

DESCRIPTION

TITLE OF INVENTION: JOINT CONFIGURATION AND CONSTRUCTION

METHOD OF JOINT CONFIGURATION

TECHNICAL FIELD

5 [0001]

The present disclosure relates to a joint configuration and a construction method of the joint configuration.

Priority is claimed on Japanese Patent Application No. 2023-050171, filed March 27, 2023, the content of which is incorporated herein by reference.

10 BACKGROUND ART

[0002]

In the related art, in a joint configuration in which a wall (supporting member) having an RC structure and a floor slab of a composite beam are joined to each other, crack prevention bars, which are provided in the floor slab and have a nominal diameter of about 6 to 10 mm and an interval of about 200 mm, might be bent and anchored to the wall. In such a configuration in the related art, the number of bent bar anchorages is small and not only stiffness but also resistance against a drawing force is also very small. Accordingly, a joint portion between the composite beam and the wall having the RC structure was designed while being regarded as a pin joint (in which stiffness and moment resistance are zero).

Most of the related arts regarding the pullout resistance of the bent bar anchorage with respect to an RC member are aimed at a column-to-beam joint portion having an RC structure. In many cases, the diameter of the bent bar anchorage is relatively large, ranging from 16 to 36 mm.

25 [0003]

In contrast, in the semi-rigid connection between a wall having an RC structure and a composite beam according to the present disclosure, a large number of reinforcing bars need to be used to anchor a floor slab to the wall having the RC structure in order to secure the stiffness and resistance of a joint portion, as compared to a general floor slab.

5 However, it is known that cracks are likely to occur in a concrete surface in a case where reinforcing bars having a large diameter are used with a small concrete cover. In many cases, a concrete thickness of the floor slab is about 130 mm to 180 mm. In the case of a deck composite slab, the net concrete thickness of the deck at a peak is about 80 mm to 130 mm. Therefore, it is difficult to increase the cover thickness from the reinforcing
10 bar to the surface of the floor slab. That is, in a case where reinforcing bars having a large diameter are used at a position close to the surface of the floor slab, the floor concrete is likely to be cracked.

[0004]

For this reason, in order to secure the stiffness and resistance of a joint portion, a
15 large number of reinforcing bars are arranged in the floor slab as compared to a general floor slab and are anchored to the wall having the RC structure, and the diameter of the reinforcing bar in the floor slab needs to be reduced particularly on the surface layer of the floor concrete for the prevention of cracks in the floor concrete. Therefore, it is considered that a method of reducing the diameter of the reinforcing bar in the floor slab
20 (a diameter of about 6 to 16 mm) and arranging a plurality of reinforcing bars of the floor slab to secure the number of reinforcing bars is effective.

[0005]

However, a height (a thickness in a length direction of the reinforcing bars of the floor slab) of the wall having the RC structure is smaller than that of a column having the
25 RC structure. Accordingly, in a case where the reinforcing bars of the floor slab are

shifted in a height direction (abutting direction), the anchorage length of the reinforcing bar of the floor slab in a shallower portion cannot be secured. As a result, a raking-out failure in which concrete fails in a conical shape at the yield resistance or less of the reinforcing bar in the floor slab is likely to occur. Further, Patent Document 1 proposes a method of evaluating anchorage resistance in a case where a plurality of bent bar anchorages are bundled and anchored in the form of bundled bars. However, the method has not been verified by an experiment or the like, and it is unknown whether or not resistance calculated by an anchorage resistance calculation equation in the related art which is determined based on experimental results in which bundled bars are not used can actually be obtained.

In contrast, Non Patent Document 1 discloses that resistance, which is only 0.7 times calculated anchorage resistance per bent bar anchorage obtained in a case where bent bar anchorages are arranged in one stage, is obtained in a case where bent bar anchorages are shifted in the height direction to be arranged in two stages. A method of arranging bent bar anchorages in a staggered manner without using bundled bars to disperse a compressive force applied from the bent bar anchorages to the concrete is also conceivable as a measure.

