

Description

PLATED PILE FOR WET TERRAIN OR MUD WHICH CAN STAND IN STABLE
POSITION AND NEEDS NO BEDROCK TO REST ON

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Technical Field of Invention

This invention relates to a pile having been improved
in accordance with fluid mechanics and hydrodynamics
10 principles by welding a steel plate of specified radius at
a point one-third of the entire length of the pile from its
upper end so that the pile can sturdily stand in a stable
upright position in mud or wet terrain, needs no bedrock to
rest on, can bear a load of relatively large amount and
15 resistant to earthquake due to its ability of vibrating in
a damped pattern when its equilibrium is disturbed.

Background of Invention

20 In the previous pile technology, the deeper the bedrock
seats in a wet terrain or mud, the longer or the more the
piles needed to reach the bedrock. After reaching the
bedrock, the piles were then impacted in order to be tightly
embedded into the bedrock. However, despite a hard effort,
25 high operational costs, energies and times, the risk that
the pile will collapse is likely still high enough in this
kind of work.

The pile currently invented is designed in such a way
based on fluid mechanics and hydrodynamics principles so
30 that when applied in mud or wet terrain, it needs no bedrock
to rest on so that only a small number of steel pipes
(component of pile) are needed in order to let it sturdily
stand upright in an extremely stable position in the mud.
The pile can stand upright in stable position as it is
35 retained by a relatively great restoration force due to the
action of surface of the steel plate welded at a point
spaced at a predetermined distance above the center of
gravity of the pile. Torque of the restoration force with

respect to center of gravity of the pile is the same as torque of the total hydrostatic force exerted by mud on the pile with respect to the center of gravity of the pile. The distance from the welded steel plate to the upper end of the pile is one-third (12 m) of the entire length of the pile (H). This distance is the same as that between the center of the total hydrostatic force working on the file and the lower end of the pile.

Other advantages of this currently invented pile are its high capacity to support load, and earthquake-resistant for being able to oscillate for a few seconds before ceasing (damped harmonic oscillation) when earthquake or dislocation takes place in the working area.

Forces working on the pile are respectively gravity (F_w), Newtonian buoyancy (F_B), friction force due to viscosity of the medium (F_v) and resistant force given by the surface of the circular steel plate (F_p).

Brief Description of The Invention

This invention is aimed at minimizing the number of piles used in mud or wet terrain; maximizing pile's capacity of a pile to bear load, increasing pile's stability and enabling the pile to be installed within mud or wet terrain having no bedrock in it or having bedrock but of deeply seated location.

Brief Description of The Drawings

Figure 1 is a vertical cross-section of the pile according this invention.

Figure 2 is a vertical cross-section of a part of the pile according to this invention where the steel plate is welded and bracketed for reinforcement.

Figure 3 is a plan view of the steel plate welded on the pile after the steel plate is reinforced with bracket.

Figure 4 is the pile with a steel plate welded on it when lowered into mud or wet terrain.

Description of The Embodiment

Pile according to this invention (1) is made of steel pipe and equipped by welding with a steel plate (2) of 0.60 m radius (R_p) at a point spaced $1/3 H$ or 12 m from the upper end of the pile. The distance of $1/3 H$ (12 m) from the upper end of the pile is the same as the distance from the lower end of the pile to the center of the total hydrostatic force acting on the pile. This equivalent length of torque arm enables the pile to stand sturdily upright (not inclined) in extra stable position in the mud or wet terrain after being equipped with a steel plate. The steel plate is of 1.6 cm (16 mm) thickness. To make the steel plate fixed tightly in the pile, it is reinforced with bracket (3) in the form of four rectangular steel plates with curved upper edges separated 90 degrees each other on the plate and extend 47.5 cm both in vertical and radial direction, respectively (a in Fig. 2).

The advantage of the pile presently invented is unveiled through fluids mechanics and dynamics principles using Fig. 4 as a reference.

It is shown in Fig. 4 the pile according to this invention equipped with a steel plate welded on it at a point spaced 12 m (h) from the upper end of the pile.

