

[Document Type] Specification

[Title of the Invention] HAT-TYPE STEEL SHEET PILE

[Technical Field of the Invention]

[0001]

The present invention relates to a hat-type steel sheet pile.

Priority is claimed on Japanese Patent Application No. 2017-193111, filed on October 2, 2017, the content of which is incorporated herein by reference.

[Related Art]

[0002]

In the related art, a hat-type steel sheet pile extending in the longitudinal direction, a plurality of which configure a wall, is known.

The hat-type steel sheet pile includes a web, a pair of flanges extending at a slope with respect to the web, and a pair of arms connected to the pair of flanges each.

When a plurality of the hat-type steel sheet piles is combined in a row in the width direction in, for example, a dock or the like, the hat-type steel sheet piles configure a wall that supports an external force exerted in a cross-section height direction orthogonal to the width direction in a plan view seen in the longitudinal direction. As a method for combining these hat-type steel sheet piles, for example, a casting method using a motion exciter in which a chucking method or a gripping method is used as described in Patent Document 1 and Patent Document 2 is known, and this is generally called a vibro-hammer method. In the vibro-hammer method, the hat-type steel sheet piles are cast onto the ground surface in a state in which the pair of flanges of the hat-type steel sheet pile are gripped using gripping portions of a construction heavy machine.

As another method, a press-in method is known. In the press-in method, the

hat-type steel sheet piles are cast onto the ground surface in a state in which the pair of arms of the hat-type steel sheet pile are respectively gripped using gripping portions of a construction heavy machine while surrounding the entire hat-type steel sheet pile from the outside of the hat-type steel sheet pile.

[Prior Art Document]

[Patent Document]

[0003]

[Patent Document 1] Japanese Patent No. 3916621

[Patent Document 2] Japanese Patent No. 4656587

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0004]

In the mechanism of the chucking method (gripping method) described in Patent Document 1, the angles of the gripping portions in the construction heavy machine rotate in accordance with the angles formed by the pair of flanges, which substantially corresponds to two flange angles. When an attempt is made to cause the gripping portions to correspond to an angle that is equal to or larger than the above-described angles, the number of fixation holes provided in the gripping portion increases, the strength of an end of the gripping portion lacks, and the size of an adjustment jig configured to adjust the location of the gripping portion increases. Therefore, the workability becomes poor, and the facility manufacturing cost increases. Therefore, it has been difficult to apply the gripping portion to the pair of flanges forming a variety of angles.

In the gripping method (gripping method) described in Patent Document 2, different positioning members become necessary in accordance with the angle formed

by the pair of flanges.

The use of individually different vibro-hammers depending on the cross section of a steel sheet piling having a variety of shapes so as to be applicable to the cross section of the steel sheet piling leads to the deterioration of the productivity of the vibro-hammers or an increase in the cost. Even in construction sites, in the case of handling cross sections having a plurality of shapes, an increase in the construction time or an increase in the construction cost attributed to the exchange of vibro-hammers is caused, and the workability degrades. Therefore, a vibro-hammer applicable to a plurality of cross sections of a steel sheet piling in the same type is effective, and even existing vibro-hammers are designed to be capable of comprehensively dealing with a plurality of types of steel sheet pilings and are used in a versatile manner.

In order to efficiently generate a casting energy for transmitting the vibration of the vibro-hammer to the hat-type steel sheet pile to tunnel through the ground in a front end section opposite to an end of the hat-type steel sheet pile in the longitudinal direction which is gripped using the vibro-hammer, a mechanical design is conducted so that the energy is smoothly transmitted from a driving portion of the vibro-hammer to the gripping portion that grips the hat-type steel sheet pile. In addition, there is a demand for narrowing the range of motion of the gripping portion and strongly gripping the hat-type steel sheet pile so that a construction error during casting or a manufacturing error of the cross section of the hat-type steel sheet pile can be absorbed. Therefore, in the case of providing a new hat-type steel sheet pile having a more favorable economic efficiency, it becomes advantageous for the new hat-type steel sheet pile to be applicable to an optimally-designed existing vibro-hammer so as to prevent the productivity of the manufacturing of the vibro-hammer or workability in

construction sites from being impaired. Particularly, in a hat-type steel sheet pile having an effective width of 900 mm that is larger than that of a U-shaped steel sheet piling having a width of 400 mm or 600 mm in the related art, horizontal deviation occurring in the cross-sectional direction of the sheet piling accompanied by the vibration of the vibro-hammer becomes large, and the casting efficiency decreases. Therefore, a double chuck-type vibro-hammer configured to suppress horizontal deviation by gripping two places of the flanges is designed in an optimal specification and used. In such a case, the provision of a cross section of a hat-type sheet piling which is applicable to the construction heavy machine is capable of directly bringing about improvement in economic efficiency.

In addition, in the press-in method as well, there has been a problem in that an applicable cross-sectional shape is limited by the limitation on the shape of a gripping portion of a construction heavy machine or the size of the entire hat-type steel sheet pile.

[0005]

The present invention has been made in consideration of the above-described problems, and an object of the present invention is to provide a hat-type steel sheet pile capable of contributing to cost reduction while ensuring cross-sectional performance and capable of ensuring the general-purpose versatility of construction heavy machines.

[Means for Solving the Problem]

[0006]

In order to solve the above-described problems and attain the relevant object, the present invention employed the following aspects.