Citation List

Patent Document

[0006]

Patent Document 1: Japanese Unexamined Patent Application, First Publication
No. H11-148172

Non Patent Document

[0007]

Non Patent Document 1: Murakami and Kubota, "Method of Estimating 90-

Degree Bending Anchorage Resistance of bars arranged in two stages and Method of Improving Resistance”, Annual Report on Concrete Engineering, Vol. 14, No. 2, 1992

SUMMARY OF INVENTION

Technical Problem

5 [0008]

However, wall reinforcing bars (supporting reinforcing bars) having a diameter larger than that of reinforcing bars of the floor slab, for example, reinforcing bars (longitudinal bars) extending in a longitudinal direction are arranged in the wall having the RC structure somewhat densely at D25@150 (a diameter of 25 mm at a pitch of 150
10 mm). In a case where the reinforcing bars of the floor slab are arranged in a staggered manner, it is difficult to establish the layout of main reinforcing bars while avoiding interference with the wall reinforcing bars and the reinforcing bars. In particular, in a case where the pitches of the wall reinforcing bars and the reinforcing bars of the floor slab are different from each other, it is more difficult to avoid interference.

15 [0009]

The present disclosure has been made in view of the above problems, and an object of the present disclosure is to provide a joint configuration that can prevent cracks of a floor slab caused by bent bar anchorages, make the bent bar anchorages and supporting reinforcing bars be less likely to interfere with each other, and obtain
20 resistance substantially equivalent to that of the bent bar anchorages used for a column-to-beam joint portion, or to provide a construction method of a joint configuration that can prevent cracks in a floor slab caused by bent bar anchorages, make the bent bar anchorages and supporting reinforcing bars be less likely to interfere with each other, and obtain pullout resistance substantially equivalent to that of the bent bar anchorages used
25 for a column-to-beam joint portion.

Solution to problem

[0010]

In order to solve the above-described problems, the present disclosure proposes the followings.

- 5 (1) According to a first aspect of the present disclosure, there is provided a joint configuration including a supporting member having an RC structure and a floor slab that is abutted against and joined to the supporting member in an abutting direction. The supporting member includes a supporting concrete; the floor slab includes a floor concrete, and a plurality of bent bar anchorages that are embedded in the supporting
- 10 concrete and the floor concrete; each of the bent bar anchorages includes an anchoring portion that extends along an up-down direction in the supporting concrete, and an extending portion that extends from an upper end portion of the anchoring portion along the abutting direction in the supporting concrete and the floor concrete; two or more bent
- 15 bar anchorages of the plurality of bent bar anchorages form a bundled bar in which the anchoring portions of the two or more bent bar anchorages are disposed in contact with each other; and one extending portion and another extending portion among the extending portions of the two or more bent bar anchorages forming the bundled bar are disposed at positions different from each other in the up-down direction.

[0011]

- 20 (2) According to a second aspect of the present disclosure, there is provided a construction method of a joint configuration for constructing a joint configuration including a supporting member having an RC structure and a floor slab that is abutted against and joined to the supporting member in an abutting direction. The supporting member includes a supporting concrete; the floor slab includes a floor concrete, and a
- 25 plurality of bent bar anchorages that are embedded in the supporting concrete and the

floor concrete; each of the bent bar anchorages includes an anchoring portion that extends along an up-down direction in the supporting concrete, and an extending portion that extends from an upper end portion of the anchoring portion along the abutting direction in the supporting concrete and the floor concrete; two or more bent bar anchorages of the plurality of bent bar anchorages form a bundled bar in which the anchoring portions of the two or more bent bar anchorages are disposed in contact with each other; and one extending portion and another extending portion among the extending portions of the two or more bent bar anchorages forming the bundled bar are disposed at positions different from each other in the up-down direction.

10 [0012]

In these disclosures, for example, even in a case where the length of the supporting member in the abutting direction is relatively short, two or more anchoring portions can be disposed in the supporting concrete of the supporting member in a small space. For this reason, it is possible to make two or more anchoring portions be less likely to interfere with, for example, supporting reinforcing bars of the supporting member.

