

APPARATUS FOR RAPID LOAD TESTING

Field of the Invention

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The invention relates to the rapid load testing of foundation piles and, in particular, the assessment of load-displacement behavior under axial loading. In particular, the invention relates to rapid load testing method, such as described by *ASTM D7383.19 Rapid Load Test*, by using drop hammer.

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Background

Rapid load testing of piles was developed as an alternative test method to conventional kentledge static load testing of pile which requires an applied axial load to the pile for extended periods of time. Rapid load testing system rely on a mass/hammer to apply load to the test pile. This can be done either through drop hammer system or launched mass system (statnamic). The impact axial load is applied on the pile head for a period less than one second with the results being used to assess the compressive resistance and corresponding load-displacement behavior of the pile. Rapid load testing therefore provides for a substantial increase in testing rates, and consequently speeding up the construction's process. The period over which the load is applied during the load test is critical. It is therefore preferred to ensure the load application period is in the range of $10 < \frac{(tf \times cp)}{L} \leq 1000$ where tf = duration of the rapid load application, L = total length of the test pile, cp = velocity of the stress wave in the test pile

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For the drop hammer system, lengthening the load application period is conventionally achieved through the use of a spring cushion which is placed on the pile and impacted by the drop hammer. The stiffness of the spring cushion determines the load application period. Conventional spring cushions are constructed from a dampening material with a spring to provide an elastic response. The dampening material is generally an elastomer with elastic behavior provided by a compression spring or the use of multiple steel

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plates. The arrangement of these two components varies among conventional systems but all are limited in the degree of control over the overall stiffness of the spring cushion. The use of compression springs provides a limited range for the spring constant. Further, having a site with multiple piles of different capacity requires a range of
5 different spring cushions each of which have to be interchanged in order to accommodate variation in pile testing. Further, as the hammer is generally of substantial weight, varying the applied load requires replacing the hammer between large and small capacity piles requiring infrastructure to move the hammer as well as storage of the individual hammers when not in use.

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Thus, this combination of multiple hammers, multiple spring cushions and limitations in controlling the stiffness of the spring cushion compromise the efficiency and efficacy of pile-soil assessment.

15 **Summary of Invention**

In a first aspect, the invention provides a cushion pad for use with a rapid load testing system, the cushion pad comprising: a block having an array of recesses in a first face, and formed of an elastomeric material; said recesses each having a channel in fluid
20 communication with an outside surface of the block, other than the first face, for venting air from said recess; wherein the cushion assembly is arranged to dampen an impact on a pile from a dynamic load.

The invention provides, therefore, a cushion pad arranged to provide a desired
25 mechanical response on impact. The cushion pad may form part of the drop hammer, or may form part of, or replace the spring cushion in a conventional rapid load test.

The cushion pad may be used separately, or include cushion inserts, having a different stiffness and elastic response behaviour. This provides for the cushion pad assembly,
30 comprising the block and inserts to be customizable depending upon the impact load, pile capacity or other parameter.

Brief Description of Drawings

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It will be convenient to further describe the present invention with respect to the accompanying drawings that illustrate possible arrangements of the invention. Other arrangements of the invention are possible and consequently, the particularity of the accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

Figures 1A to 1E are elevation views of the progressive steps in the set-up for a rapid load test;

15 Figure 2A is an isometric view of a cushion pad according to one embodiment of the present invention;

Figure 2B is an isometric view of a cushion insert according to one embodiment of the present invention;

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Figure 3 is an isometric view of a counterweight assembly according to one embodiment of the present invention;

Figures 4A and 4B are isometric views of hammer bucket assemblies according to various embodiments of the present invention;

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Figures 5A and 5B are isometric views of a guide frame and hammer bucket assembly according to a further embodiment of the present invention, and;

30 Figure 6 is an example test characteristic for a rapid load test according to one embodiment of the present invention.

Detailed Description

Figures 1A to 1E show progressive views for the set-up of a rapid load test. Figure 1A shows the test pile 10 having a load cell 15 and a bearing plate for transmitting load from the drop hammer to the load cell. The pile 10 include strain gauges 25 placed around the circumferential face of the pile to assess the load distribution along the pile. The strain gauges 25, for instance, will also indicate if the applied load from the drop hammer is eccentric with the test failing if the eccentricity of the load is beyond acceptable limits. Placed at a distance of at least 15m is a hydraulic power unit 30 and generator 35 for operating the equipment.

Next a stabilizer frame 45 is mounted over the pile cap and a spring cushion 40 placed on the bearing plate 20. A reflector 50 is mounted to the pile with laser 65 placed at approximately 15m away so as to measure displacement of the pile following application of the load. The instrumentation further includes an accelerometer to measure the acceleration of the pile head.

Next, as shown in Figure 1C, a guide frame 55 is mounted to the stabilizer frame 45 and the drop hammer 60 mounted within the guide frame. Once the instrumentation 65 is in place, as shown in Figure 1E, the test can commence.