(1) A hat-type steel sheet pile according to an aspect of the present invention is a hat-type steel sheet pile a plurality of which configure a wall and which extends in

a longitudinal direction, the hat-type steel sheet pile including a web extending in a width direction in which the wall extends in a plan view seen in the longitudinal direction, a pair of flanges which are connected to outer ends of the web in the width direction and extend at a slope with respect to the web in the plan view, and a pair of arms which are connected to ends of the pair of flanges each in the width direction on a side opposite to the web and extend in the width direction in the plan view, in which a relationship between a sectional area A (cm^2/m) and a sectional moment of inertia I (cm^4/m) around a cross-sectional gravity center line extending in the width direction in the plan view per meter as a size of the hat-type steel sheet pile in the width direction satisfies Expression (1), and, when a distance between a first intersection point of extended lines from the pair of flanges each in the plan view and the cross-sectional gravity center line is represented by $D1$ (mm), and a distance between second intersection points of the pair of flanges each with the cross-sectional gravity center line is represented by $D2$ (mm),

Expression (2A) and Expression (2B),

Expression (3A) and Expression (3B),

Expression (4A) and Expression (4B), or

Expression (5A) and Expression (5B) are satisfied.

$$A < 0.00252I + 94.4 \dots (1)$$

$$262.6 < D1 < 281.0 \dots (2A)$$

$$496.9 < D1 < 520.9 \dots (3A)$$

$$621.5 < D1 < 650.9 \dots (4A)$$

$$625.2 < D1 < 654.8 \dots (5A)$$

$$484.0 < D2 < 499.0 \dots (2B)$$

$$474.0 < D2 < 489.0 \dots (3B)$$

$$476.0 < D2 < 491.0 \cdots (4B)$$

$$474.0 < D2 < 489.0 \cdots (5B)$$

[0007]

According to the hat-type steel sheet pile according to this aspect, the relationship between the sectional area A and the sectional moment of inertia I around the cross-sectional gravity center line extending in the width direction in the plan view seen in the longitudinal direction per meter as the size of the hat-type steel sheet pile in the width direction satisfies Expression (1). Therefore, even in the case of ensuring or changing the cross-sectional performance in a current hat-type steel sheet pile, it becomes possible to decrease the sectional area, and it is possible to contribute to cost reduction.

[0008]

In addition, the relationship between D1 and D2 satisfies any one relationship of Expression (2A) and Expression (2B), Expression (3A) and Expression (3B), Expression (4A) and Expression (4B), and Expression (5A) and Expression (5B). Therefore, it is possible to divert a current construction heavy machine for the steel sheet piling of the present invention by changing the dimension in the width direction of a pair of gripping portions of a construction heavy machine used at the time of working current hat-type steel sheet piles having a variety of sizes, and it is possible to ensure the general-purpose versatility of the construction heavy machines. Furthermore, it becomes possible to make the distance between the second intersection points in the hat-type steel sheet pile according to the aspect identical to any of the distances between the second intersection points in the current hat-type steel sheet piles having a variety of sizes. In addition, it becomes possible to make a slope angle between the pair of flanges in the hat-type steel sheet pile according to the aspect

identical to any of slope angles between the flanges in the current hat-type steel sheet piles having a variety of sizes.

In such a case, it is possible to grip the hat-type steel sheet pile of the present invention as it is using the gripping portions of the construction heavy machine used at the time of working the current hat-type steel sheet pile having a variety of sizes, and it is possible to smoothly carry out a construction work that is carried out using a construction heavy machine in the related art.

[0009]

(2) In the hat-type steel sheet pile according to (1), D1 and D2 may satisfy Expression (2A) and Expression (2B).

[0010]

(3) In the hat-type steel sheet pile according to (1), D1 and D2 may satisfy Expression (3A) and Expression (3B).

[0011]

(4) In the hat-type steel sheet pile according to (1), D1 and D2 may satisfy Expression (4A) and Expression (4B).

[0012]

(5) In the hat-type steel sheet pile according to (1), D1 and D2 may satisfy Expression (5A) and Expression (5B).

[0013]

(6) In the hat-type steel sheet pile according to (1), an effective width W (mm) between outer ends of the pair of arms each in the width direction may satisfy Expression (6), and a distance H (mm) in a cross-section height direction orthogonal to the width direction in the plan view between a surface of the web along the width direction on a side opposite to the cross-sectional gravity center line and a surface of

the arm along the width direction on a side opposite to the cross-sectional gravity center line may satisfy Expression (7).

$$876 \leq W \leq 932 \cdots (6)$$

$$H \leq 400 \cdots (7)$$

[0014]

In this case, the effective width W satisfies Expression (6), and the distance H satisfies Expression (7). Therefore, there is a rising possibility that the entire hat-type steel sheet pile can be surrounded from the outside of the hat-type steel sheet pile in the plan view while gripping the arms using the gripping portions of the construction heavy machine for a press-in method using the current versatile construction heavy machine for the press-in method. Therefore, it is possible to further ensure the general-purpose versatility of construction heavy machines.

[0015]

(7) In the hat-type steel sheet pile according to any one of (1) to (6), a distance L (mm) between a third intersection point of perpendicular lines that pass through the second intersection points of the pair of flanges each with the cross-sectional gravity center line and are orthogonal to the pair of flanges each and the cross-sectional gravity center line, a distance H (mm) in a cross-section height direction orthogonal to the width direction in the plan view between a surface of the web along the width direction on a side opposite to the cross-sectional gravity center line and a surface of the arm along the width direction on a side opposite to the cross-sectional gravity center line, and a distance C (mm) between the surface of the web along the width direction on the side opposite to the cross-sectional gravity center line and the cross-sectional gravity center line may satisfy Expression (8).

$$L > H - C \cdots (8)$$

[0016]

In this case, the third intersection point is located on the outside of the hat-type steel sheet pile in the cross-section height direction in the plan view. Therefore, at the time of casting the hat-type steel sheet pile onto the ground surface, it is possible to discharge soil located in the inside of the hat-type steel sheet pile in the plan view toward the outside along the width direction of the hat-type steel sheet pile through a width-direction portion between the pair of arms. The workability of the hat-type steel sheet pile can be ensured by providing the above-described mobilized earth pressure effect to the hat-type steel sheet pile.