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[0013]

(3) According to a third aspect of the present disclosure, in the joint configuration according to (1), the anchoring portions of the two or more bent bar anchorages forming the bundled bar may be disposed at an equivalent position in the abutting direction.

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(4) According to a fourth aspect of the present disclosure, in the construction method of a joint configuration according to (2), the anchoring portions of the two or more bent bar anchorages forming the bundled bar may be disposed at an equivalent position in the abutting direction.

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In these disclosures, it is possible to provide bent bar anchorages that are arranged in multiple layers and can obtain pullout resistance substantially equivalent to the pullout resistance of bent bar anchorages arranged in a single layer and used for a column-to-beam joint portion. The inventors have intensively studied the positions of the anchoring portion and the extending portion of each of two or more bent bar anchorages forming the bundled bar in the floor concrete of the floor slab. As a result, it was found that, in a case where one extending portion and another extending portion among two or more extending portions are disposed at positions different from each other in the up-down direction (disposing one extending portion and another extending portion among the two or more extending portions at positions different from each other in the up-down direction) and two or more anchoring portions are disposed at the same position in the abutting direction, the bent bar anchorages exhibit pullout resistance substantially equivalent to the pullout resistance of bent bar anchorages arranged in a single layer and used for a column-to-beam joint portion.

Therefore, the joint configuration can include bent bar anchorages that are arranged in multiple layers and can obtain pullout resistance substantially equivalent to the pullout resistance of bent bar anchorages arranged in a single layer and used for a column-to-beam joint portion. In addition, the joint configuration including bent bar anchorages, which are arranged in multiple layers and can obtain pullout resistance substantially equivalent to the pullout resistance of bent bar anchorages arranged in a single layer and used for a column-to-beam joint portion, can be constructed in the construction method of a joint configuration. In these disclosures, the plurality of bent bar anchorages can be more reliably anchored to the supporting member, so that the concrete failure resistance of the anchoring portion can be improved. Further, the bent bar anchorages can be caused to yield in advance, so that ductile failure caused by the

elongation and deformation of the bent bar anchorages can be induced.

[0014]

(5) According to a fifth aspect of the present disclosure, in the joint configuration according to (1) or (3), the extending portion of the bent bar anchorage, which has a smallest diameter, among the two or more bent bar anchorages forming the bundled bar may be disposed at a highest position among the extending portions of the two or more bent bar anchorages.

(6) According to a sixth aspect of the present disclosure, in the construction method of a joint configuration according to (2) or (4), the extending portion of the bent bar anchorage, which has the smallest diameter, among the two or more bent bar anchorages forming the bundled bar may be disposed at the highest position among the extending portions of the two or more bent bar anchorages.

In these disclosures, it is possible to suppress the occurrence of cracks in the floor concrete.

[0015]

(7) According to a seventh aspect of the present disclosure, in the joint configuration according to any one of (1), (3), and (5), a plurality of the bundled bars may be provided at intervals in a crossing direction crossing a virtual plane parallel to each of the abutting direction and the up-down direction, and in a case where an equivalent reinforcing bar diameter $d_{r,eq}$ of the bundled bars is defined by Equation (1), a distance in the crossing direction between the bundled bars adjacent to each other in the crossing direction may be six or more times the equivalent reinforcing bar diameter $d_{r,eq}$.

Here, $d_{r,i}$ is a diameter of an i -th bent bar anchorage among n sets of the two or more bent bar anchorages forming one bundled bar.

[0016]

$$d_{r,eq} = \sqrt{\sum_{i=1}^n (d_{r,i}^2)} \quad \cdot \cdot (1)$$

[0017]

(8) According to an eighth aspect of the present disclosure, in the construction method of a joint configuration according to any one of (2), (4), and (6), a plurality of the bundled bars may be constructed to be provided at intervals in a crossing direction crossing a virtual plane parallel to each of the abutting direction and the up-down direction, and in a case where an equivalent reinforcing bar diameter $d_{r,eq}$ of the bundled bars is defined by Equation (2), the bundled bars may be constructed such that a distance in the crossing direction between the bundled bars adjacent to each other in the crossing direction is six or more times the equivalent reinforcing bar diameter $d_{r,eq}$.

