

DESCRIPTION

Title of Invention: Z-SHAPED STEEL SHEET PILE

Technical Field

[0001]

The present invention relates to a Z-shaped steel sheet pile including a web portion and flange portions at both ends of the web portion.

Background Art

[0002]

A so-called Z-shaped steel sheet pile having flange portions at both ends and a web portion in an intermediate portion is known (see Patent Literature 1).

Citation List

Patent Literature

[0003]

PTL 1: Japanese Unexamined Patent Application

Publication No. 2002-294691

Summary of Invention

Technical Problem

[0004]

Z-shaped steel sheet piles have an asymmetrical cross section. Thus, when being driven one by one, the Z-shaped steel sheet piles are rotated. The Z-shaped steel sheet piles thus fail to keep moving straight and receive a high resistance at a joint portion at which the steel sheet piles

are fitted together, whereby installation of the Z-shaped steel sheet piles is difficult in many cases. The Z-shaped steel sheet piles thus have a low-installability problem.

Examples of a method for improving the installability of Z-shaped steel sheet piles include a method for driving Z-shaped steel sheet piles by coupling in advance two Z-shaped steel sheet piles together so that the piles have a symmetrical cross section, i.e., a hat-shaped cross section (see Fig. 11 in Patent Literature 1) and fitted joint portions are coupled and fastened to each other by performing operations such as caulking or welding.

However, in the case where two Z-shaped steel sheet piles are coupled together to have a symmetrical cross section, the steel sheet piles have a large cross section and thus receive a higher insertion resistance during the driving operation. Thus, such piles necessitate a special driving machine.

Moreover, in order to regularly transmit the driving force of the driving machine to the steel sheet piles, the method for chucking the steel sheet piles involves chucking at two points, that is, the web portion of each Z-shaped steel sheet pile is individually chucked and thus a special driving machine is required.

[0005]

The present invention has been made to solve the above-

described problems and aims to obtain a highly installable Z-shaped steel sheet pile that dispenses with a special driving machine.

Solution to Problem

[0006]

The inventor studied the cause of the rotation (twist) of conventional Z-shaped steel sheet piles that occurs while the Z-shaped steel sheet piles are driven. Fig. 20 and Fig. 21 illustrate results of the study. Fig. 20 and Fig. 21 illustrate a typical Z-shaped steel sheet pile 21 that includes flange portions 25a and 25b at both ends of a web portion 23.

In the driving operation, the peripheral ground (in regions A and B surrounded by dotted circles in Fig. 20) locally receives a large shear force on the inner side of corner portions 29a and 29b of the Z-shaped steel sheet pile 21. Consequently, the arrangement state of soil particles is changed and the volume of the ground increases (dilatancy of soil). When the volume of the peripheral ground increases, an eccentric earth pressure occurs, that is, the earth pressure of the corresponding portions locally increases. Thus, the Z-shaped steel sheet pile 21 receives a force in the directions of arrows illustrated in Fig. 21 and is thus deformed and rotated (twisted).

On the basis of the above-described study, the inventor

considered that the Z-shaped steel sheet pile can keep moving straight in the driving operation by receiving earth pressure commensurate with the eccentric earth pressure from the peripheral ground so as to be prevented from being deformed or rotated (twisted).

The present invention has been accomplished on the basis of the above-described findings and specifically includes components described below.

[0007]

(1) A Z-shaped steel sheet pile according to the invention is a Z-shaped steel sheet pile that includes a web portion; flange portions disposed at both ends of the web portion; and joint portions disposed at ends of the flange portions, wherein protrusions are provided on outer-surface-side portions of the flange portions of the Z-shaped steel sheet pile, on outer-surface-side portions of the web portion of the Z-shaped steel sheet pile, or on at least one outer-surface-side portion of the flange portions and at least one outer-surface-side portion of the web portion, at positions on both sides of a center of the web portion.

[0008]

(2) In the Z-shaped steel sheet pile described in the above paragraph (1), the protrusion provided on the web portion is disposed at a certain distance from the center of the web portion, the certain distance being half or more

than half a distance from the center of the web portion to an outer surface of a corresponding one of the flange portions.