A key feature of the invention is the use of a cushion pad 75, as shown in Figure 2A. The cushion pad 75 may be a block formed from a polymer material having known properties to provide a dampening effect to the impact. The cushion pad includes an array of recesses 85 for receiving impact inserts 80. The recesses 85 include venting channels 90 which will be explained later. It will be noted that whilst four recesses are shown, any suitable number may be used. The number and depth of the recesses, when used without the impact inserts may be designed to further modify the mechanical behaviour of the pad.

- A key feature of the invention is the selectability of dampening and elastic performance during the test. As mentioned, in order to achieve elastic behaviour the prior art includes compression springs or steel plates. This limits the range of elasticity that is possible not to mention the issues of having widely disparate stiffness between the dampening element, in this case provided by impact pads 75, and the elastic component, in this case provided by the impact insert 80. By having the impact pad 75 arranged to receive the insert 80, the number of inserts is controllable depending upon the required applied load for the test. In certain circumstances, the stiffness of the insert 80 will be greater than the stiffness of the material of the pad 75. For instance, the impact pad 75 may be constructed from a high durometer elastomer with elasticity provided by the insert 80 which may be, for instance, a higher durometer elastomer or possibly a thermo-plastic possible, non-limiting examples of elastomers include neoprene, natural rubber, isoprene rubber, nitrile rubber, silicone, EVA and butadiene rubber.
- As an example of the designability of the assembly of pad and insert, the insert 80 may be a high glass transition temperature thermo-plastic - such as ABS, polycarbonate, PEEK or PET - or a combination of different type of rubbery material and so providing an elastic component different to that of the dampening component 75. Further still, the insert 80 may be fibre reinforced whereby the fibre is selected to be highly elastic within an elastomeric matrix and so providing good elastic behaviour within the load range. The pad also may be fibre reinforced thus providing the test designers the ability to combine elastic and dampening components within a single pad whilst still allowing for higher elastic behaviour through inserting an appropriate insert 80.
- To ensure smooth loading during the load test, a venting channel 90 is provided for each recess so as to allow for the escape of air.
- Whilst Figures 2A and 2B show a square pad and a round insert, these are not limitations on the invention. The pad may be any convenient shape having recesses shaped also for convenience including round, square, elliptical or otherwise. The inserts may then correspondingly be shaped.

In a further embodiment, the insert 80 may be a layered composite construction so as to provide a further variability in stiffness as required for the desired test conditions.

- 5 The insert 80 may further include a circumferential channel 95 so as to provide an escape path for air for eventual venting through channel 90.

Figure 3 shows the application of the pad/insert. A further critical departure from conventional use is the application of the pad/insert to the drop hammer. Figure 3
10 shows a counterweight assembly 115 whereby a counterweight 100 has mounted thereto pads 105A, B, 110A, B at the top end bottom to form the assembly 115. Said counterweight assembly arranged to replace a drop hammer for a raid load test.

Conventional systems vary the mechanical behaviour of the test, to lengthen the period
15 of applied load, using spring cushions at the impact site. As mentioned, these conventional systems are flawed by the use of compression springs and similar. They are further limited by height restrictions and so having a limited number of components at the impact site. By moving the control of dampening/elastic components to the drop weight rather than the use of a spring cushion, such limitations are avoided.

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It will be appreciated, however, that the cushion pad and cushion inserts may be arranged to act in place of a spring cushion.

Figures 4A and 4B show two arrangements of a hammer bucket assembly 120, 145.
25 The hammer bucket 125 in each case includes an array of cavities 130, 132 for receiving counter-weight assemblies 165. In the first embodiment of Figure 4A, a single layer of counter-weight assemblies 135A, B are inserted into the cavity in order to achieve the desired load for the hammer bucket assembly 120. Figure 4B shows an alternative arrangement whereby the hammer bucket assembly 140 requires a significantly larger
30 load and so the counter-weight assemblies are stacked in two layers 155, 160. Once within the cavities 130, 132 the counter-weight assemblies are in sliding engagement

with the bucket 125, 145 so as to allow compression of the cushion pads. The counter-weight assemblies and cavities within the bucket may include mutually cooperative elements to allow movement along the axis of impact, but prevent lateral movement.

- 5 The hammer bucket assembly acts in place of the drop hammer within the test set-up shown in Figures 1A to 1E or replaces the reaction counter-weight for a combustion (statnamic test). A drop hammer arrangement is shown in Figures 5A and 5B whereby a guide frame 170 includes a guide channel 175 for receiving a hammer bucket 185. This is then positioned ready for use with the various bearing components placed within
10 the void 180 upon which the hammer bucket assembly 185 is dropped.

Thus, the invention includes the advantages of being able to precisely define the required elasticity/dampening behaviour required for a particular test. This is achieved by any one individually or a combination of any of the following features:

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- (i) Controlling the materials used in the cushion pad and/or insert;
 - (ii) The number of inserts used with the cushion pad including using none;
 - (iii) The number of cushion pads and/or inserts used for each counter-weight assembly;
 - 20 (iv) The number of cushion assemblies used within each hammer bucket assembly.

The breath of controllable perimeters for any one of the above features provides for a substantially different and beneficial arrangement and so achieving higher test capacity,
25 a lengthening of the loading duration as well as a smooth loading onto the pile.