Here, $d_{r,i}$ is a diameter of an i-th bent bar anchorage among n sets of the two or more bent bar anchorages forming one bundled bar.

[0018]

$$d_{r,eq} = \sqrt{\sum_{i=1}^n (d_{r,i}^2)} \quad \cdot \cdot (2)$$

[0019]

According to these disclosures, for example, a resistance evaluation equation in the related art not assumed to be used for bundled bars or bent bar anchorages of reinforcing bars arranged in multiple layers can be used for bundled bars or bent bar anchorages of reinforcing bars arranged in multiple layers.

Advantageous Effects of Invention

[0020]

According to the joint configuration of the present disclosure, it is possible to

provide bent bar anchorages, which have pullout resistance substantially equivalent to the pullout resistance of bent bar anchorages arranged in a single layer and used for a column-to-beam joint portion, using bundled bars or bent bar anchorages of reinforcing bars arranged in multiple layers. In addition, according to the construction method of a joint configuration of the present disclosure, it is possible to construct a joint configuration including bent bar anchorages that have pullout resistance substantially equivalent to the pullout resistance of bent bar anchorages arranged in a single layer and used for a column-to-beam joint portion.

BRIEF DESCRIPTION OF DRAWINGS

10 [0021]

[FIG. 1] A floor frame view of a building in which a joint configuration of Specification 1 according to an embodiment of the present disclosure is used.

[FIG. 2] A cross-sectional view taken along cutting-plane line A1-A1 in FIG. 1.

[FIG. 3] A cross-sectional view taken along cutting-plane line A2-A2 in FIG. 2.

15 [FIG. 4] A diagram showing an example of a collapse mode of a wall concrete due to an anchoring bar.

[FIG. 5] A diagram showing another example of the collapse mode of the wall concrete due to the anchoring bar.

[FIG. 6] A diagram showing another example of the collapse mode of the wall concrete due to the anchoring bar.

[FIG. 7] A diagram showing another example of the collapse mode of the wall concrete due to the anchoring bar.

[FIG. 8] A cross-sectional view of a main portion of a building in which a joint configuration of Specification 2 is used.

25 [FIG. 9] A cross-sectional view of a main portion of a building in which a joint

configuration of Specification 3 is used.

[FIG. 10] A cross-sectional view of a main portion of a building in which a joint configuration of Specification 4 is used.

5 [FIG. 11] A diagram showing a schematic configuration of a specimen used in an experiment.

[FIG. 12] A diagram viewed in a direction of arrow A5 of FIG. 11.

[FIG. 13] A front view of an experimental device to which a specimen is attached.

[FIG. 14] A sectional view taken along cutting-plane line A8-A8 in FIG. 13.

10 [FIG. 15] A diagram showing an experimental result of an average stress with respect to a reinforcing bar stress at the time of an expected maximum load.

[FIG. 16] A diagram showing a change in calculated anchorage resistance due to a specimen.

DESCRIPTION OF EMBODIMENTS

15 [0022]

A building in which a joint configuration according to an embodiment of the present disclosure is used will be described below with reference to FIGS. 1 to 16.

First, a joint configuration used to examine floor reinforcing bars (reinforcing bars) to be described later, which can obtain pullout resistance substantially equivalent to the pullout resistance of bent bar anchorages arranged in a single layer and used for a column-to-beam joint portion, will be described.

[0023]

[1. Configuration of building in which joint configuration of Specification 1 is used]

As shown in FIGS. 1 and 2, a building 1 includes a core wall 10, a plurality of columns 20, and a composite beam 25. In FIG. 1, the composite beam 25 is shown by a

two-dot chain line.

The core wall 10 has a rectangular tubular shape. The core wall 10 includes a pair of first walls (supporting members) 11 and a pair of second walls (supporting members) 12.

5 Each of the pair of first walls 11 and the pair of second walls 12 has a reinforced concrete (RC) structure.

[0024]

As shown in FIG. 2, the first wall 11 includes a wall concrete (supporting concrete) 14, a plurality of wall reinforcing bars (supporting reinforcing bars) 15, a
10 baseplate 16, and a plurality of headed studs 17.