[Effects of the Invention]

[0017]

According to the hat-type steel sheet pile of the present invention, it is possible to contribute to cost reduction while ensuring cross-sectional performance and to ensure the general-purpose versatility of construction heavy machines.

[Brief Description of the Drawings]

[0018]

FIG. 1 is a view showing a hat-type steel sheet pile corresponding to mainly a type 10H according to an embodiment of the present invention and a plan view of the hat-type steel sheet pile seen in a longitudinal direction.

FIG. 2 is a graph showing a relationship between a sectional area and a sectional moment of inertia of the hat-type steel sheet pile.

FIG. 3 is a view showing a hat-type steel sheet pile corresponding to mainly a type 25H according to the same embodiment and a plan view of the hat-type steel sheet pile seen in a longitudinal direction.

FIG. 4 is a view showing a hat-type steel sheet pile corresponding to mainly a

type 45H according to the same embodiment and a plan view of the hat-type steel sheet pile seen in a longitudinal direction.

FIG. 5(a) is a view showing gripping portions used in a vibro-hammer method, and FIG. 5(b) is a view showing gripping portions used in a press-in method, in a construction heavy machine for the hat-type steel sheet pile.

[Embodiments of the Invention]

[0019]

Hereinafter, a hat-type steel sheet pile 1 according to an embodiment of the present invention will be described with reference to FIG. 1 and FIG. 2. As shown in FIG. 1, the hat-type steel sheet pile 1 extends in a longitudinal direction (Z direction). A plurality of the hat-type steel sheet piles 1 is disposed in a width direction (a direction orthogonal to the Z direction and an X direction described below) to configure a wall. The wall extends in one direction in a plan view seen in the longitudinal direction. In the following description, the one direction will be referred to as the width direction (X direction), and the direction orthogonal to the width direction in the plan view will be referred to as a cross-section height direction (Y direction). In addition, among individual variables to be used in the description, variables having a duplicate reference symbol will not be expressed with a unit in some cases.

[0020]

The hat-type steel sheet pile 1 includes a web 10 extending in the width direction, a pair of flanges 11 connected to outer ends of the web 10 in the width direction, and a pair of arms 12 connected to ends of the pair of flanges 11 each in the width direction on a side opposite to the web 10. The flange 11 extends at a slope with respect to the web 10 in the plan view. The pair of flanges 11 gradually spread

in the width direction as the flanges extend from the web 10. The slope angles of the pair of flanges 11 each with respect to the width direction are the same as each other. The arms 12 extend in the width direction in the plan view.

[0021]

To the respective outer ends of the pair of arms 12 in the width direction, joints 13 are connected. The joint 13 forms a C shape in the plan view and includes a joint opening 13A that opens in the cross-section height direction. Directions in which the joint openings 13A of the pair of arms 12 each are opposite to each other in the plan view. The shape of the hat-type steel sheet pile 1 except for the joints 13 is formed to be linearly symmetric with respect to, as a criterion, a central line in the width direction in the plan view.

[0022]

A plurality of the hat-type steel sheet piles 1 is disposed in a row in the width direction. Orientations of the cross-section height directions of the hat-type steel sheet piles 1 adjacent to each other in the width direction are the same as each other. The plurality of hat-type steel sheet piles 1 configures a wall extending in the width direction by joining the joints 13 adjacent to each other together by means of fitting.

[0023]

In addition, in the hat-type steel sheet pile 1 according to the embodiment of the present invention, a relationship between a sectional area A (cm^2/m) and a sectional moment of inertia I (cm^4/m) around a cross-sectional gravity center line M extending in the width direction in the plan view (hereinafter, simply referred to as the sectional moment of inertia) per meter as the size of the hat-type steel sheet pile in the width direction (that is, per meter as the width of the hat-type steel sheet pile) satisfies Expression (1). Here, the cross-sectional gravity center line M extending in the width

direction in the plan view refers to a straight line that passes through the gravity center of the hat-type steel sheet pile 1 in the plan view and extends in the width direction.

$$A < 0.00252I + 94.4 \cdots (1)$$

The sectional area A and the sectional moment of inertia I per meter as the size of the hat-type steel sheet pile in the width direction are values obtained by dividing the sectional area and the sectional moment of inertia per steel sheet piling 1 by an effective width W of the steel sheet piling. In the following description, “per meter as the size of the hat-type steel sheet pile in the width direction” will be omitted, and the value will be simply referred to as the sectional area or the sectional moment of inertia.

[0024]

Hereinafter, a technical meaning of Expression (1) will be described.

The hat-type steel sheet pile 1 supports an external force exerted in the cross-section height direction and is thus demanded to be favorable in terms of cross-sectional performance, for example, the sectional moment of inertia, a cross-sectional coefficient, or the like. Therefore, it is demanded to change the cross-sectional shape of a current hat-type steel sheet pile to a cross-sectional shape contributing to cost reduction by further decreasing the sectional areas along both directions of the width direction and the cross-section height direction while ensuring or changing the cross-sectional performance in the cross-sectional shape of the current hat-type steel sheet pile.

Therefore, the present inventors summarized the cross-sectional characteristics and the principal dimensions of current hat-type steel sheet piles by type. The results are shown in Table 1. A distance C in Table 1 refers to a distance (mm) between a surface of the web 10 along the width direction on a side opposite to the

cross-sectional gravity center line M and the cross-sectional gravity center line M.