[0009]

(3) In the Z-shaped steel sheet pile described in the above paragraph (1) or (2), the protrusions provided on both sides of the center of the web portion are equidistant from the center of the web portion.

[0010]

(4) In the Z-shaped steel sheet pile described in any one of the above paragraphs (1) to (3), the protrusion provided on the web portion protrudes in a direction parallel to outer surface of the flange portion.

[0011]

(5) In the Z-shaped steel sheet pile described in any one of the above paragraphs (1) to (4), an angle at which the protrusion is attached falls within a range of 45° to 135° .

[0012]

(6) In the Z-shaped steel sheet pile described in any one of the above paragraphs (1) to (5), the protrusion has a height of 50 mm or larger.

Advantageous Effects of Invention

[0013]

In the present invention, a Z-shaped steel sheet pile

includes a web portion, flange portions disposed at both ends of the web portion, and joint portions disposed at ends of the flange portions, and protrusions are provided on outer-surface-side portions of the flange portions of the Z-shaped steel sheet pile, on outer-surface-side portions of the web portion of the Z-shaped steel sheet pile, or on at least one outer-surface-side portion of the flange portions and at least one outer-surface-side portion of the web portion, at positions on both sides of a center of the web portion. Thus, in the driving operation, the Z-shaped steel sheet pile can be prevented from being deformed or rotated (twisted) and can keep moving straight.

Keeping the straight movement of the Z-shaped steel sheet pile facilitates installation of a steel sheet pile wall constituted by Z-shaped steel sheet piles at a predetermined position and reduces the resistance at joint fitted portions while the steel sheet piles are driven. Thus, the installation speed and the installability can be increased without using a special installation machine.

Brief Description of Drawings

[0014]

[Fig. 1] Fig. 1 illustrates a Z-shaped steel sheet pile according to one embodiment of the present invention.

[Fig. 2] Fig. 2 illustrates the entire shape of the Z-shaped steel sheet pile illustrated in Fig. 1.

[Fig. 3] Fig. 3 illustrates an operation of the Z-shaped steel sheet pile illustrated in Fig. 1 (part 1).

[Fig. 4] Fig. 4 illustrates an operation of the Z-shaped steel sheet pile illustrated in Fig. 1 (part 2).

[Fig. 5] Fig. 5 illustrates the height of protrusions of a Z-shaped steel sheet pile according to one embodiment of the present invention.

[Fig. 6] Fig. 6 illustrates the range within which protrusions are provided in a Z-shaped steel sheet pile according to one embodiment of the present invention (part 1).

[Fig. 7] Fig. 7 illustrates the range within which protrusions are provided in a Z-shaped steel sheet pile according to one embodiment of the present invention (part 2).

[Fig. 8] Fig. 8 illustrates the range within which protrusions are provided in a Z-shaped steel sheet pile according to one embodiment of the present invention (part 3).

[Fig. 9] Fig. 9 illustrates an arrangement mode of protrusions of a Z-shaped steel sheet pile according to one embodiment of the present invention (part 1).

[Fig. 10] Fig. 10 illustrates an arrangement mode of protrusions of a Z-shaped steel sheet pile according to one embodiment of the present invention (part 2).

[Fig. 11] Fig. 11 illustrates an arrangement mode of protrusions of a Z-shaped steel sheet pile according to one embodiment of the present invention (part 3).

[Fig. 12] Fig. 12 illustrates an arrangement mode of protrusions of a Z-shaped steel sheet pile according to one embodiment of the present invention (part 4).

[Fig. 13] Fig. 13 illustrates an arrangement mode of protrusions of a Z-shaped steel sheet pile according to one embodiment of the present invention (part 5).

[Fig. 14] Fig. 14 illustrates an arrangement mode of protrusions of a Z-shaped steel sheet pile according to one embodiment of the present invention (part 6).

[Fig. 15] Fig. 15 illustrates an angle at which protrusions of a Z-shaped steel sheet pile according to one embodiment of the present invention are attached.

[Fig. 16] Fig. 16 illustrates a Z-shaped steel sheet pile (model) according to Example 1 of the present invention.

[Fig. 17] Fig. 17 is a graph showing results of experiments conducted on the Z-shaped steel sheet pile (model) according to Example 1 of the present invention.

