

DESCRIPTION

TITLE OF INVENTION: CONSTRUCTION ASSISTANCE DEVICE FOR STEEL SHEET PILING, CONSTRUCTION ASSISTANCE METHOD FOR STEEL SHEET PILING, WALL CONSTRUCTION METHOD, MANAGEMENT METHOD FOR STEEL SHEET PILING, WALL, STEEL SHEET PILING, RECORDING MEDIUM, AND PROGRAM

TECHNICAL FIELD

[0001]

10 The present invention relates to a construction support device for a steel sheet pile, a construction support method for a steel sheet pile, a wall construction method, a management method for a steel sheet pile, a wall, a steel sheet pile, a recording medium, and a program.

BACKGROUND ART

15 [0002]

Steel sheet piles can be installed into the ground while engaging interlocks with each other, thereby constructing a continuous wall structure having, for example, water-stopping or sand-blocking properties. Such steel sheet piles are widely used not only as permanent structures to be used semi-permanently, but also as temporary structures such as earth retaining works or temporary cofferdam works. In the case of temporary structures, when their use is finished, the steel sheet piles are pulled out and removed, and reusable ones are reused. Whether or not reuse is possible is determined depending, for example, on the magnitude of deformation that has occurred during construction or during use. The main body portion of a steel sheet pile has a plate-like shape. Accordingly, when the deformation amount is large, the interlocks become deformed, making smooth engagement difficult. This leads to difficulties in its installation during construction, or to insufficient performance of the function of preventing the inflow or outflow and leakage of soil, groundwater, seawater, or the like by the wall structure. Accordingly, the determination of reusability based on the magnitude of deformation is important.

25 [0003]

On the other hand, in recent years, systems for supporting the construction

and design of steel sheet piles have been increasingly utilized. For example, Patent Literature 1 proposes a technique in which, by applying a SLAM method to a measurement method for the underground position of sheet piles, the insertion of sheet piles at a desired angle can be accurately achieved at a construction site without the need for skilled engineers, while checking the inclination angle in real time. Patent Literature 2 proposes a technique in which the layout of a sheet pile wall section is determined by a computer system via the Internet.

CITATION LIST

PATENT LITERATURE(S)

10 [0004]

Patent Literature 1: JP 6478305 B

Patent Literature 2: JP 2009-528461 A

SUMMARY OF THE INVENTION

PROBLEM(S) TO BE SOLVED BY THE INVENTION

15 [0005]

However, in the determination of reusability of steel sheet piles, the system utilization as described above has not progressed, and the reusability has been determined, for example, according to criteria independently established by leasing companies or industry associations. In such a case, since there are no clear conditions for calculating the criteria, excessively strict criteria may be set, or, in the case of a type of steel sheet pile for which there are few construction performance data serving as the basis of the criteria, it may be difficult to determine appropriate criteria, resulting in insufficient progress in reuse.

[0006]

25 Accordingly, an object of the invention is to provide a construction support device for a steel sheet pile, a construction support method for a steel sheet pile, a wall construction method, a management method for a steel sheet pile, a wall, a steel sheet pile, a recording medium, and a program, which make it possible to promote appropriate reuse of steel sheet piles by systematizing the determination of reusability of steel sheet piles.

MEANS FOR SOLVING THE PROBLEM(S)

30 [0007]

[1] A construction support device for a steel sheet pile, the device including: an input unit configured to accept input of a dimension of at least one portion of the steel sheet pile; and a determination unit configured to determine reusability of the steel sheet pile by comparing the dimension with a predetermined condition.

5 [2] The construction support device for the steel sheet pile according to [1], in which the input unit is configured to further accept input of a construction condition of the steel sheet pile in reuse; and the determination unit is configured to determine the reusability of the steel sheet pile according to the construction condition.

[3] The construction support device for the steel sheet pile according to [1], further
10 including an information generation unit configured to generate, in a case where the steel sheet pile is determined to be reusable, information indicating a limit condition under which the steel sheet pile remains in a reusable state.

[4] The construction support device for the steel sheet pile according to [1], further
15 including an information generation unit configured to generate, in a case where the steel sheet pile is determined to be not reusable under at least one construction condition, information indicating a repair condition for making the steel sheet pile reusable, or information indicating a construction condition under which reuse is possible.

[5] The construction support device for the steel sheet pile according to [1], further
20 including: a history collection unit configured to collect a history of the dimension; a training data generation unit configured to generate training data from the history of the dimension; and a relearning unit configured to relearn, using the training data, a determination model for determining whether or not the steel sheet pile is reusable.

[6] The construction support device for the steel sheet pile according to [5], in which
25 the history collection unit is configured to collect a history of a construction condition of the steel sheet pile in reuse in addition to the history of the dimension, and the training data generation unit is configured to generate the training data from the history of the dimension and the history of the construction condition.