The length of the pile is H (36 m). First the pile is lowered into the mud until a depth of $(H-h)$ meter where the plate is welded. The pile is then impacted or let freely move into the depth of y meter from the steel plate following the resultant force working on it. The mud has a density of ρ_L kg/m³ and viscosity of μ Pascal.second (Poise). Mass of the pile added with that of the load is m kg, radius of the pile is R m, radius of the steel plate is R_p m and gravitation acceleration is g m/second².

Forces acting on the pile are respectively gravity (F_w), Newton's buoyancy force (F_B), friction force due to the viscosity of the mud (F_v) and retaining force given by the plate (F_p).

$$F_w = mg,$$

$$F_B = \pi R^2 (H - h + y) \rho_L g,$$

$$F_V = \mu \frac{d}{dt} [2\pi R (H - h + y)] = 2\pi R \mu \frac{dy}{dt},$$

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$$F_P = \pi (R_p^2 - R^2) \rho_L g y.$$

Resultant force that moves the pile downward = $F_w - F_B - F_V - F_P$.

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$$m \frac{d^2 y}{dt^2} = mg - \pi R^2 (H - h + y) \rho_L g - 2\pi R \mu \frac{dy}{dt} - \pi (R_p^2 - R^2) \rho_L g y$$

$$m \frac{d^2 y}{dt^2} + 2\pi R \mu \frac{dy}{dt} + \pi \rho_L g (R_p^2 - 2R^2) y = mg - \pi R^2 (H - h) \rho_L g.$$

$$(2\pi R \mu)^2 - 4m\pi \rho_L g (R_p^2 - 2R^2) < 0.$$

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Solution to this differential equation is

$$y(t) = e^{pt} (A \cos Qt + B \sin Qt) + \frac{m - \pi R^2 (H - h) \rho_L}{\pi \rho_L (R_p^2 - 2R^2)}$$

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$$V(t) = \frac{dy}{dt} = e^{pt} [(BP - AQ) \sin Qt + (AP + BQ) \cos Qt]$$

where

$$P = -\frac{\pi R \mu}{m}$$

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$$Q = \frac{1}{m} \sqrt{\pi \rho_L mg (R_p^2 - 2R^2) + \pi^2 R^2 \mu^2} = \omega,$$

$$A = -\frac{[m - \pi R^2 (H - h) \rho_L]}{\pi \rho_L (R_p^2 - 2R^2)},$$

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$$B = -\frac{R \mu [m - \pi R^2 (H - h) \rho_L]}{\rho_L (R_p^2 - 2R^2) \sqrt{\pi \rho_L mg (R_p^2 - 2R^2) + \pi^2 R^2 \mu^2}}.$$

When $t = 0$,

$y(t) = 0$ and $V(t) = 0$.

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When $t = \infty$ (indefinite),

$$y(t) = y_m = \frac{m - \pi R^2 (H - h) \rho_L}{\pi \rho_L (R_p^2 - 2R^2)},$$

5 and

$$V(t) = 0.$$

10 $Y(t)$ and $v(t)$ show that the pile oscillates in damped harmonic pattern in the mud or wet terrain due to the viscosity of the mud of μ Pascal.second (Poise). The velocity of the pile gets reduced through times and lower and finally ceases in a depth of

$$d = (H - h) + y_m$$

$$15 = (H - h) + \frac{m - \pi R^2 (H - h) \rho_L}{\pi \rho_L (R_p^2 - 2R^2)}.$$

The length of the pile left stand upright above the mud surface is $H - y_m = 12 - y_m$ or

$$20 \quad 12 - \frac{m - \pi R^2 (H - h) \rho_L}{\pi \rho_L (R_p^2 - 2R^2)}.$$

Frequency (f) and oscillation period (T) of the pile are respectively

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$$f = \frac{1}{2\pi} \cdot \frac{1}{m} \sqrt{\pi \rho_L m g (R_p^2 - 2R^2) + \pi R^2 \mu^2}$$

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$$T = \frac{2\pi m}{\sqrt{\pi \rho_L m g (R_p^2 - 2R^2) + \pi^2 R^2 \mu^2}}.$$

This theory matches the facts encountered in the field, i.e., the pile presently invented does not need a bedrock to rest on in the mud or wet terrain, and 2) the load a pile can bear is relatively very large.