[0025]

TYPE	SECOND MOMENT OF AREA I cm ⁴ /m	CROSS SECTION COEFFICIENT Z cm ³ /m	CROSS- SECTIONAL AREA A cm ² /m	UNIT MASS W _g kg/m ²	EFFECTIVE HEIGHT H mm	EFFECTIVE WIDTH W mm	WEB SHEET THICKNESS tw mm	DISTANCE	
								C	D1 D2
10H	10,500	902	122.2	96.0	230.0	900.0	10.8	115.0	271.8 489.5
25H	24,400	1,610	160.4	126.0	300.0	900.0	13.2	150.0	508.9 479.0
45H	45,000	2,450	207.8	163.0	368.0	900.0	15.0	184.0	636.2 480.8
50H	51,100	2,760	236.3	186.0	370.0	900.0	17.0	185.0	640.0 478.6

[Table 1]

[0026]

Next, FIG. 2 shows a correlation chart between the sectional moment of inertia I and the sectional areas A of the four types in Table 1. A straight line connecting the respective values of current types 10H and 45H is represented by S, and

the right side of Expression (1) is derived. That is, in the case of satisfying Expression (1), it can be said that the sectional area per sectional moment of inertia is smaller than that of the current hat-type steel sheet pile and the cross-sectional shape is more economic than that of the current hat-type steel sheet pile.

If necessary, the upper limit of the sectional area A (cm^4/m) may be set to $0.00252I + 94.0$ or $0.00252I + 93.6$. The lower limit of the sectional area A (cm^4/m) does not need to be particularly determined, but may be set to 40 and, if necessary, may be set to $0.00252I + 40$.

[0027]

It is economical that it is possible to divert exclusive construction heavy machines for the respective types (including an accessory for gripping or the like, which will be true below) corresponding to the hat-type steel sheet piles of the existing types 10H, 25H, 45H, and 50H as they are. From this viewpoint, configurational requirements except for Expression (1) will be described by a product corresponding to each of the types.

As described below, the hat-type steel sheet pile according to the embodiment of the present invention can be classified into four kinds of a product corresponding to the type 10H, a product corresponding to the type 25H, a product corresponding to the type 45H, and a product corresponding to the type 50H. These four kinds of corresponding products of the present embodiment all satisfy Expression (1).

[0028]

(Product corresponding to type 10H)

The configurational requirements except for Expression (1) will be described using the hat-type steel sheet pile 1 of the type 10H indicating a hat-type steel sheet pile having a sectional moment of inertia I of approximately 10,500 (cm^4/m) as an

example.

It was found that, when a distance D1 (mm) in the cross-section height direction and a distance D2 (mm) in the width direction are appropriately set by combining both in a cross section of a hat-type steel sheet pile, it is possible to apply a construction heavy machine for the hat-type steel sheet pile of the existing type 10H as it is, and it is possible to efficiently transmit a casting energy generated using a vibro-hammer to the hat-type steel sheet pile. The distance D1 refers to a distance between a first intersection point P1 of extended lines from the pair of flanges 11 each in the plan view and the cross-sectional gravity center line M. The distance D2 refers to a distance between second intersection points P2 of the pair of flanges 11 each with the cross-sectional gravity center line M in the plan view.

[0029]

In addition, in the hat-type steel sheet pile corresponding to the type 10H, the distance D1 between the first intersection point P1 of the extended lines from the pair of flanges 11 each in the plan view and the cross-sectional gravity center line M satisfies Expression (2A).

$$262.6 < D1 < 281.0 \cdots (2A)$$

Hereinafter, a technical meaning of Expression (2A) will be described.

In order to cast the hat-type steel sheet pile 1 onto the ground surface using a vibro-hammer method as shown in FIG. 5(a), it is economical that it is possible to divert a construction heavy machine corresponding to the current hat-type steel sheet pile of the type 10H as it is. Therefore, in order to use gripping portions 30 configured to grip the second intersection points P2 of the pair of flanges 11 of the hat-type steel sheet pile 1 with the cross-sectional gravity center line M, it is demanded that the distances D1 are almost the same as each other in the current hat-type steel

sheet piles. This is because, when the distances D1 are almost the same as each other, the gripping portions 30 of the construction heavy machine for the current hat-type steel sheet pile of the type 10H are capable of easily gripping the pair of flanges 11 of the hat-type steel sheet pile 1.

[0030]

Here, the distance D1 is expressed by Expression (20) using the dimensions of the respective portions of the hat-type steel sheet pile 1 shown in FIG. 1.

$$D1 = (B/2) \times \tan\theta + C - tw/2 \cdots (20)$$

Here, B represents a dimension (mm) of the web 10 in the width direction, θ represents a flange angle ($^\circ$), C represents a distance (mm) between the surface of the web 10 along the width direction on the side opposite to the cross-sectional gravity center line M and the cross-sectional gravity center line M, and tw represents a thickness dimension (mm) of the web 10 respectively.

[0031]

Next, it was found that, as a result of investigating the distance D1 at which the absorption of a construction error or the transmission of an appropriate casting energy can be attained, Expression (21) and Expression (22) are obtained. Here, a distance H refers to a distance (effective height) between the surface of the web 10 along the width direction on the side opposite to the cross-sectional gravity center line M and a surface of the arm 12 along the width direction on a side opposite to the cross-sectional gravity center line M.

$$D1_{MAX} = (B/2) \times \tan\theta + C - (tw/2) + 0.04 \times H \cdots (21)$$

$$D1_{MIN} = (B/2) \times \tan\theta + C - (tw/2) - 0.04 \times H \cdots (22)$$

That is, when the value of D1 of the hat-type steel sheet pile 1 is in a range from D1_{MAX} in Expression (21) to D1_{MIN} in Expression (22) regarding the dimensions

of the respective portions of the current hat-type steel sheet pile, efficient casting can be realized.

[0032]

In addition, Expression (2A) was obtained from the respective dimensions of the current hat-type steel sheet pile of the type 10H, Expression (21), and Expression (22).

[0033]

In addition, in the hat-type steel sheet pile of the type 10H, the distance D2 between the second intersection points P2 of the pair of flanges 11 each with the cross-sectional gravity center line M satisfies Expression (2B).

$$484.0 < D2 < 499.0 \cdots (2B)$$

Hereinafter, a technical meaning of Expression (2B) will be described.