[Fig. 18] Fig. 18 illustrates a Z-shaped steel sheet pile (model) according to Example 2 of the present invention.

[Fig. 19] Fig. 19 is a graph showing results of experiments conducted on the Z-shaped steel sheet pile (model) according to Example 2 of the present invention.

[Fig. 20] Fig. 20 illustrates a mechanism by which Z-shaped steel sheet piles are rotated (twisted) when being driven (part 1).

[Fig. 21] Fig. 21 illustrates a mechanism by which Z-shaped steel sheet piles are rotated (twisted) when being driven (part 2).

Description of Embodiments

[0015]

A Z-shaped steel sheet pile 1 according to an embodiment includes a web portion 3, flange portions 5a and 5b disposed at both ends of the web portion 3, and joint portions 7a and 7b disposed at ends of the flange portions 5a and 5b.

In the following description, as illustrated in Fig. 1, a line that passes through the center of the web portion 3 and that is parallel to the flange portions 5a and 5b is defined as a border line (a dot-and-dash line in the drawing). On the upper side of the border line in the drawing, a portion on an inner side of a corner portion 9a formed by the flange portion 5a and the web portion 3 is defined as an inner-surface-side portion and a portion on an outer side of the corner portion 9a is defined as an outer-surface-side portion. Similarly, on the lower side of the border line, a portion on an inner side of a corner portion 9b is defined as an inner-surface-side portion and a portion

on an outer side of the corner portion 9b is defined as an outer-surface-side portion.

The Z-shaped steel sheet pile 1 according to the embodiment is characterized by including protrusions 11a and 11b at both end portions of the web portion on the outer-surface-side portions.

[0016]

As illustrated in Fig. 1, the protrusions 11a and 11b protrude in such a direction as to be aligned with the outer surfaces of the flange portions at positions on the web portion 3 adjacent to the corner portions 9a and 9b. As illustrated in Fig. 2(b), the protrusions 11a and 11b are provided throughout the length of the Z-shaped steel sheet pile 1.

[0017]

Referring now to Fig. 3 and Fig. 4, the operation of the Z-shaped steel sheet pile 1 having the above-described structure is described.

As described above, in the driving operation, the peripheral ground (regions A and B surrounded by dotted circles in Fig. 3) locally receives a large shear force on the inner side of the corner portions 9a and 9b of the Z-shaped steel sheet pile 1. On the other hand, since the protrusions 11a and 11b are disposed on the outer side of the corner portions 9a and 9b, the peripheral ground

(regions C and D surrounded by dotted circles in Fig. 3) also locally receives a large shear force on the outer side of the corner portions 9a and 9b.

Consequently, as illustrated in Fig. 4, the eccentric earth pressures occur on the inner and outer sides of the corner portions 9a and 9b and these eccentric earth pressures cancel each other out, whereby the steel sheet piles can be prevented from being rotated (twisted) while being driven. Thus, the asymmetric Z-shaped steel sheet piles 1 can keep moving straight even when being driven one by one.

[0018]

Here, the protrusions 11a and 11b are provided to generate eccentric earth pressures commensurate with the eccentric earth pressures that occur on the inner side of the corner portions 9a and 9b. The height H of the protrusions 11a and 11b (see Fig. 5) may thus be changed in accordance with the eccentric earth pressures that occur on the inner side of the corner portions 9a and 9b. It is desirable that the protrusion height H be 50 mm or larger in order that a large local shear force is generated in the ground on the periphery of the protrusions 11a and 11b to exert a sufficient rotation (twist) prevention effect. On the other hand, the upper limit of the protrusion height H may be appropriately determined in consideration of factors

such as the size of the Z-shaped steel sheet pile or the driving force of the driving machine in addition to the eccentric earth pressures that occur on the inner side of the corner portions 9a and 9b. If the protrusions are provided so as to be applicable to the widest range of driving conditions, it is desirable that the protrusion height H be smaller than or equal to the flange length of the Z-shaped steel sheet pile.