[7] The construction support device for the steel sheet pile according to [1], in which
30 the steel sheet pile includes a plurality of steel sheet piles, the construction support device further includes: an information registration unit configured to register information including the dimension as management information for each of the steel

sheet piles; and an output unit configured to output the management information.

[8] The construction support device for the steel sheet pile according to [7], in which the output unit is configured to output the management information so as to record the management information in a recording medium incorporated in each of the steel sheet piles.

[9] The construction support device for the steel sheet pile according to [1], in which the steel sheet pile includes a plurality of steel sheet piles, and the construction support device further includes an output unit configured to output information indicating a construction sequence in which the steel sheet piles are arranged, in order from higher to lower reusability or from lower to higher reusability, from one end to another end in a longitudinal direction of a wall.

[10] A construction support method for a steel sheet pile, the method including: measuring a dimension of at least one portion of the steel sheet pile; and determining reusability of the steel sheet pile by comparing the dimension with a predetermined condition recorded in a server.

[11] A wall construction method, including constructing a wall by using, at least in part, a steel sheet pile determined to be reusable by the construction support method according to [10].

[12] The wall construction method according to [11], in which the steel sheet pile includes a plurality of steel sheet piles; and the steel sheet piles are arranged in order from higher to lower reusability or from lower to higher reusability, from one end to another end in a longitudinal direction of the wall.

[13] A management method for a steel sheet pile, the method including preferentially retaining the steel sheet pile determined to be reusable by the construction support method according to [10].

[14] A wall constructed by using, at least in part, a steel sheet pile whose reusability has been determined by comparing a dimension of at least one portion of the steel sheet pile with a predetermined condition.

[15] The wall according to [14], in which the steel sheet pile includes a plurality of steel sheet piles, and the steel sheet piles are arranged in order from higher to lower reusability or from lower to higher reusability, from one end to another end in a longitudinal direction of the wall.

[16] The wall according to [15], in which a recording medium, in which management information including the dimension is recorded, is incorporated in the steel sheet pile that constitutes at least a part of the wall.

5 [17] A steel sheet pile incorporating a recording medium in which management information is recorded, in which the management information includes a dimension of at least one portion of the steel sheet pile, reusability of the steel sheet pile being able to be determined by comparison between the dimension and a predetermined condition.

10 [18] A recording medium incorporated into a steel sheet pile, management information of the steel sheet pile being recorded therein, in which the management information includes a dimension of at least one portion of the steel sheet pile, reusability of the steel sheet pile being able to be determined by comparison between the dimension and a predetermined condition.

15 [19] A program causing a computer to execute: accepting input of a dimension of at least one portion of a steel sheet pile; and determining reusability of the steel sheet pile by comparing the dimension with a predetermined condition.

20 [20] The program according to claim 19, in which the steel sheet pile includes a plurality of steel sheet piles, and the program causes the computer to further execute indicating a construction sequence in which the steel sheet piles are arranged, in order from higher to lower reusability or from lower to higher reusability, from one end to another end in a longitudinal direction of a wall.

[0008]

25 According to the above configuration, by systematizing the determination of reusability of steel sheet piles, it is possible to promote appropriate reuse of steel sheet piles. Specifically, for example, by providing determination results in real time as to whether or not steel sheet piles are reusable at various locations where measurement or imaging of steel sheet piles after use is performed, the process of selecting steel sheet piles to be reused can be accelerated. In addition, since the determination can be made based on unified criteria regardless of the location and
30 the criteria can also be updated by relearning or the like, it is possible to carry out detailed determinations according to construction conditions or the like, and it is also possible to improve the accuracy of the determination by reflecting the installation

results of reused steel sheet piles.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 schematically illustrates a construction support method for a steel
5 sheet pile according to an exemplary embodiment of the invention.

Fig. 2 illustrates flowcharts of a determination process and a relearning
process in a server in an example illustrated in Fig. 1.

Fig. 3 is a block diagram illustrating components for executing the processes
illustrated in Fig. 2.

10 Fig. 4 is a flowchart illustrating an information inquiry process in the server in
the example illustrated in Fig. 1.

Fig. 5 is a block diagram illustrating components for executing the process
illustrated in Fig. 4.

15 Fig. 6 illustrates an example of the amount of deformation of a steel sheet
pile.

Fig. 7 illustrates another example of the amount of deformation of a steel
sheet pile.

Fig. 8 illustrates still another example of the amount of deformation of a steel
sheet pile.

20 Fig. 9 conceptually illustrates an example of determining the reusability of
steel sheet piles by comparing a dimension with a predetermined condition.

Fig. 10 conceptually illustrates an example in which a dimension of a steel
sheet pile is compared with a predetermined condition, and the reusability thereof is
determined according to a construction condition at the time of reuse.

25 Fig. 11 conceptually illustrates an example of generating information
indicating a limit condition under which a steel sheet pile remains in a reusable state.

Fig. 12 illustrates exemplary determination results to be output.