As described above, when the hat-type steel sheet pile 1 is press-in using the vibro-hammer method by employing the construction heavy machine for the current hat-type steel sheet pile of the type 10H, it is possible to carry out an operation in a stable state by gripping portions of the hat-type steel sheet pile 1 on the cross-sectional gravity center line M using the gripping portions 30 of the construction heavy machine. Therefore, it is demanded that the distances D2 are almost the same as each other in the current hat-type steel sheet piles. This is because, when the distances D2 are almost the same as each other, the gripping portions 30 of the construction heavy machine for the current hat-type steel sheet pile of the type 10H are capable of gripping the hat-type steel sheet pile 1 as it is.

[0034]

In addition, as a result of narrowing down the distance D2 enabling the attainment of the absorption of the construction error or the transmission of an

appropriate casting energy, it was found that Expression (23) and Expression (24) are an appropriate range.

$$D2_{MAX} = D2 + 10 \cdots (23)$$

$$D2_{MIN} = D2 - 5 \cdots (24)$$

That is, when the value of D2 of the hat-type steel sheet pile 1 is in a range from D2_{MAX} in Expression (23) to D2_{MIN} in Expression (24), efficient casting can be realized.

Here, the effective width W refers to a distance from a fitting center of the joint 13 on one side in the width direction to a fitting center of the joint 13 on the other side in the width direction.

As the fitting state of the joints 13, there are compressive fitting, neutral fitting, tensile fitting, and the like. That is, compressive fitting is a state in which the joints 13 adjacent to each other are compressed by each other in the width direction, tensile fitting is a state in which the joints 13 adjacent to each other are stretched by each other in the width direction, and neutral fitting is an intermediate state between compressive fitting and tensile fitting in which the joints 13 adjacent to each other are neither compressed nor stretched by each other. The effective width W in the present embodiment corresponds to the distance between the joint centers in the neutral fitting state.

[0035]

In addition, Expression (2B) was obtained from the respective dimensions of the current type 10H, Expression (23), and Expression (24).

[0036]

In addition, in the hat-type steel sheet pile corresponding to the type 10H, the effective width W (mm) between the outer ends of the pair of arms 12 each in the

width direction satisfies Expression (6).

$$876 \leq W \leq 932 \dots (6)$$

Hereinafter, a technical meaning of Expression (6) will be described.

In order to press-in the hat-type steel sheet pile 1 using, for example, not the vibro-hammer method but a press-in method as shown in FIG. 5(b), it is economical to divert a construction heavy machine for the press-in method which is used for the current hat-type steel sheet pile of the type 10H. Therefore, in order to use gripping portions 40 configured to grip both ends of the pair of arms 12 of the hat-type steel sheet pile 1, it is preferable that the effective widths W are almost the same as each other in the current hat-type steel sheet piles. This is because, when the effective widths W are almost the same as each other, the gripping portions 40 of the construction heavy machine are capable of gripping both ends of the pair of arms 12 in the current press-in method for the hat-type steel sheet pile of the type 10H.

[0037]

In addition, it was confirmed that, in the construction heavy machine for the press-in method that is used for the hat-type steel sheet pile of the type 10H, a distance in the width direction which can be gripped using the gripping portions 40 is 876 mm to 932 mm. That is, in a case where the effective width W satisfies Expression (6), it is possible to employ the construction heavy machine in the current press-in method. It was possible to confirm that the distances in the width direction of the type 20H, the type 45H, and the type 50H other than the type 10H are 876 mm to 932 mm. Therefore, for the products corresponding to these types as well, it is preferable to satisfy Expression (6).

[0038]

In addition, in the hat-type steel sheet pile corresponding to the type 10H, the

distance H (mm) satisfies Expression (7).

$$H \leq 400 \cdots (7)$$

Hereinafter, a technical meaning of Expression (7) will be described.

As described above, the hat-type steel sheet pile 1, in the case of employing the construction heavy machine in the current press-in method for the hat-type steel sheet pile of the type 10H, the gripping portions 40 of the construction heavy machine surrounds the entire hat-type steel sheet pile 1 from the outside of the hat-type steel sheet pile 1, and thus it is preferable that the distance H is almost the same as that of the current hat-type steel sheet pile. This is because, when the distance H is almost the same, the gripping portions 40 of the construction heavy machine are capable of surrounding the entire hat-type steel sheet pile 1 from the outside of the hat-type steel sheet pile 1.

[0039]

In addition, it was confirmed that, in the construction heavy machine in the press-in method which is employed for the current hat-type steel sheet pile of the type 10H, a distance in the cross-section height direction in which the entire hat-type steel sheet pile 1 can be surrounded by the gripping portions 40 is 400 mm or less. That is, in a case where the distance H satisfies Expression (7), it is possible to employ the gripping portions 40 of the current construction heavy machine. It was possible to confirm that the distances in the cross-section height direction of the type 20H, the type 45H, and the type 50H other than the type 10H are 400 mm or less. Therefore, for the products corresponding to these types as well, it is preferable to satisfy Expression (6).

[0040]

In addition, in the hat-type steel sheet pile corresponding to the type 10H, a

distance L (mm) between a third intersection point P3 of perpendicular lines that pass through the second intersection points P2 of the pair of flanges 11 each with the cross-sectional gravity center line M and are orthogonal to the pair of flange 11 each and the cross-sectional gravity center line M, the distance H (mm) between the web 10 and the arms 12, and the distance C (mm) between the surface of the web 10 along the width direction on the side opposite to the cross-sectional gravity center line M and the cross-sectional gravity center line M satisfy Expression (8).

$$L > H - C \cdots (8)$$

[0041]

Hereinafter, a technical meaning of Expression (8) will be described.