[0019]

Now, the positions at which and the ranges within which the protrusions 11a and 11b are disposed (in the longitudinal direction of the Z-shaped steel sheet pile) are described. Generally, in a dense (hard) sand ground, a local shear force tends to be increasingly exerted on the corner portions 9a and 9b. Thus, by providing the protrusions 11a and 11b throughout the length of the Z-shaped steel sheet pile 1, as illustrated in Fig. 2, the Z-shaped steel sheet pile 1 can be prevented from being rotated (twisted) while being driven.

The positions at which and the ranges within which the protrusions 11a and 11b are disposed may be appropriately determined in accordance with the length of the Z-shaped steel sheet pile 1, the ground conditions, or the required accuracy of the wall. For example, as illustrated in Fig. 6, a protrusion may be continuously disposed within a

predetermined range near an end portion of the Z-shaped steel sheet pile 1. Examples of the predetermined range include a range extending approximately $1/2$ to $1/3$ the entire length of the Z-shaped steel sheet pile 1 from the end of the Z-shaped steel sheet pile 1.

[0020]

In the ground constituted by loose (soft) sand or in the ground constituted by loose (soft) sand except for a dense (hard) sand ground layer lying only around the end portions of the steel sheet pile, the local shear force exerted on the corner portions 9a and 9b is small at portions other than the end portion of the steel sheet pile and thus the steel sheet pile is rotated (twisted) to a small degree. Thus, as illustrated in Fig. 7, the Z-shaped steel sheet pile can sufficiently move straight while being driven even though the Z-shaped steel sheet pile has protrusions 11a and 11b at only the end portions.

In the case of the ground having an intermediate hardness (an intermediate between a loose layer to a hard layer) or the cohesive soil, each of the protrusions 11a and 11b may be discretely provided within the range extending approximately $1/2$ to $1/3$ the entire length of the Z-shaped steel sheet pile 1 from the end (lower end) of the steel sheet pile, as illustrated in Fig. 8.

In either case, the protrusions 11a and 11b are

disposed at the end portions of the Z-shaped steel sheet pile 1.

[0021]

Since a component such as a strut or waling may be joined to the outer surface of the flange portion of the Z-shaped steel sheet pile 1, it is preferable that the protrusions 11a and 11b be disposed so as to be on lines extending from the outer surfaces of the flange portions or at positions closer to the center of the web portion (the center of the steel sheet pile) than the outer surfaces of the flange portions. In the example illustrated in Fig. 1, the protrusions 11a and 11b are arranged so as to be aligned with the outer surfaces of the flange portions. Fig. 9 illustrates an example in which the protrusions 11a and 11b are arranged so as to be closer to the center of the web portion than the outer surfaces of the flange portions.

In the case where the protrusions 11a and 11b are arranged so as to be closer to the center of the web portion than the outer surfaces of the flange portions, the protrusions 11a and 11b have to be separated from the center of the web portion by a predetermined distance toward the flange portions since the resistance against the eccentric earth pressures that occur on the inner side of the corner portions 9a and 9b decreases if the protrusions 11a and 11b are positioned too close to the center of the web portion.

When the distance from the center of the web portion to the outer surface of each flange portion is defined as W_o , as illustrated in Fig. 10, it is preferable that the predetermined distance be set at $0.5W_o$ or larger and W_o or smaller. This effect is proved in relation to Example 2, described below.

[0022]

Regarding the arrangement of the protrusions 11a and 11b, the protrusions 11a and 11b disposed on opposite sides of the center of the web portion may be equidistant from the center of the web portion or at different distances from the center of the web portion as illustrated in Fig. 11.

[0023]

Although the example in which the protrusions 11a and 11b are disposed on the web portion 3 has been described thus far, the protrusions 11a and 11b may be disposed on the outer-surface-side portions of the flange portions as illustrated in Fig. 12. In this case, the protrusions 11a and 11b may be disposed at positions on the outer-surface-side portions of the flange portions near the corner portions, as illustrated in Fig. 12(a), or may be disposed at positions on the outer-surface-side portions of the flange portions near the joint portions, as illustrated in Fig. 12(b). Alternatively, the protrusions 11a and 11b may be disposed at any position within the range, on the outer-

surface-side portions of the flange portions, extending from the vicinity of the corner portions to the vicinity of the joint portions.