DESCRIPTION OF EMBODIMENT(S)

[0010]

30 Hereinafter, a preferred exemplary embodiment of the invention will be
described in detail with reference to the accompanying drawings. In the specification
and drawings, components having substantially the same functional configuration are

denoted by the same reference numerals, and redundant descriptions thereof are omitted.

[0011]

Fig. 1 schematically illustrates a construction support method for a steel sheet pile according to an exemplary embodiment of the invention. In the illustrated example, first, a dimension(s) of at least one portion of a steel sheet pile after use is/are acquired. More specifically, an operator measures the dimension of the steel sheet pile or takes an image of the steel sheet pile. The dimension does not necessarily have to be acquired for all of the steel sheet piles. The measured dimension is input, for example, as a numerical value into a terminal device, and transmitted to a server 10 via a network. The captured image is transmitted to the server 10, for example, after being converted into a numerical value of the dimension of the steel sheet pile by image analysis in the terminal device, or as image data. When the image data is transmitted to the server 10, image analysis for calculating the dimension of the steel sheet pile from the image data including the steel sheet pile is executed in the server 10. In the server 10, it is determined, through processing as described later, whether the steel sheet pile is reusable, and the determination result is output to the terminal device via the network.

[0012]

The determination result may be output, for example, in real time to the same terminal device on which the measurement or imaging has been performed, or to a terminal device for an administrator located in a place different from where the measurement or imaging has been performed, or may be stored in the server 10 and read out as needed. For example, when the determination result is output in real time, the determination result can be used even without information for identifying each steel sheet pile. On the other hand, when, for example, an ID for identifying each steel sheet pile is assigned and recorded, the input information and the determination results can be accumulated, and the determination result for any steel sheet pile can be retrieved at any point in time.

[0013]

Fig. 2 is a flowchart illustrating a determination process in the server in the example illustrated in Fig. 1. Fig. 3 is a block diagram illustrating components for

executing the process illustrated in Fig. 2. In the server 10 functioning as a construction support device for a steel sheet pile, a computer operates in accordance with a program to implement functions of respective units as described below. The program may be stored in advance in a memory of the computer, may be read from a removable recording medium, or may be downloaded via a network. The functions of the server 10 do not necessarily have to be implemented by a single server device that communicates with a terminal device, and may be implemented, for example, by cooperation between a server device that communicates with the terminal device and another server device that communicates with the server device via the Internet or the like.

[0014]

First, as processing of an input unit 110, input of data indicating a dimension(s) of at least one portion of a steel sheet pile after use is accepted. As already described, this processing may be processing in which input of a numerical value or the like of a dimension of the steel sheet pile directly measured is accepted, or may be processing in which a dimension of the steel sheet pile is calculated by image analysis from image data obtained by imaging the steel sheet pile. Accordingly, information input to the input unit 110 may be data that directly indicates a dimension, such as a numerical value, or may be data that can be used to calculate a dimension, such as image data. Herein, both cases are treated as input of a dimension of the steel sheet pile. Here, the dimension of at least one portion of the steel sheet pile to be input may be, for example, a dimension indicating a two-dimensional shape of a cross-section of the steel sheet pile, or may be a dimension indicating a three-dimensional shape of the entire steel sheet pile, specifically, a dimension indicating a camber deformation amount, a deflection deformation amount, a torsional deformation amount, or the like, as will be described later.

[0015]

Next, as processing of a determination unit 120, whether or not the steel sheet pile is reusable is determined by comparing the input dimension of the steel sheet pile with a predetermined condition. Whether the steel sheet pile is reusable may be determined, for example, by comparing a deformation amount of the steel sheet pile with a threshold value. The deformation amount of the steel sheet pile may

be directly measured, or may be calculated from the measured dimension of the steel sheet pile. Even in a simple determination based on the threshold value of the deformation amount, by performing the determination in the server 10, it is possible to make the determination even if the criterion is not known at a site where the dimension of the steel sheet pile is measured or an image thereof is captured. In addition, it is easy to set criteria that are classified according to, for example, the length, thickness, and cross-sectional shape of the steel sheet pile. Furthermore, whether or not the steel sheet pile is reusable may also be determined, for example, by comparing a parameter calculated from one or more deformation amounts with a threshold value.

[0016]

The determination unit 120 may determine whether or not the steel sheet pile is reusable according to a construction condition(s) of the steel sheet pile at the time of reuse. Whether or not the steel sheet pile is actually reusable may depend on construction conditions. For example, when the steel sheet pile is installed into soft ground at the time of reuse, reuse may be possible even if the current deformation amount is relatively large, since the possibility of an increase in deformation during construction is low. On the other hand, when the steel sheet pile is installed into hard ground at the time of reuse, reuse may become difficult due to an increase in deformation during construction, even if the current deformation amount is relatively small. Accordingly, on the server 10, the construction condition of the steel sheet pile at the time of reuse may be accepted as input via the input unit 110, and the determination unit 120 may determine whether or not the steel sheet pile is reusable based on a criterion corresponding to the input construction condition. More specifically, for example, whether or not the steel sheet pile is reusable may be determined by comparing a parameter calculated from one or more deformation amounts and construction conditions with a threshold value.