The wall concrete 14 has the shape of a plate that is rectangular as viewed in a thickness direction (abutting direction X) of the wall concrete 14. The wall concrete 14 is disposed in a state where the thickness direction of the wall concrete 14 is along a horizontal plane and the wall concrete 14 extends in an up-down direction Z.

15 The plurality of wall reinforcing bars 15 include a plurality of longitudinal bars 15a and a plurality of transverse bars 15b. The plurality of longitudinal bars 15a and the plurality of transverse bars 15b are embedded in the wall concrete 14. The plurality of longitudinal bars 15a are arranged to be separated from each other and extend in the up-down direction Z. The plurality of transverse bars 15b extend along the horizontal
20 plane and are joined to the plurality of longitudinal bars 15a.

[0025]

As shown in FIGS. 2 and 3, the baseplate 16 is disposed on an outer surface of the wall concrete 14. The baseplate 16 is exposed to the outside. The baseplate 16 is disposed to be offset from the outer surface of the wall concrete 14 toward the wall
25 concrete 14, and the surface of the baseplate 16 may be covered with the wall concrete

14. Only a schematic configuration of a floor slab 28 to be described later is shown in FIG. 3.

As shown in FIG. 2, the plurality of headed studs 17 are fixed to a main surface 16a of the baseplate 16 that faces the inside of the wall concrete 14. The plurality of headed studs 17 protrude from the baseplate 16 toward the inside of the wall concrete 14. The plurality of headed studs 17 are embedded in the wall concrete 14. The baseplate 16 may be fixed to the wall concrete 14 by a method of not using the plurality of headed studs 17. For example, the baseplate 16 may be fixed with post-installed anchors, stud dowels (perforated steel plate), or mechanical anchoring.

[0026]

As shown in FIG. 1, the pair of first walls 11 face each other in a direction along the horizontal plane.

As shown in FIG. 2, a shear plate 18 is joined to a main surface 16b of the baseplate 16 opposite to the main surface 16a by welding, bolts, or the like. The shear plate 18 is joined to the first wall 11.

A plurality of bolt holes (not shown) are formed in the shear plate 18. The plurality of bolt holes are arranged side by side in a state of being separated from each other in the up-down direction Z.

[0027]

As shown in FIG. 1, the pair of second walls 12 are formed to have the same configuration as the pair of first walls 11.

The second wall 12 is disposed in a state where a thickness direction of the second wall 12 is along the horizontal plane and the second wall 12 extends in the up-down direction Z. The pair of second walls 12 face each other in a direction along the horizontal plane. The pair of second walls 12 connects end portions of the first walls 11

in a width direction.

Elevator shafts (not shown), a stair hall, and the like are disposed in a space inside the core wall 10.

[0028]

5 The column 20 extends along the up-down direction Z. The plurality of columns 20 are arranged around the core wall 10 at positions separated from the core wall 10 while being at intervals from each other. For example, the column 20 has an RC structure. The column may have a steel encased reinforced concrete/steel framed reinforced concrete (SRC) structure, a concrete-filled steel tube (CFT) structure, or the like.

[0029]

As shown in FIGS. 1 and 2, the composite beam 25 includes a plurality of first steel beams (steel beams) 26, a plurality of second steel beams (steel beams) 27, and a floor slab 28. The first walls 11 and the floor slab 28 form a joint configuration 29 of Specification 1. Similarly, the second walls 12 and the floor slab 28 form the joint configuration 29 of Specification 1. That is, either the first steel beams 26 or the second steel beams 27 abutting against the wall 11 or 12 can be used in the joint configuration 29 of Specification 1 of the present embodiment.

For example, each of the first steel beam 26 and the second steel beam 27 is an H-section steel made of steel. The first steel beam 26 and the second steel beam 27 may not be H-section steels. For example, a T-section steel in which an upper flange is removed from the H-section steel may be used. Further, a T-beam in which a beam having a reinforced concrete structure and the floor slab 28 are integrated with each other may be used.