[0024]

As illustrated in Fig. 13, the protrusion 11a may be disposed on the outer surface of the corresponding flange portion in the vicinity of the corner portion 9a and the protrusion 11b may be disposed in the vicinity of the joint portion 7b.

Alternatively, as illustrated in Fig. 14, the protrusion 11a may be disposed on the outer-surface-side portion of the corresponding flange portion in the vicinity of the corner portion 9a and the protrusion 11b may be disposed on the corresponding outer-surface-side portion of the web portion in the vicinity of the corner portion 9b.

In the case where the protrusion 11b is disposed on the outer-surface-side portion of the web portion, a waling or strut can be attached to the outer surface of the flange portion near the protrusion 11b. In other words, in the case where an earth-retaining wall is formed using the Z-shaped steel sheet piles 1, the protrusion 11a or 11b may be disposed on the outer-surface-side portion of the web portion so as not to protrude outward beyond the outer surface of the corresponding flange portion at a side at which the waling or strut is to be attached.

In this respect, the Z-shaped steel sheet pile 1 illustrated in Fig. 1, Fig. 9, Fig. 11, and Fig. 14 can be said as a Z-shaped steel sheet pile to which a waling or strut is suitably attached.

[0025]

Referring now to Fig. 15, a protrusion attachment angle θ will be described.

The protrusion attachment angle θ is an angle that each of the protrusions 11a and 11b forms with the outer surface of the corresponding flange portion (see Fig. 15(a)) or with the outer surface of the web portion (see Fig. 15(b)). Here, it is preferable that the protrusion attachment angle θ be 45° or larger and 135° or smaller. When the protrusion attachment angle θ is determined so as to fall within this range, soil blocking between the protrusions 11a and 11b and the steel sheet pile can be prevented, whereby an insertion resistance can be prevented from increasing at the time of driving the steel sheet piles.

[0026]

In the above description, one protrusion is provided on each of both sides of the center of the web portion. However, protrusions may be provided at multiple positions on each side of the center of the web portion. In the case where protrusions are provided at multiple positions, the protrusions may be provided only at each of the flange

portions 5a and 5b, or only at the web portion 3. Instead, the protrusions may be provided at both the web portion 3 and the flange portions 5a and 5b.

Example 1

[0027]

Referring now to Fig. 16 and Fig. 17, Example 1 of the present invention will be described. A board having a thickness of 9 mm was formed into a Z shape (a sheet pile height of 400 mm and a sheet pile width of 450 mm) by bending. Joint members 13a and 13b (models) were welded at end portions of the board to form a Z-shaped steel sheet pile (model) 15 (see Fig. 16). The length of the steel sheet pile was determined as 12 m and the driving completion length (driven length) was determined as 11 m.

Z-shaped steel sheet piles (models) 15 respectively including protrusions 11a and 11b with heights of 30 mm, 50 mm, and 80 mm were driven independently, the protrusions 11a and 11b each being disposed at an end portion of the web portion at the corresponding one of the corner portions 9a and 9b formed by the web portion 3 and the flange portions 5a and 5b, the protrusions 11a and 11b protruding in such a direction as to be aligned with the outer surfaces of the flange portions.

The driving was performed in the following order: a first one of the Z-shaped steel sheet piles of each type was

independently driven and then a second one of the Z-shaped steel sheet piles of each type was joined and fitted to the first one and driven. The protrusions 11a and 11b were disposed at only the end portions of each steel sheet pile and had a length of 100 mm in the longitudinal direction of the steel sheet pile. For comparison, a model having no protrusions was similarly driven.

[0028]

The graph of Fig. 17 shows the results of experiments. The vertical axis in the graph of Fig. 17 indicates a steel-sheet-pile drivable length (m) and the horizontal axis in the graph indicates a protrusion height (mm). The steel-sheet-pile drivable length (m) is a drivable length that a second Z-shaped steel sheet pile (model) 15 is drivable at the time when the second Z-shaped steel sheet pile is driven after being fitted to the Z-shaped steel sheet pile (model) 15, which has been independently driven in advance, at a joint portion.