When the hat-type steel sheet pile 1 is cast onto the ground surface using the vibro-hammer method or the press-in method, a pair of mobilized earth pressures (earth pressures) act against each other from the pair of flanges 11 facing each other in the width direction toward the inside in the width direction. Therefore, soil surrounded by the web 10 and the pair of flanges 11 is compacted by the mobilized earth pressures, and there is a case where the construction load for constructing the hat-type steel sheet pile 1 increases or the hat-type steel sheet pile 1 deforms due to a repulsive force from the soil.

[0042]

Therefore, the third intersection point P3 of the action lines of the mobilized earth pressures is disposed on the outside in the cross-section height direction of the arms 12 in the cross-section height direction (lower than the arms 12 in FIG. 1). In such a case, when the mobilized earth pressures act on the soil surrounded by the web 10 and the pair of flanges 11, it becomes possible to push out the soil to the outside of the arms 12 along the cross-section height direction (mobilized earth pressure effect).

Therefore, the increase in the construction load or the deformation of the hat-type steel sheet pile 1 can be suppressed. In addition, when Expression (8) is satisfied, it is possible to dispose the third intersection point P3 of the action lines of the mobilized earth pressures on the outside of the arms 12 in the cross-section height direction.

[0043]

(Product corresponding to type 25H)

Next, a hat-type steel sheet pile 2 corresponding to the type 25H of the present embodiment will be described with reference to FIG. 3. In the hat-type steel sheet pile 2 corresponding to the type 25H, a portion having the same configuration as described above will be given the same reference sign and will not be described again, and only a difference will be described.

[0044]

As shown in FIG. 3, in the hat-type steel sheet pile 2 corresponding to the type 25H, particularly, the size in the cross-section height direction is larger than that of the hat-type steel sheet pile 1. Therefore, the distance L, the distance C, and the distance H in the hat-type steel sheet pile 2 do not satisfy Expression (8).

In addition, in the hat-type steel sheet pile 2 corresponding to the type 25H, Expression (3A) is satisfied instead of Expression (2A).

$$496.9 < D1 < 520.9 \cdots (3A)$$

[0045]

In the hat-type steel sheet pile 2 corresponding to the type 25H, Expression (3A) was obtained from the respective dimensions of the current hat-type steel sheet pile of the type 25H, Expression (21), and Expression (22).

Here, the type 25H refers to a hat-type steel sheet pile having a sectional moment of inertia of approximately 24,400 (cm⁴/m).

[0046]

In addition, in the hat-type steel sheet pile 2 corresponding to the type 25H, Expression (3B) is satisfied instead of Expression (2B).

$$474.0 < D2 < 489.0 \cdots (3B)$$

In the hat-type steel sheet pile 2 corresponding to the type 25H, Expression (3B) was obtained from the respective dimensions of the current hat-type steel sheet pile of the type 25H, Expression (23), and Expression (24).

[0047]

(Product corresponding to type 45H)

Next, a hat-type steel sheet pile 3 corresponding to the type 45H of the present embodiment will be described with reference to FIG. 4. In the hat-type steel sheet pile 3 corresponding to the type 45H, a portion having the same configuration as described above will be given the same reference sign and will not be described again, and only a difference will be described.

[0048]

As shown in FIG. 4, in the hat-type steel sheet pile 3 corresponding to the type 45H, particularly, the size in the cross-section height direction is larger than that of the hat-type steel sheet pile 2. Therefore, the distance L, the distance C, and the distance H in the hat-type steel sheet pile 3 corresponding to the type 45H do not satisfy Expression (8).

In addition, in the hat-type steel sheet pile 3 corresponding to the type 45H, Expression (4A) is satisfied instead of Expression (2A).

$$621.5 < D1 < 650.9 \cdots (4A)$$

[0049]

In the hat-type steel sheet pile 3 corresponding to the type 45H, Expression

(4A) was obtained from the respective dimensions of the current hat-type steel sheet pile of the type 45H, Expression (21), and Expression (22).

Here, the type 45H refers to a hat-type steel sheet pile having a sectional moment of inertia of approximately 45,000 (cm⁴/m).

[0050]

In addition, in the hat-type steel sheet pile 3 corresponding to the type 45H, Expression (4B) is satisfied instead of Expression (2B).

$$476.0 < D2 < 491.0 \cdots (4B)$$

In the hat-type steel sheet pile 3 corresponding to the type 45H, Expression (4B) was obtained from the respective dimensions of the current hat-type steel sheet pile of the type 45H, Expression (23), and Expression (24).

[0051]

(Product corresponding to type 50H)

Next, a hat-type steel sheet pile 4 corresponding to the type 50H of the present embodiment will be described. In the hat-type steel sheet pile 4 corresponding to the type 50H, a portion having the same configuration as described above will be given the same reference sign and will not be described again, and only a difference will be described. The cross-sectional shape of the hat-type steel sheet pile corresponding to the type 50H is almost the same as that of the type 45H and is not drawn.

In the hat-type steel sheet pile 4 corresponding to the type 50H, Expression (5A) and Expression (5B) are satisfied. Expression (5A) and Expression (5B) are obtained from the respective dimensions of the type 50H, Expression (21), Expression (22), Expression (23), and Expression (24).

Here, the type 50H refers to a hat-type steel sheet pile having a sectional moment of inertia of approximately 51,100 (cm⁴/m).

$$625.2 < D1 < 654.8 \dots (5A)$$

$$474.0 < D2 < 489.0 \dots (5B)$$

[0052]

As described above, the relationship between the sectional area A and the sectional moment of inertia I around the cross-sectional gravity center line M extending in the width direction in the plan view seen in the longitudinal direction per meter as the size of the hat-type steel sheet pile in the width direction satisfies Expression (1), it becomes possible to decrease the sectional area while ensuring or changing the cross-sectional performance in the current hat-type steel sheet pile, and it is possible to contribute to cost reduction.