[0017]

After the processing by the determination unit 120, processing by information generation units 130A and 130B is executed as necessary. The information generation unit 130A generates, when the steel sheet pile is determined to be reusable in the determination unit 120, information indicating a limit condition under

which the steel sheet pile remains in a reusable state. The limit condition is, for example, the number of times the steel sheet pile can be reused. When a deformation amount is used in determining whether or not the steel sheet pile is reusable, the number of times the steel sheet pile can be reused can be calculated by dividing the difference between the current deformation amount and the deformation amount at which the steel sheet pile is no longer reusable, by a predicted deformation amount per reuse. Alternatively, the limit condition may include, as a premise, a construction condition(s) at the time of reuse of the steel sheet pile. This makes it possible to express, for example, a state such that reuse is possible three more times in soft ground and reuse is possible two more times in hard ground. The soft ground and the hard ground may be indicated by a range of N-values, for example. The limit condition is not necessarily the number of times the steel sheet pile can be reused, but may alternatively be a construction condition under which reuse is possible. For example, information indicating an N-value of the ground or an installation depth at which reuse is possible may be generated. Further, for example, in a case where a plurality of steel sheet piles are vertically joined and installed, information may be generated indicating that a preceding steel sheet pile installed into a deep position is not reusable but a subsequent steel sheet pile installed into a shallow position is reusable.

[0018]

The information generation unit 130B generates information indicating a repair condition for making the steel sheet pile reusable, when the steel sheet pile is determined by the determination unit 120 to be not reusable under at least one construction condition. The repair condition is, for example, a type of correction of the steel sheet pile or an amount of deformation that needs to be reduced by the correction. For example, when whether or not the steel sheet pile is reusable is determined by comparing a parameter calculated from one or more deformation amounts with a threshold value, information may be generated regarding a type of correction for correcting the deformation amount that has the greatest effect on the parameter, or regarding a reduction amount of deformation required to bring the parameter within a range defined by the threshold value. Alternatively, when the steel sheet pile is reusable under a construction condition, the information generation unit

130B may generate information indicating the construction condition under which reuse is possible. In this case, for example, information indicating an N-value of the ground or an installation depth at which installation is possible as the construction condition, may be generated. Further, for example, in a case where a plurality of steel sheet piles are vertically joined and installed, information may be generated indicating that a preceding steel sheet pile installed into a deep position is not reusable but a subsequent steel sheet pile installed into a shallow position is reusable.

[0019]

The output unit 140 outputs the determination result by the determination unit 120 and the information generated by the information generation units 130A and 130B. For example, the output unit 140 may output, as the determination result, a list view for a plurality of steel sheet piles, as will be described later. The output unit 140 may also output information indicating a construction sequence in which the steel sheet piles are arranged, in order from higher to lower reusability or from lower to higher reusability, from one end to the other end in a longitudinal direction of a wall. The invention is not limited to these examples, and the output unit 140 outputs various types of information, such as the reusability of the steel sheet piles, the limit condition, the repair condition, or management information. As described above, the output unit 140 may output information to the same terminal device to which information was input via the input unit 110, or may output information to a terminal device different from the one to which the information was input. Alternatively, the output unit 140 may output information to a recording device of the server 10 or an external device, and the information may be accumulated in the recording device. The accumulated information can be read out and output at any time, and can also be retrieved as a history in an information inquiry process described later.

[0020]

Fig. 2 also illustrates a relearning process in the server 10. The relearning process is, for example, a process of retraining a determination model for determining whether or not a steel sheet pile is reusable, using a dimension history of steel sheet piles input to the server 10. The server 10 does not necessarily have to include the relearning process; however, the relearning process makes it possible to improve the accuracy of the determination.

[0021]

In the relearning process, a history collection unit 150 collects a dimension history or a construction condition history of steel sheet piles based on installation results of the steel sheet piles. The history collection unit 150 may collect, for example, a dimension history of each steel sheet pile before and after construction, or may collect a construction condition history. These data may be those input in the past via the input unit 110. Further, the history collection unit 150 may collect a parameter history calculated from a dimension(s) of steel sheet piles, a parameter history calculated from a construction condition(s), or a parameter history calculated from a combination of the dimension of steel sheet piles and the construction condition. These parameters may be those calculated in the past by the determination unit 120. Even when such parameters as described above are collected, the history collection unit 150 indirectly collects the dimension history or the construction condition history. A training data generation unit 160 generates training data from data including the collected history, and a relearning unit 170 relearns the model using the generated training data. In the determination as to whether a steel sheet pile is reusable, which is executed by the determination unit 120 in the exemplary embodiment, it is possible to use, for example, a model for predicting an amount of deformation of the steel sheet pile in a case where the steel sheet pile is reused, based on the current amount of deformation of the steel sheet pile. If relearning is performed using training data that reflects dimensional changes of steel sheet piles before and after actual reuse as described above, it is possible to appropriately determine whether or not the steel sheet pile is reusable by more accurately predicting the amount of deformation of the steel sheet pile after reuse through improvement of the accuracy of the model. When the determination unit 120 makes a determination according to a construction condition(s) of the steel sheet pile, training data may be generated and the model may be relearned for each construction condition. Alternatively, a model that uses, as an input, a construction condition(s) in addition to the current amount of deformation of the steel sheet pile may be used.