[0029]

As illustrated in the graph of Fig. 17, in the cases of the Z-shaped steel sheet pile having no protrusion and the Z-shaped steel sheet pile whose protrusion height is 30 mm, the driving completion length (driven length) did not arrive at 11 m due to an increase of the insertion resistance of the steel sheet pile in the middle of driving the second Z-

shaped steel sheet pile (including a joint fitting portion). This is because, as described above, the resistance at the joint fitted portion increased during driving of the second Z-shaped steel sheet pile (including a joint fitting portion) as a result of rotation (twist) of the first Z-shaped steel sheet pile (model) 15 in the ground due to a local earth pressure (eccentric earth pressure) that has occurred at the time of independently driving the first Z-shaped steel sheet pile.

[0030]

On the other hand, in the cases of the Z-shaped steel sheet piles whose protrusion heights are 50 mm and 80mm, respectively, the driving completion length (driven length) of the second Z-shaped steel sheet piles (models) 15 arrived at 11 m. This is because the resistance at the joint fitted portion did not increase during driving of the second Z-shaped steel sheet pile (including a joint fitting portion) because the first Z-shaped steel sheet pile (model) 15 was prevented from being rotated (twisted) while being independently driven with an effect of the protrusions 11a and 11b.

From the above experiments, the effects of the protrusions 11a and 11b were proven.

Example 2

[0031]

In a manner similar to the case of Example 1, driving experiments were conducted on five types of Z-shaped steel sheet pile (model) 15 having the same basic structure as that of Example 1 but having different distances X from the center of the web portion to each of the protrusions 11a and 11b ($X = 0, 50 \text{ mm}, 100 \text{ mm}, 150 \text{ mm}, \text{ or } 200 \text{ mm}$) (see Fig. 18). The graph of Fig. 19 shows the results of experiments.

As illustrated in the graph of Fig. 19, in the case of the Z-shaped steel sheet pile having a distance X of 100 mm or larger, the steel-sheet-pile drivable length was around the driving completion length, whereby an effect of significantly improving the installability (prohibition of rotation) of the Z-shaped steel sheet pile was proved. It can be said that these results have proved that positioning the protrusions 11a and 11b at a certain distance from the center of the web portion is effective, the certain distance being half or more than half a distance from the center of the web portion to the outer surface of each of the flange portions.

Reference Signs List

[0032]

A, B, C, D region

1 Z-shaped steel sheet pile

3 web portion

5a, 5b flange portion

7a, 7b joint portion

9a, 9b corner portion

11a, 11b protrusion

13a, 13b joint member

15 Z-shaped steel sheet pile (model)

21 Z-shaped steel sheet pile (conventional example)

23 web portion

25a, 25b flange portion

29a, 29b corner portion

CLAIMS

[Claim 1]

A Z-shaped steel sheet pile, comprising a web portion; flange portions disposed at both ends of the web portion; and joint portions disposed at ends of the flange portions, wherein protrusions are provided on outer-surface-side portions of the flange portions of the Z-shaped steel sheet pile, on outer-surface-side portions of the web portion of the Z-shaped steel sheet pile, or on at least one outer-surface-side portion of the flange portions and at least one outer-surface-side portion of the web portion, at positions on both sides of a center of the web portion, and

the protrusions are approximately plate-like, disposed approximately parallel to the direction of the length of the Z-shaped steel sheet pile, and attached at an angle from 45° to 135° to the outer surface of the flange portion or to the outer surface of the web portion.

[Claim 2]

The Z-shaped steel sheet pile according to Claim 1, wherein the protrusion provided on the web portion is disposed at a certain distance from the center of the web portion, the certain distance being half or more than half a distance from the center of the web portion to an outer surface of a corresponding one of the flange portions.

[Claim 3]

The Z-shaped steel sheet pile according to Claim 1 or 2, wherein the protrusions provided on both sides of the center of the web portion are equidistant from the center of the web portion.

[Claim 4]

The Z-shaped steel sheet pile according to any one of Claims 1 to 3, wherein the protrusion provided on the web portion protrudes in a direction parallel to outer surface of the flange portion.

[Claim 5]

The Z-shaped steel sheet pile according to any one of Claims 1 to 4, wherein the protrusion has a height of 50 mm or larger.