25 The first steel beam 26 is provided between the core wall 10 and the column 20

adjacent to each other and between the columns 20 adjacent to each other, and extends in a direction along the horizontal plane.

The second steel beam 27 is provided between the core wall 10 and the first steel beam 26 adjacent to each other and between the first steel beams 26 adjacent to each other, and extends along the horizontal plane.

Since the configuration of the first steel beam 26 is equivalent to the configuration of the second steel beam 27, the second steel beam 27 provided between the core wall 10 and the first steel beam 26 adjacent to each other will be described below as an example.

[0030]

As shown in FIGS. 2 and 3, the second steel beam 27 includes a first flange 31, a second flange 32, and a web 33. The first flange 31 and the second flange 32 are disposed along the horizontal plane and face each other in the up-down direction Z. The first flange 31 is disposed above the second flange 32.

The web 33 is disposed between the first flange 31 and the second flange 32. The web 33 is joined to each of the center of the first flange 31 in the width direction and the center of the second flange 32 in the width direction. Alternatively, the web 33 is integrally formed with the first flange 31 and the second flange 32 to be positioned at the center of the first flange 31 in the width direction and the center of the second flange 32 in the width direction.

A plurality of bolt holes (not shown) are formed at each of end portions of the web 33 in the abutting direction X. The plurality of bolt holes are arranged side by side in a state of being separated from each other in the up-down direction Z.

[0031]

As shown in FIG. 2, the floor slab 28 is disposed such that a thickness direction

of the floor slab 28 is along the up-down direction Z. The floor slab 28 is abutted against and joined to the first wall 11 in the abutting direction X. Hereinafter, one side of the floor slab 28 facing the first wall 11 will be referred to as a first side X1 in the abutting direction X (also simply referred to as a first side X1). A side opposite to the first side X1 will be referred to as a second side X2 in the abutting direction X (also simply referred to as a second side X2).

As shown in FIGS. 2 and 3, the floor slab 28 includes a deck plate 36, a floor concrete 37, and a plurality of bundled bars 45.

A steel plate is bent or the like to form the deck plate 36. The deck plate 36 is disposed on the first flanges 31 of the second steel beams 27.

The floor concrete 37 is formed in the shape of a flat plate and is disposed on the deck plate 36. The bundled bars 45 include a plurality (two or more) of bent bar anchorages (bent reinforcing bar anchorages) 38 and tie wires (bundling members) 44. The plurality of bent bar anchorages 38 include a plurality of first anchoring bars 42A and a plurality of second anchoring bars 42B.

[0032]

Although not shown, the plurality of bent bar anchorages 38 (floor slab 28) may include reinforcing bars in a direction crossing the abutting direction X. Further, although not shown, the plurality of bent bar anchorages 38 may include reinforcing bars, which are arranged along the abutting direction X and not embedded (anchored) in the wall concrete 14, in addition to the plurality of first anchoring bars 42A and the plurality of second anchoring bars 42B.

[0033]

In the present embodiment, the configuration of the first anchoring bar 42A and the configuration of the second anchoring bar 42B are the same except for the diameters

and lengths of the first anchoring bar 42A and the second anchoring bar 42B. For this reason, a component of the first anchoring bar 42A is denoted by a numeral to which a capital letter “A” is added or a combination of a numeral and a small letter to which a capital letter “A” is added. A component of the second anchoring bar 42B

5 corresponding to the component of the first anchoring bar 42A is denoted by the same numeral as that of the first anchoring bar 42A to which a capital letter “B” is added or a combination of the same numeral and small letter as those of the first anchoring bar 42A to which a capital letter “B” is added. Accordingly, repeated description thereof will be omitted. For example, an anchoring portion 42aA to be described later of the first
10 anchoring bar 42A and an anchoring portion 42aB to be described later of the second anchoring bar 42B have the same configuration except for diameters and lengths.

