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LOAD TRANSMISSION APPARATUS

[0001] Field of the Invention

[0002] This invention relates to a load transmission apparatus utilized when loading/unloading by a pile load testing device, a piling device, or a ground compaction device.

[0003] Conventional Arts

[0004] A method for loading by dropping a weight has been utilized for the pile load testing, piling, and ground compacting.

[0005] However, if the weight is to be dropped in order to load, the loading process is performed in a quite short period of time, which generates an impact force transmitted to a force receiving site such as the pile and ground. Accordingly, for example a tensile force may be generated to the force receiving site to damage the same and to cause a public nuisance such as noise and vibration.

[0006] The pile load testing, which is performed by dropping the weight, is titled as a dynamic load testing. The dynamic load testing requires a very short period of time, i.e., 5-30ms and estimation of static bearing capacity needs to be performed through complicated analysis based on the wave theory as the pile is regarded as a single dimension elastic body.

[0007] A conventional technology discloses an accelerated load testing to shorten the loading time and prevent the tensile force on the pile by using a load transmission apparatus which is comprised of a spring positioned between the weight on which the load is applied and the pile (receiving site).

[0008] Problems to be Resolved by the Invention

[0009] The conventional technology of the load transmission apparatus has the following points to be improved.

[0010] If the load transmission apparatus is composed of the spring only, even after dropping the weight and applying the load, the spring amplitudes/vibrates and repeatedly collides against the pile head, thereby repeatedly generating noise and vibration.

[0011] In order to suppress the noise and vibration, a buffer material such as cushioning may be utilized but the loading efficiency decreases simultaneously

with transferring of the weight to the pile.

[0012] Alternatively, there is a method to catch the weight bouncing after loading. However, a device to accomplish this process of catching the bouncing weight is rather complicated and expensive.

[0013] OBJECT AND SUMMARY OF INVENTION

[0014] An object of this invention is to resolve the above-described problems and to provide the load transmission apparatus with a simple but effective structure for loading.

[0015] Another object of this invention is to provide the load transmission apparatus which minimizes the noise and vibration generated upon initial loading.

[0016] Another object of this invention is to provide the load transmission apparatus which is highly durable and less expensive.

[0017] Overall, this invention is to accomplish at least any one of the above objectives.

[0018] Means to Resolve the Problems

[0019] In order to accomplish the objects, this invention provides the load transmission apparatus, which is positioned between the loading unit and a receiving unit and comprises at least one spring element and a damping device in series to the spring. The damping effect of the damping device during the period of loading is larger than that during the period of unloading. The loading unit is to apply the loading force and may be the weight which may freely be dropped, a hydraulic or diesel hammer, and a reaction force block launched by a reaction force as igniting special propellant. Further, the receiving unit is to receive the load of the loading unit and may be the pile for the pile load testing, a driving pile, or the ground for a weight dropping compaction method.

[0020] Also, the load transmission apparatus is positioned between the weight member and the receiving unit and is comprised of plural springs parallel to each other and the damping device connected at least with one spring. The damping effect of the damping device is larger when unloading than when loading. For example, two springs may be arranged in parallel to each other and the damping device may be connected to one of the spring in series thereto.

[0021] The load transmission apparatus of this invention adjusts at least one of the amount of the load and the loading time by adjusting at least one spring constant of one spring. Also, the damping coefficient of the damping device may be adjusted to adjust the speed of the movement of the loading unit in unloading direction.

[0022] BRIEF DESCRIPTION OF DRAWINGS

[0023] FIG. 1 is a isometric view of the load transmission apparatus of this invention;

[0024] FIG. 2 is a view showing a pattern of loading by the load transmission apparatus of this invention;

[0025] FIG. 3(a) is a diagrammatic chart showing the relation between the time and speed of the loading unit for the load transmission apparatus of this invention;

[0026] FIG. 3(b) is a diagrammatic chart showing the relation between the time and speed of the loading unit of a comparative example;

[0027] FIG. 4(a) is a diagrammatic chart showing the relation between the time and displacement of the loading unit;

[0028] FIG. 4(b) is a diagrammatic chart showing the relation between the time and displacement of a comparative example.

[0029] Preferred Embodiment of the Invention

[0030] Embodiments of this invention will be explained below with reference to the figures presented.

[0031] (A) Applicable Condition/Requirement

[0032] A load transmission apparatus 1 of this invention is positioned between a loading unit 4 and a receiving unit 5, so that the load of the loading unit 4 is transferred to the receiving unit 5.

[0033] The loading unit 4 is used to apply a load by freely dropping a weight 4a. The loading unit 4 can be hydraulic, diesel hammer or a reaction force block launched by a reaction force as igniting special propellant.

[0034] The receiving unit 5 is used to receive the load of the loading unit 5. The receiving unit 5 can be a pile for a pile load testing, a driving pile, or a ground for a weight dropping compaction method.

[0035] (B) Load Transmission Apparatus

[0036] The load transmission apparatus is comprised of a plurality of springs 21, 22 parallel to each other and a damping device 3 connected with the respective springs 21, 22 in series.

[0037] The material used to make the springs 21, 22 is not limited but they may be made of a steel spring with a strong resilient force. The number of the springs 21, 22 arranged in parallel may be selected as necessary, and increasing the number of the spring allows controlling a higher maximum load and the loading time.

[0038] FIG. 1 shows an example of this invention with two springs 21 and 22 arranged in parallel to each other. A spring constant of the springs 21, 22 can be adjusted as desired according to a mass of the loading unit 4 and the loading time. For example, a spring having with the spring constant of being 4 times much as the spring 21 can be used as the spring 22.