[0022]

Fig. 4 is a flowchart illustrating the information inquiry process in the server in the example illustrated in Fig. 1. Fig. 5 is a block diagram illustrating components

for executing the process illustrated in Fig. 4. As described above, in the exemplary embodiment, the server 10 may output determination results in real time, or may accumulate input information and determination results so as to make them available for inquiry at any time. In this case, the server 10 may identify individual steel sheet piles, and may store the information as management information to make it available for inquiry for each steel sheet pile. In the information inquiry process, an information acquisition unit 180 acquires information for each steel sheet pile. The acquired information is, for example, information input via the input unit 110 or a parameter calculated by the determination unit 120. The acquired information is similar to that collected by the history collection unit 150 in the relearning process, including histories of the dimension and construction condition of steel sheet piles. An information registration unit 190 registers the acquired information in a database 191 as management information for each steel sheet pile, and an information association unit 200 records the management information registered in the database 191 in association with management information previously registered. The output unit 210 outputs the management information registered in the database 191. Similar to the output of information in the above-described determination process, the management information may be output to a terminal device or to a recording device. The output unit 210 may also output the management information in order to perform recording in a recording medium incorporated in each steel sheet pile.

[0023]

As a recording medium incorporated in a steel sheet pile, for example, a label described in International Publication No. 2024/076299 can be used. This label makes it possible to read identification information of a steel member or the like to which the label is attached, by optical code reading or Near Field Communication (NFC). For example, in a recording medium such as this label, the management information as described above, specifically a dimension of at least one portion of a steel sheet pile that can be used to determine reusability by comparison with a predetermined condition, may be recorded. The invention is not limited to the example of the label described above, and various recording media that can be incorporated in steel sheet piles can likewise be used. A recording medium in which such management information has been recorded, and a steel sheet pile in which the

recording medium is incorporated, are also encompassed in the exemplary embodiment of the invention.

[0024]

Figs. 6 to 8 each illustrate an example of the amount of deformation of a steel sheet pile. Fig. 6 illustrates a warp deformation amount d_1 of the steel sheet pile, which is a deformation in a direction perpendicular to a surface of a wall formed by the steel sheet pile. The warp deformation amount d_1 is measured, for example, as a distance between a straight line passing through both upper and lower ends of the steel sheet pile in a vertical direction and a portion of the steel sheet pile at an intermediate part thereof that is farthest from the straight line. Fig. 7 illustrates a deflection deformation amount d_2 , which is a deformation in a direction parallel to a surface of a wall formed by the steel sheet pile and perpendicular to a height direction of the steel sheet pile (i.e., a horizontal direction at the time of installation). The deflection deformation amount d_2 is measured, for example, as a distance between a straight line passing through both upper and lower ends of the steel sheet pile in the vertical direction and one end thereof in a width direction, and a portion of the steel sheet pile at an intermediate part thereof that is farthest from the straight line. Fig. 8 illustrates a torsional deformation amount d_3 , which is defined as a distance between one of four corners of the steel sheet pile (i.e., both upper and lower ends in the vertical direction and both ends in the width direction) and a plane on which the other three corners are placed. As described above, in the exemplary embodiment, it is possible to determine whether or not the steel sheet pile is reusable by comparing such a deformation amount of the steel sheet pile, or a parameter calculated from a plurality of deformation amounts, with a threshold value.

[0025]

According to the exemplary embodiment of the invention described above, by systematizing the determination for reuse of steel sheet piles using the server 10, appropriate reuse of steel sheet piles can be promoted. Specifically, for example, since determination results as to whether or not used steel sheet piles are reusable are provided in real time at various locations where the steel sheet piles are measured or imaged after use, a process of selecting steel sheet piles to be reused can be expedited. In addition, since the determination can be made based on unified

criteria regardless of the location and the criteria can also be updated by relearning or the like, it is possible to carry out detailed determinations according to construction conditions or the like, and it is also possible to improve the accuracy of the determination by reflecting the installation results of reused steel sheet piles.

5 [0026]

In the above example, the determination of reusability of a steel sheet pile is performed as a binary determination of whether or not the steel sheet pile is reusable. However, the exemplary embodiment of the invention is not limited thereto. For example, a score indicating the reusability of the steel sheet pile may be calculated
10 on the basis of a deformation amount of the steel sheet pile or a magnitude of a difference between a threshold value and a parameter calculated from the deformation amount or from the deformation amount and construction condition. Whether or not the steel sheet pile is reusable may be determined by further comparing this score with a threshold value. Alternatively, the score itself may be
15 output as the reusability of the steel sheet pile. Furthermore, in a case where a score is calculated indicating that the higher the score is, the smaller the deformation is, rankings indicating reuse priorities may be assigned in order from a steel sheet pile having a higher score, that is, a higher reusability, among a plurality of steel sheet piles.