[0053]

In addition, when the relationship between D1 and D2 satisfies any one relationship of Expression (2A) and Expression (2B), Expression (3A) and Expression (3B), Expression (4A) and Expression (4B), and Expression (5A) and Expression (5B), it is possible to divert the current construction heavy machine by changing the dimension in the width direction of the pair of gripping portions 30 of the construction heavy machine used at the time of working the current hat-type steel sheet piles having a variety of sizes, and it is possible to ensure the general-purpose versatility of the construction heavy machine.

[0054]

In addition, when the effective width W between the outer ends of the pair of arms 12 each satisfies Expression (6) and the distance H in the cross-section height direction orthogonal to the width direction in the plan view between the web 10 and the arms 12 in the width direction satisfies Expression (7), there is a rising possibility that the hat-type steel sheet pile can be worked using a current versatile construction

heavy machine for the press-in method. Therefore, it is possible to further ensure the general-purpose versatility of construction heavy machines.

[0055]

In addition, when the third intersection point P3 of the perpendicular lines that pass through the second intersection points P2 of the pair of flanges 11 each with the cross-sectional gravity center line M and are orthogonal to the pair of flanges 11 each is located on the outside of the hat-type steel sheet piles 1 to 4 in the plan view (that is, the hat-type steel sheet pile satisfies Expression (8)), at the time of casting the hat-type steel sheet pile onto the ground surface, it is possible to discharge soil located in the inside of the hat-type steel sheet piles 1 to 4 in the plan view toward the outside along the width direction of the hat-type steel sheet pile through a width-direction portion between the pair of arms 12. In addition, the workability of the hat-type steel sheet pile can be ensured by providing the above-described mobilized earth pressure effect to the hat-type steel sheet pile.

[Examples]

[0056]

Next, example of the present embodiment will be described. Twenty cases were designed by trial and error so as to satisfy the conditions of Expression (1), Expression (2), and Expression (2A) to Expression (5B). The design results are shown in Table 2. A distance C in Table 2 refers to a distance (mm) between a surface of the web 10 along the width direction on a side opposite to the cross-sectional gravity center line M and the cross-sectional gravity center line M.

[0057]

[Table 2]

TYPE	SECOND MOMENT OF AREA I cm ⁴ /m	CROSS SECTION COEFFICIENT Z cm ³ /m	CROSS- SECTIONAL AREA A cm ² /m	UNIT MASS Wg kg/m ²	EFFECTIVE HEIGHT H mm	EFFECTIVE WIDTH W mm	WEB SHEET THICKNESS tw mm	DISTANCE C mm	DISTANCE		VALUE OF 0.00252I+94.4
									D1 mm	D2 mm	
EXAMPLE1	8,479	805	115.1	90.3	210.0	900.0	10.0	105.0	271.8	489.5	115.8
EXAMPLE2	8,329	772	110.6	86.8	215.0	876.0	9.0	107.5	273.2	491.9	115.4
EXAMPLE3	10,749	893	116.9	91.8	240.0	900.0	10.4	120.0	269.9	486.0	121.5
EXAMPLE4	10,968	912	117.1	91.9	240.0	920.0	11.1	120.0	269.6	485.6	122.0
EXAMPLE5	11,579	940	121.0	95.0	246.0	900.0	10.8	123.0	269.3	485.0	123.6
EXAMPLE6	11,542	928	119.3	93.7	246.0	930.0	11.0	123.0	270.5	487.1	123.5
EXAMPLE7	20,597	1,367	135.9	106.7	300.0	900.0	10.6	150.0	516.0	485.6	146.3
EXAMPLE8	18,508	1,269	129.3	101.5	290.0	932.0	10.5	145.0	516.1	485.7	141.0
EXAMPLE9	25,667	1,549	144.7	113.6	330.0	900.0	11.0	165.0	514.8	484.5	159.1
EXAMPLE10	25,541	1,495	137.7	108.1	340.0	880.0	10.0	170.0	514.7	484.4	158.8
EXAMPLE11	34,614	1,865	155.1	121.7	370.0	900.0	12.9	185.0	505.2	475.4	181.6
EXAMPLE12	34,643	1,867	153.4	120.4	370.0	932.0	13.5	185.0	505.0	475.3	181.7
EXAMPLE13	35,317	1,937	161.0	126.4	364.1	900.0	12.0	182.1	636.8	480.4	183.4
EXAMPLE14	35,156	1,931	158.9	124.7	364.0	930.0	12.5	182.0	637.0	480.5	183.0
EXAMPLE15	44,333	2,408	198.6	155.9	368.0	900.0	15.2	184.0	637.3	480.8	206.1
EXAMPLE16	44,481	2,413	197.2	154.8	368.0	930.0	15.9	184.0	637.0	480.5	206.5
EXAMPLE17	49,099	2,649	214.5	168.4	370.0	900.0	17.2	185.0	637.1	480.6	218.1
EXAMPLE18	49,296	2,655	213.1	167.3	370.0	930.0	18.0	185.0	636.1	479.9	218.6
EXAMPLE19	46,757	2,451	191.7	150.5	380.0	930.0	16.0	190.0	621.7	490.3	212.2
EXAMPLE20	50,239	2,641	204.1	160.2	380.0	900.0	17.0	190.0	652.8	475.2	221.0

[0058]

All of the examples satisfy Expression (1). Examples 1 to 6 satisfy

Expression (2A) and Expression (2B). Therefore, the hat-type steel sheet piles of Examples 1 to 6 can be classified into the product corresponding to the type 10H. That is, the hat-type steel sheet piles can be worked using the current construction heavy machine for the hat-type steel sheet pile of the type 10H.

Examples 7 to 12 satisfy Expression (3A) and Expression (3B). Therefore, the hat-type steel sheet piles of Examples 7 to 12 can be classified into the product corresponding to the type 25H. That is, the hat-type steel sheet piles can be worked using the current construction heavy machine for the hat-type steel sheet pile of the type 25H.