[0039] The spring 22 is connected with the damping device 3 in series. The number of spring connected with the damping device 3 is not limited to one and may be selected as desired, and the damping device 3 may be connected with the respective springs.

[0040] The damping device 3 is used to reduce the travel speed and amplitude/vibration of the loading unit 4. The damping device 3 in this invention is the type with different damping coefficients at the loading direction (direction A in FIG. 2) and the unloading direction (direction B in FIG. 2). That is, the damping device should be non-linear where when the loading unit 4 is transferring toward the loading direction, the damping coefficient is set to be zero or lower to prevent from reducing the load of the loading unit 4, and when the loading unit 4 is transferring toward the unloading direction, the damping coefficient is set to be higher to reduce the travel speed and amplitude.

[0041] The damping device 3 is a damper, a shock absorber, or an active damper with non-linear type varying the damping coefficient according to the traveling direction and displacement. The damping device 3 can be an oil damper, an air damper, and so on.

[0042] Embodiment

[0043] Operation of the load transmission apparatus 1 of this invention will be explained next.

[0044] Condition for Analysis

[0045] In the following section, the case when employing the load transmission apparatus 1 of this invention as shown in FIG. 2 and the case when the damping device 3 is not used as in the comparative example are compared to analyze the behavior of the loading unit 4 both at loading and after loading.

[0046] The mass of the loading unit 4 is about 20 tons, and the speed at the load transmission apparatus 1 with the loading unit 4 colliding against the receiving unit 5 is about 5 (m/s). The spring constant of the spring 21 is 0.0 (kN/m), and the spring constant of the spring 22 is 3158.3 (kN/m).

[0047] Further, the analysis was performed under the condition that the damping device 3, employed in the load transmission apparatus 1 of this invention, shows the damping coefficient of 0.0 (kN s/m) until the receiving load on the receiving unit 5 reaches maximum and that after reaching the maximum load, the damping coefficient is 125.7 (kN s/m). The load applied on the receiving unit 5 reaches maximum when the spring contracts most.

[0048] Here, in the comparative example, the mass of the loading unit 4 is set to be 20 (ton); the speed at collision between the loading unit 4 and the receiving unit 5 is 5 (m/s); and the spring constant of the springs is 3158.3 (kN/m).

[0049] Comparison of the Result

[0050] FIG. 3 illustrates the relationship between the time passed after the load transmission apparatus 1 contacting the receiving unit 5 and the travel speed of the loading unit 4. FIG. 2 illustrates a value of the speed of the loading unit 4 becomes positive when traveling in the direction of A and negative in the direction of B in FIG. 2.

[0051] FIG. 3(a) illustrates the result of analysis when using the load transmission apparatus 1 of this invention. When FIG. 3(a) is compared with FIG. 3(b) illustrating the comparative example, the travel speed of the loading unit 4 in both figures is almost identical until the load reaches maximum (the travel speed of the loading unit 4 becomes 0). However, when the unloading

process begins, the travel speed of the comparative example increases just like in the loading process while the travel speed of the loading unit 4 in this invention does not show such an increase and converges at the lower point. This is because the force reserved in the spring is absorbed by the damping device 3. Finally, the bouncing speed of the loading unit 4 in the comparative example becomes 3.8 (m/s) while the bouncing speed of the loading unit 4 in the present invention stays around 1.4 (m/s).

[0052] Furthermore, FIG. 4 illustrates the relation between the travel time and the displacement of the loading unit 4 after the load transmission apparatus 1 contacts the receiving unit 5.

[0053] The displacement of the loading unit 4 in the comparative example draws parabola and bounces above the point where the loading process starts as shown in FIG. 4(b). In comparison, the displacement of the loading unit 4 in this invention shows the movement almost identical to the comparative example until reaching maximum displacement. However, when the unloading process begins, the travel speed of the loading unit 4 of this invention does not regain the speed rate/increase during the loading process. When the travel speed in the comparative example returns to the initial point in FIG. 4(b), the travel speed in this invention in FIG. 4(a) returns about 0.15m only. As a result, the load transmission apparatus 1 of this invention makes it possible to quickly reduce the amplitude without reducing the load.

[0054] Operation

[0055] The result of the above analysis shows when the desirable damping device 3 is used. However, use of the damping device 3, with different amplitude attenuation force between the loading period and the unloading period, effectively prevents/reduces the noise and vibration while providing effective loading process. Also, by adjusting the damping coefficient of the damping device 3, the travel time and the amplitude can be adjusted.

[0056] Advantages of the Invention

[0057] Because of the above-described structure, the load transmission apparatus of this invention has the following advantages.

[0058] The damping device of this invention is nonlinear, which gives a

simple structure with effective loading process.

[0059] After the load reaches maximum, this invention effectively reduces the travel speed and attenuates the amplitude, thereby suppressing the noise and vibration generated after the initial loading to minimum.

[0060] The load transmission apparatus of this invention gives a simple structure with an excellent durability and less expensive manufacturing cost.

WHAT WE CLAIM IS:

1. A load transmission apparatus positioned between a loading unit and a receiving unit, comprising: at least one spring and a damping device connected in series relative to said spring, wherein damping effect of said damping device is larger during a loading process than an unloading process.

2. A load transmission apparatus positioned between a loading unit and a receiving unit, comprising plural springs parallel to each other and a damping device connected in series relative to at least one spring, wherein damping effect of said damping device is larger during a loading process than an unloading process.

3. The load transmission apparatus according to Claims 1 or 2, wherein at least one spring constant is adjusted to adjust at least one of the amount of load and loading time.

4. The load transmission apparatus according to any one of Claims 1-3, wherein the damping coefficient of the damping device is adjusted to adjust the travel speed of the loading unit in an unloading direction.