20 [0027]

The exemplary embodiment of the invention includes a wall constructed with steel sheet piles whose reusability has been determined. The wall does not necessarily have to be entirely constructed with steel sheet piles whose reusability has been determined, and it suffices if at least a part of the wall is formed from steel
25 sheet piles whose reusability has been determined. A recording medium in which the management information as described above is recorded may be incorporated in the steel sheet piles whose reusability has been determined. In a case where the score as described above is calculated as the reusability, during construction of a wall, the steel sheet piles can be arranged in order from one end to the other end in the
30 longitudinal direction of the wall in accordance with a sequence of higher reusability to lower reusability, or vice versa. In this manner, for example, steel sheet piles having lower reusability, that is, steel sheet piles which are close to the limit of

reusability and thus have a relatively high possibility of becoming non-reusable after the next pulling-out, are gathered together, thereby facilitating management of the steel sheet piles after pulling-out. In addition, since steel sheet piles having low reusability may require attention even at the time of its installation during construction, if such steel sheet piles are gathered together rather than scattered, the construction can be facilitated. Furthermore, the exemplary embodiment of the invention includes a management method for steel sheet piles in which steel sheet piles whose reusability has been determined to be reusable are preferentially retained.

[0028]

In the illustrated example, a steel sheet pile having a hat-shaped cross section is exemplified. However, the exemplary embodiment of the invention is not limited to the hat-shaped cross section, and can be utilized for determining whether or not steel sheet piles having various cross sections, such as U-shaped, Z-shaped, and straight web steel sheet piles, are reusable. Even in the case of steel sheet piles having cross sections such as the hat-shaped cross section, which are used less frequently in temporary structures compared to the U-shaped cross section, appropriate reuse of the steel sheet piles can be promoted by unifying criteria for determination and reflecting a large number of installation results in the determination criteria through systematization.

[0029]

Hereinafter, further specific examples of the exemplary embodiment of the invention will be described.

[0030]

Fig. 9 conceptually illustrates an example of determining the reusability of steel sheet piles by comparing a dimension with a predetermined condition. Exemplary dimensions of the steel sheet piles are listed in Table 1 below. For one or more of such dimensions of the steel sheet piles, a reusable range can be set based on both an upper limit value and a lower limit value, or on either the upper limit value or the lower limit value. For example, if the dimension is too large or too small relative to a predetermined value, the interlock engagement may become difficult, and the structure may fail to function as a wall. When the dimension of the steel sheet pile falls within the reusable range (steel sheet pile 1), the steel sheet pile is determined

to be reusable; whereas when the dimension of the steel sheet pile does not fall within the reusable range (steel sheet pile 2 and steel sheet pile 3), the steel sheet pile is determined to be not reusable. When the determination is based on multiple dimensions, the steel sheet pile is determined to be reusable only if all of the dimensions fall within the reusable range. In the illustrated example, the determination is made as either acceptable (OK) or not acceptable (NG); however, for example, a score may be calculated such that the score decreases as the dimension approaches the upper or lower limit of the reusable range, and the determination may be made such that the higher the score, the higher the reusability.

When scores are calculated for multiple dimensions, for example, the average value of the scores calculated for the respective dimensions may be output, or the lowest score may be output as a representative value. Further, for example, a construction condition value indicating two or more attributes may be used, such as a product of the rated output of a vibratory hammer and the installation time, in the same manner as an integrated current value (a product of the current value of an excavator and the excavation time) used in pile construction management.

[0031]

Table 1

Items	Specific Examples
Dimensions	Height
	Plate thickness
	Length
	Overall width
	Difference in vertically cut section
	Overall width difference
	End deflection
	Interlock opening width
	Flange angle
	Arm angle
	Camber
	Deflection
	Twist
Construction Conditions	Number of vibrations of vibratory hammer
	Vibration amplitude of vibratory hammer
	Hydraulic pressure of vibratory hammer
	Rated output of vibratory hammer
	Press-in force of press-in machine
	Pull-out force of press-in machine
	Stroke of press-in machine
	Weight of ram
	Drop stroke of ram
	Number of water jet cutters
	Discharge pressure of water jet cutter
	Discharge volume of water jet cutter
	Number of revolutions of earth auger
	Torque value of earth auger
	Installation time
	Installation time at maximum N-value layer
	N-value
	Penetration depth
	Installation count

Table 1: Specific Examples of Dimensions and Construction Conditions
[0032]

