the reaction anchor 120 is illustrated by a reinforced bored pile. Reinforced steel bars 122 are welded around the lower end of each tension member 130 so that during casting of the reaction anchors 120, the other ends of the reinforced steel bars 122 are embedded in concrete to a predetermined depth to transfer tension load taken up by the tension member 130 to the reaction anchors 120; in this manner, the load taken up by each tension member 130 is safely and strongly transferred to the reaction anchor 120. For illustration, FIG. 2E is a section across the lower part of the tension member 130 showing the use of 40 numbers of 40 mm reinforced steel bars 122 to evenly transfer substantially 1600 tonnes or more of tension from the tension member 130 to the reaction anchor 120 (in FIG. 2B, only 3 of the reinforced steel bars 122 are illustrated). Also as shown in FIGs. 2B and 2E, staggered fillet welds 124 are used to join the reinforced steel bars 122 to surfaces of the tension members 130; as an example, each fillet weld 124 has a substantially 10 mm leg length and is substantially 200 mm long. In use, the reinforced steel bars 122 may remain exposed, as illustrated in FIG. 2B or they may be covered in concrete as illustrated in FIG. 2C. In another embodiment, the tension member 130 may be connected to the reaction anchors 120 by using various sizes and numbers of reinforced steel bars to meet the designed tension load.

[0026] FIG. 5 shows a set-up 100a according to another embodiment of the present invention. As shown in FIG. 5, the setup 100a is a variation of that shown in FIG. 2A in

that each hydraulic jack 26 is now disposed in the space between the top transfer beam 150e and the bearing plate 134 of the associated aperture 132. An advantage in the use of this setup 100a is that the use of shim plates and wedges is obviated as the contact gaps in the apertures are taken up as the hydraulic jacks 26 are extended before the test load is applied onto the transfer beam formation. In another embodiment, depending on the size of the tension members and the apertures, more than one hydraulic jack 26 may be used inside each aperture 132. Advantageously, these hydraulic jacks 26 may be mounted on the associated bearing plate 134 in an inverted manner. With the hydraulic jacks 26 mounted on the bearing plates 134, this set-up enhances workplace safety by not requiring workmen to position the hydraulic jacks or to work at a height above the ground.

[0027] 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 invention. For example, the number of reaction anchors may be 3 or more and the transfer beam formation may be prismatic with a polygonal base.

CLAIMS:

1. A compression load test for a pile using reaction anchors comprising:
 - a test pile;
 - a tension member connected substantially vertically on top of each of two or more reaction anchors, wherein the two or more reaction anchors are disposed around the test pile;
 - a plurality of transfer beams being arranged in a formation so that a middle section has a predetermined moment of inertia and rigidity, and the middle section is disposed substantially above a top of the test pile while two peripheral ends of a top transfer beam in the formation are connected to a pair of associated tension members via an aperture formed in each tension member; and
 - one or more actuator(s) for applying a load on the test pile against the transfer beam formation or against the associated tension members.
2. A compression load test according to claim 1, wherein the plurality of transfer beams is arranged in a substantially reversed triangle formation and a transfer beam forming the base of the reversed triangle is connected to two reaction anchors.
3. A compression load test according to claim 1, wherein the plurality of transfer beams is arranged in a substantially reversed pyramid formation and ends of each of two transfer beams forming the base of the reversed pyramid are connected to two associated reaction anchors.
4. A compression load test according to claim 2 or 3, wherein each aperture is located near a top end of the associated tension member, such that the aperture is dimensioned to receive an end of the transfer beam forming the base of the beam formation.
5. A compression load test according to any one of claims 1-4, wherein the one or more actuator(s) comprise(s) one or more hydraulic jack(s) being disposed near the top of the test pile.

6. A compression load test according to claim 4, wherein the one or more actuator(s) comprise(s) one or more hydraulic jack(s) being disposed between the transfer beam and a bearing plate of the associated aperture.
7. A compression load test according to claim 5 or 6, further comprising one or more load cells being disposed above the one or more hydraulic jack(s) to determine the load on the test pile.
8. A compression load test according to any one of claims 1-7, wherein, when the reaction anchor is a reinforced concrete pile and the tension member is a steel beam, each tension member is connected to the associated reaction anchor via a predetermined number of reinforced steel bars being disposed around the tension member so that one end of each reinforced steel bar is welded to the tension member and the other end is embedded in concrete in the reaction anchor.
9. A method for conducting compression load test on a pile using reaction anchors, the method comprising:
 - disposing two or more reaction anchors around a test pile and connecting a tension member substantially vertically on top of each reaction anchor;
 - arranging a plurality of transfer beams in a formation to transmit reaction loads from the two or more tension members to a top of the test pile;
 - connecting a top beam of the transfer beams formation to the associated tension members; and
 - applying a load above or below the transfer beam formation so that a predetermined test load is applied on the top of the test pile.
10. A method according to claim 9, wherein arranging the plurality of transfer beams in a formation comprises arranging the plurality of transfer beams in a substantially reversed triangle formation with the substantial apex being disposed near the top of the test pile.
11. A method according to claim 9, wherein arranging the plurality of transfer beams in a formation comprises arranging the plurality of transfer beams in a substantially

reversed pyramid formation with the substantial apex being disposed near the top of the test pile.

12. A method according to claim 10 or 11, wherein loads on the plurality of transfer beams in reaction to the predetermined test load are linearly and uniformly distributed.

13. A method according to claim 10 or 11, wherein loads on the plurality of transfer beams in reaction to the predetermined test load are uniformly spaced apart point loads.

14. A method according to any one of claims 9-13, wherein connecting a beam of the transfer beams formation to the associated tension members comprises forming an aperture in each of the associated tension member and receiving an end of the beam in the associated aperture.

15. A method according to any one of claims 9-14, wherein applying a load below the transfer beams formation comprises operating one or more hydraulic jack(s) between the transfer beams formation and the top of the test pile.

16. A method according to claim 14, wherein applying a load above the transfer beams formation comprises operating one or more hydraulic jack(s) disposed between the end of the beam and the associated aperture.

17. A method according to claim 16, further comprising disposing one or more load cells above the top of the test pile or in each of the aperture to determine the test load.

18. A method according to claim 15 or 16, wherein applying a load above or below the transfer beam formation so that a predetermined test load is applied on the top of the test pile further comprises disposing one or more load cells above the one or more hydraulic jack(s).

19. A method according to any one of claims 9-18, wherein, when the reaction anchor is a reinforced concrete pile and the tension member is a steel beam, connecting a tension member substantially vertically on top of each reaction anchor comprises disposing a

predetermined numbers of reinforced steel bars disposed around the tension member, welding one end of each reinforced steel bar to the tension member and embedding the opposite end in concrete during casting of each reaction anchor.