Examples 13 to 18 satisfy all of Expression (4A), Expression (5A), Expression (4B), and Expression (5B). Therefore, the hat-type steel sheet piles of Examples 13 to 18 can be classified into the product corresponding to the type 45H and also into the product corresponding to the type 50H. That is, the hat-type steel sheet piles of Examples 13 to 18 can be worked using the current construction heavy machine for the hat-type steel sheet piles of both the type 45H and the type 50H.

Example 19 satisfies Expression (4A) and Expression (4B). Therefore, the hat-type steel sheet pile of Example 19 can be classified into the product corresponding to the type 45H. That is, the hat-type steel sheet pile of Example 19 can be worked using the current construction heavy machine for the hat-type steel sheet pile of the type 45H.

Example 20 satisfies Expression (5A) and Expression (5B). Therefore, the hat-type steel sheet pile of Example 20 can be classified into the product corresponding to the type 50H. That is, the hat-type steel sheet pile of Example 20 can be worked using the current construction heavy machine for the hat-type steel sheet pile of the type 50H.

[0059]

Hitherto, the embodiment and the examples of the present invention have been described in detail with reference to the drawings, but the specific configuration is not limited thereto, and modification, combination, removal, and the like of the configuration within the scope of the gist of the present invention are also included in the scope of the present invention. Furthermore, the respective configurations described in the embodiment may be appropriately combined together.

[0060]

For example, in the above-described embodiment, the configuration in which the effective width W (mm) between the outer ends of the pair of arms 12 each in the width direction satisfies Expression (6), and the distance H (mm) in the cross-section height direction between the web 10 and the arms 12 satisfies Expression (7) has been described, but the configuration is not limited to such an aspect. The effective width W may not satisfy Expression (6), or the distance H may not satisfy Expression (7).

[Industrial Applicability]

[0061]

According to the present invention, it is possible to contribute to cost reduction while ensuring the cross-sectional performance and to ensure the general-purpose versatility of construction heavy machines. Therefore, the present invention is significantly industrially applicable.

[Brief Description of the Reference Symbols]

[0062]

1, 2, 3, 4 Hat-type steel sheet pile

10 Web

11 Flange

- 12 Arm
- M Cross-sectional gravity center line

1. A hat-type steel sheet pile a plurality of which configure a wall and which extends in a longitudinal direction, the hat-type steel sheet pile comprising:

a web extending in a width direction in which the wall extends in a plan view seen in the longitudinal direction;

a pair of flanges which are connected to outer ends of the web in the width direction and extend at a slope with respect to the web in the plan view; and

a pair of arms which are connected to ends of the pair of flanges each in the width direction on a side opposite to the web and extend in the width direction in the plan view,

wherein a relationship between a sectional area A (cm^2/m) and a sectional moment of inertia I (cm^4/m) around a cross-sectional gravity center line extending in the width direction in the plan view per meter as a size of the hat-type steel sheet pile in the width direction satisfies Expression (1), and

when a distance between a first intersection point of extended lines from the pair of flanges each in the plan view and the cross-sectional gravity center line is represented by $D1$ (mm), and a distance between second intersection points of the pair of flanges each with the cross-sectional gravity center line is represented by $D2$ (mm),

Expression (2A) and Expression (2B),

Expression (3A) and Expression (3B),

Expression (4A) and Expression (4B), or

Expression (5A) and Expression (5B)

are satisfied,

$$A < 0.00252I + 94.4 \cdots (1)$$

$$262.6 < D1 < 281.0 \cdots (2A)$$

$$496.9 < D1 < 520.9 \dots (3A)$$

$$621.5 < D1 < 650.9 \dots (4A)$$

$$625.2 < D1 < 654.8 \dots (5A)$$

$$484.0 < D2 < 499.0 \dots (2B)$$

$$474.0 < D2 < 489.0 \dots (3B)$$

$$476.0 < D2 < 491.0 \dots (4B)$$

$$474.0 < D2 < 489.0 \dots (5B).$$

2. The hat-type steel sheet pile according to Claim 1,
wherein D1 and D2 satisfy Expression (2A) and Expression (2B).

3. The hat-type steel sheet pile according to Claim 1,
wherein D1 and D2 satisfy Expression (3A) and Expression (3B).

4. The hat-type steel sheet pile according to Claim 1,
wherein D1 and D2 satisfy Expression (4A) and Expression (4B).

5. The hat-type steel sheet pile according to Claim 1,
wherein D1 and D2 satisfy Expression (5A) and Expression (5B).

6. The hat-type steel sheet pile according to Claim 1,
wherein an effective width W (mm) between outer ends of the pair of arms
each in the width direction satisfies Expression (6), and a distance H (mm) in a cross-
section height direction orthogonal to the width direction in the plan view between a
surface of the web along the width direction on a side opposite to the cross-sectional

gravity center line and a surface of the arm along the width direction on a side opposite to the cross-sectional gravity center line satisfies Expression (7),

$$876 \leq W \leq 932 \cdots (6)$$

$$H \leq 400 \cdots (7).$$

7. The hat-type steel sheet pile according to any one of Claims 1 to 6, wherein a distance L (mm) between a third intersection point of perpendicular lines that pass through the second intersection points of the pair of flanges each with the cross-sectional gravity center line and are orthogonal to the pair of flanges each and the cross-sectional gravity center line, a distance H (mm) in a cross-section height direction orthogonal to the width direction in the plan view between a surface of the web along the width direction on a side opposite to the cross-sectional gravity center line and a surface of the arm along the width direction on a side opposite to the cross-sectional gravity center line, and a distance C (mm) between the surface of the web along the width direction on the side opposite to the cross-sectional gravity center line and the cross-sectional gravity center line satisfies Expression (8),

$$L > H - C \cdots (8).$$