Table 1 also lists exemplary construction conditions. In the installation of steel sheet piles, a construction machine such as a vibratory hammer, a press-in machine, or a diesel hammer is used. When a vibratory hammer or a press-in machine is used, one or more of the construction conditions in Table 1 may be employed. When a diesel hammer is used, the construction condition(s) relating to the ram in Table 1 may be employed. A water jet is used to facilitate the penetration of the steel sheet pile by jetting water underground. When a water jet is used in the construction of the

steel sheet pile, a construction condition(s) relating to the water jet may be employed together with the condition(s) relating to the construction machine as described above. An earth auger is used to facilitate the penetration of the steel sheet pile by excavating a region adjacent to the steel sheet pile, specifically, for example, the inside of the web of Hat-type steel sheet pile or U-type steel sheet pile. When an earth auger is used in the construction of the steel sheet pile, a construction condition(s) relating to the earth auger may be employed together with the condition(s) relating to the construction machine as described above. The installation time, N-value of the ground, penetration depth, and the like, which are listed as construction conditions in Table 1, may be commonly employed regardless of the construction machine used. Further, the installation count indicates, for example, how many times the steel sheet pile to be reused has been installed.

[0033]

Fig. 10 conceptually illustrates an example in which a dimension of a steel sheet pile is compared with a predetermined condition, and the reusability thereof is determined according to a construction condition at the time of reuse. In the illustrated example, a deformation amount after reuse is predicted based on the current dimension of the steel sheet pile according to the construction condition. When the current dimension of the steel sheet pile is within a reusable range, input of the construction condition of the steel sheet pile at the time of reuse is accepted, and it is determined whether the dimension obtained by adding the deformation amount predicted from the construction condition to the current dimension falls within the reusable range. In the case of construction condition A (case A), since the dimension after construction falls within the reusable range, it is determined to be reusable (OK). On the other hand, in the case of construction condition B (case B), since the dimension after construction does not fall within the reusable range, it is determined to be non-reusable (NG). For the sake of simplicity, an example is given in which the amount of deformation increases linearly with respect to the parameter of the construction condition. However, the invention is not limited to this example, and the relationship between the construction condition and the amount of deformation may also be represented by a higher-order function or by a nonlinear function such as an exponential function or a trigonometric function. Furthermore, depending on the

construction condition, the amount of deformation may decrease with respect to the parameter, that is, may vary in the opposite direction to that of other construction conditions.

[0034]

5 Fig. 11 conceptually illustrates an example of generating information indicating a limit condition under which a steel sheet pile remains in a reusable state. In the illustrated example, as in Fig. 10 described above, the amount of deformation after reuse is predicted from the current dimension of the steel sheet pile. In the case where the amount of deformation caused by a single construction does not exceed
10 the reusable range, it is determined how many times a similar construction can be performed before the amount of deformation exceeds the reusable range. In the illustrated example, since the amount of deformation remains within the reusable range up to the third construction, the number of constructions is determined as three, which constitutes the limit construction condition of the steel sheet pile, specifically
15 determined as the number of times the steel sheet pile can be reused. For example, if a construction condition such as the N-value of the ground changes, the relationship between the construction condition and the amount of deformation (in the illustrated example, the slope of the straight line) also changes. Accordingly, as described in the example above, the state can be represented such that, in the case of soft ground,
20 the steel sheet pile can be reused three more times, whereas in the case of hard ground, it can be reused two more times.

[0035]

 The function representing the relationship between the construction condition and the amount of deformation, as illustrated in the examples of Fig. 10 and Fig. 11,
25 may be updated by the relearning process as described above. The function to be used may be selected depending on the type of steel sheet pile, such as hat-shaped, U-shaped, Z-shaped, or straight web steel sheet piles. Furthermore, the function to be used may be selected from among a plurality of functions representing the relationship between a certain construction condition and the amount of deformation,
30 depending on another construction condition. Specifically, for example, a function representing the relationship between a construction condition concerning a vibratory hammer and the amount of deformation may be selected depending on a

construction condition concerning the ground, such as the N-value.

[0036]

Fig. 12 illustrates exemplary determination results to be output. In the illustrated example, determination results indicating whether or not a plurality of steel sheet piles are reusable are displayed in a list. In addition to the ID of the steel sheet piles and whether or not the steel sheet piles are reusable, the list may also display, as in the illustrated example, the dimension of the steel sheet piles and the reusable range of that dimension. Such determination results may be displayed, for example, on the screen of a terminal device, or may be printed out. Moreover, the determination results may be accumulated and retrieved as a history.

EXPLANATION OF CODES

[0037]

10...server, 110...input unit, 120...determination unit, 130A, 130B...information generation unit, 140...output unit, 150...history collection unit, 160...training data generation unit, 170...relearning unit, 180...information acquisition unit, 190...information registration unit, 191...database, 200...information association unit, 210...output unit.

CLAIM(S)

[Claim 1]

A construction support device for a steel sheet pile, the device comprising:
an input unit configured to accept input of a dimension of at least one portion
5 of the steel sheet pile; and
a determination unit configured to determine reusability of the steel sheet pile
by comparing the dimension with a predetermined condition.