If the maximum load a pile can bear is M_M kg and the mass of the pile is M_T kg (so $m = M_T + M_M$), M_M can easily be

calculated from the following equation.

$$\frac{(M_T + M_M) - \pi R^2 (H - h) \rho_L}{\pi \rho_L (R_p^2 - 2R^2)} = 12.$$

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$$M_M = 12\pi \rho_L (R_p^2 - 2R^2) + \pi R^2 (H - h) \rho_L - M_T.$$

As an illustration, (not to limit the scope of invention), a pile made of steel pipe having density of $7.86 \times 10^3 \text{ kg/m}^3$, length of 36 m, outer radius of 0.125 m and thickness of 0.016 m (mass of the pile, M_T , 3326.523 kg) and equipped with a steel plate having radius of $R_p = 0.60 \text{ m}$, is applied in mud of $2.5 \times 10^3 \text{ kg/m}^3$ density (ρ_L). The maximum load the pile can bear is (M_M) 30.58 tons.

If the same pile is not equipped with steel plate cited above, the differential equation of the pile motion in the mud will be given in the next page.

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$$m \frac{d^2 y}{dt^2} + 2\pi R \mu \frac{dy}{dt} - \pi \rho_L g R^2 y = mg - \pi R^2 (H - h) \rho_L g$$

$$(2\pi R \mu)^2 + 4m(\pi \rho_L g R^2) > 0.$$

$$y(t) = C_1 e^{n_1 t} + C_2 e^{n_2 t} - \frac{\{m - \pi R^2 (H - h) \rho_L\}}{\pi \rho_L R^2}$$

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$$v(t) = n_1 C_1 e^{n_1 t} + n_2 C_2 e^{n_2 t}$$

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$$n_1 = -\frac{\pi R \mu}{m} + \frac{1}{m} \sqrt{(\pi R \mu)^2 + \pi m \rho_L g R^2}$$

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$$C_1 = 0,5 \left[1 + \frac{\pi R \mu}{\sqrt{(\pi R \mu)^2 + \pi m \rho_L g R^2}} \right] \left[\frac{m - \pi R^2 (H - h) \rho_L}{\pi \rho_L R^2} \right],$$

$$n_2 = -\frac{\pi R \mu}{m} - \frac{\sqrt{(\pi R \mu)^2 + \pi m \rho_L g R^2}}{m},$$

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$$C_2 = 0,5 \left[1 - \frac{\pi R \mu}{\sqrt{(\pi R \mu)^2 + \pi m \rho_L g R^2}} \right] \left[\frac{m - \pi R^2 (H - h) \rho_L}{\pi \rho_L R^2} \right].$$

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Y(t) dan v(t) show that when t = 0, then y = 0, v = 0, and when t = ∞ (indefinite), then y is indefinite and v is indefinite. This means that after being lowered or imbedded into the mud or wet terrain, pile equipped with no steel plate will undergo a downward accelerated motion until the depth of no end (sinking). This downward motion will cease if the pile reaches a bedrock that possibly seats in the

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mud. If the bedrock seats deep below the surface, a great number of piles are needed to reach the bedrock. This is one of the advantage belonging to the prior arts. It is the solution to this drawback and inefficiency this invention
5 tries to give.

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Claim

1. A pile made of steel pipe suitable for the application in mud or wet terrain, the pile needs no bedrock to rest on, can bear a load of relatively large amount, will never collapse or be inclined in position and resistant to earthquake due to its ability of vibrating in a damped pattern when its equilibrium is disturbed, characterized by a steel plate of at least 1.20 m diameter and 16 mm thickness welded at a point spaced one-third of the entire length from the upper end of the pile for retaining and ceasing of the downward movement of the pile as well as stabilizing its upright position in mud or wet terrain.
2. The use of plated pile disclosed in Claim 1 .