[Claim 2]

The construction support device for the steel sheet pile according to claim 1,
10 wherein
the input unit is configured to further accept input of a construction condition
of the steel sheet pile in reuse; and
the determination unit is configured to determine the reusability of the steel
sheet pile according to the construction condition.

15 [Claim 3]

The construction support device for the steel sheet pile according to claim 1,
further comprising an information generation unit configured to generate, in a case
where the steel sheet pile is determined to be reusable, information indicating a limit
condition under which the steel sheet pile remains in a reusable state.

20 [Claim 4]

The construction support device for the steel sheet pile according to claim 1,
further comprising an information generation unit configured to generate, in a case
where the steel sheet pile is determined to be not reusable under at least one
construction condition, information indicating a repair condition for making the steel
25 sheet pile reusable, or information indicating a construction condition under which
reuse is possible.

[Claim 5]

The construction support device for the steel sheet pile according to claim 1,
further comprising:
30 a history collection unit configured to collect a history of the dimension;
a training data generation unit configured to generate training data from the
history of the dimension; and

a relearning unit configured to relearn, using the training data, a determination model for determining whether or not the steel sheet pile is reusable.

[Claim 6]

5 The construction support device for the steel sheet pile according to claim 5, wherein

the history collection unit is configured to collect a history of a construction condition of the steel sheet pile in reuse in addition to the history of the dimension, and

10 the training data generation unit is configured to generate the training data from the history of the dimension and the history of the construction condition.

[Claim 7]

The construction support device for the steel sheet pile according to claim 1, wherein

15 the steel sheet pile includes a plurality of steel sheet piles, the construction support device further comprises: an information registration unit configured to register information including the dimension as management information for each of the steel sheet piles; and an output unit configured to output the management information.

[Claim 8]

20 The construction support device for the steel sheet pile according to claim 7, wherein the output unit is configured to output the management information so as to record the management information in a recording medium incorporated in each of the steel sheet piles.

[Claim 9]

25 The construction support device for the steel sheet pile according to claim 1, wherein

the steel sheet pile includes a plurality of steel sheet piles, and

30 the construction support device further comprises an output unit configured to output information indicating a construction sequence in which the steel sheet piles are arranged, in order from higher to lower reusability or from lower to higher reusability, from one end to another end in a longitudinal direction of a wall.

[Claim 10]

A construction support method for a steel sheet pile, the method comprising:
measuring a dimension of at least one portion of the steel sheet pile; and
determining reusability of the steel sheet pile by comparing the dimension
with a predetermined condition recorded in a server.

5 [Claim 11]

A wall construction method, comprising constructing a wall by using, at least
in part, a steel sheet pile determined to be reusable by the construction support
method according to claim 10.

[Claim 12]

10 The wall construction method according to claim 11, wherein
the steel sheet pile includes a plurality of steel sheet piles; and
the steel sheet piles are arranged in order from higher to lower reusability or
from lower to higher reusability, from one end to another end in a longitudinal
direction of the wall.

15 [Claim 13]

A management method for a steel sheet pile, the method comprising
preferentially retaining the steel sheet pile determined to be reusable by the
construction support method according to claim 10.

[Claim 14]

20 A wall constructed by using, at least in part, a steel sheet pile whose
reusability has been determined by comparing a dimension of at least one portion of
the steel sheet pile with a predetermined condition.

[Claim 15]

25 The wall according to claim 14, wherein
the steel sheet pile includes a plurality of steel sheet piles, and
the steel sheet piles are arranged in order from higher to lower reusability or
from lower to higher reusability, from one end to another end in a longitudinal
direction of the wall.

[Claim 16]

30 The wall according to claim 15, wherein
a recording medium, in which management information including the
dimension is recorded, is incorporated in the steel sheet pile that constitutes at least

a part of the wall.

[Claim 17]

A steel sheet pile incorporating a recording medium in which management information is recorded, wherein

5 the management information includes a dimension of at least one portion of the steel sheet pile, reusability of the steel sheet pile being able to be determined by comparison between the dimension and a predetermined condition.

[Claim 18]

10 A recording medium incorporated into a steel sheet pile, management information of the steel sheet pile being recorded therein, wherein

 the management information includes a dimension of at least one portion of the steel sheet pile, reusability of the steel sheet pile being able to be determined by comparison between the dimension and a predetermined condition.

[Claim 19]

15 A program causing a computer to execute:
 accepting input of a dimension of at least one portion of a steel sheet pile;
 and
 determining reusability of the steel sheet pile by comparing the dimension with a predetermined condition.

20 [Claim 20]

 The program according to claim 19, wherein
 the steel sheet pile includes a plurality of steel sheet piles, and
 the program causes the computer to further execute indicating a construction sequence in which the steel sheet piles are arranged, in order from higher to lower
25 reusability or from lower to higher reusability, from one end to another end in a longitudinal direction of a wall.