[0034]

For example, a reinforcing bar is bent to form the first anchoring bar 42A. The first anchoring bar 42A includes an anchoring portion 42aA, an extending portion 42bA,
15 and a bent portion 42cA. The first anchoring bar 42A may include a diameter-increasing portion, which resists the drawing of the first anchoring bar 42A, instead of the bent portion 42cA.

The anchoring portion 42aA extends along the up-down direction Z in the wall concrete 14. The anchoring portion 42aA is embedded (anchored) in the wall concrete
20 14.

The extending portion 42bA extends toward the second side X2 along the abutting direction X. An end portion of the extending portion 42bA facing the first side X1 is embedded in the wall concrete 14.

A portion of the extending portion 42bA other than the end portion is embedded
25 in the floor concrete 37.

[0035]

The bent portion 42cA is formed in a quarter-circular arc shape. The bent portion 42cA is joined to each of an upper end portion of the anchoring portion 42aA and the end portion of the extending portion 42bA facing the first side X1.

5 The first anchoring bar 42A may include a second anchoring bar that extends downward from an end portion of the extending portion 42bA facing the second side X2, or the like. Alternatively, the first anchoring bar 42A may include a second anchoring bar that is folded in a direction facing the first side X1 via a hook having a central angle of 180° at the end portion of the extending portion 42bA facing the second side X2, or
10 the like.

[0036]

The diameter of the second anchoring bar 42B is larger than the diameter of the first anchoring bar 42A. That is, the bent bar anchorage 38, which has the smallest diameter, of the anchoring bars 42A and 42B is the first anchoring bar 42A. The second
15 anchoring bar 42B includes an anchoring portion 42aB, an extending portion 42bB, and a bent portion 42cB that have the same configuration as the anchoring portion 42aA, the extending portion 42bA, and the bent portion 42cA of the first anchoring bar 42A.

The first anchoring bar 42A and the second anchoring bar 42B may have the same diameter. The first anchoring bar 42A may include a diameter-increasing portion,
20 which resists the drawing of the first anchoring bar 42A, instead of the bent portion 42cA.

[0037]

The anchoring portions 42aA and 42aB are disposed at an equivalent position in the abutting direction X. The fact that the anchoring portions 42aA and 42aB are
25 disposed at the equivalent position in the abutting direction X mentioned here means that,

for example, an absolute value of a difference between the projected anchorage lengths of the anchoring bars 42A and 42B is 4 times or less the diameter of the second anchoring bar 42B (the largest diameter of the plurality of bent bar anchorages 38). The projected anchorage length of the first anchoring bar 42A means the length of a portion
 5 of the first anchoring bar 42A, which is anchored to the wall concrete 14, in the abutting direction X (see the projected anchorage length L_{dh} in FIG. 2). The same applies to the projected anchorage length of the second anchoring bar 42B.

[0038]

The anchoring portions 42aA and 42aB may be disposed in contact with each
 10 other. Since the anchoring portions 42aA and 42aB are disposed in this manner, the lengths of the anchoring bars 42A and 42B, which are anchored to the wall concrete 14, in the abutting direction X are aligned. Therefore, the positioning of the anchoring bars 42A and 42B is facilitated, so that the workability of the anchoring bars 42A and 42B is improved.

15 [0039]

It is preferable that the minimum value of the projected anchorage lengths of the plurality of anchoring bars 42A and 42B (the plurality of bent bar anchorages 38) is $1/2$ or more times the length of the first wall 11 in the abutting direction X (a length D_w in FIG. 2). The reason for this is that tensile stress acts on an edge end of the wall
 20 concrete 14, which faces the second side X2 in a thickness direction (abutting direction X), in the up-down direction Z due to bending moment acting on the first wall 11 having the RC structure from the composite beam 25. Accordingly, biaxial tensile stress acts on the wall concrete 14 due to composite stress in which drawing forces of the anchoring bars 42A and 42B and the tensile stress are combined with each other, so that the wall
 25 concrete 14 is likely to fail.

In general, since the walls 11 and 12 having the RC structure support a vertical force (a self-weight and a live load) acting on the building 1, the walls 11 and 12 are subjected to a compressive force in a height direction (Z-direction) at all times.

Therefore, it is sufficient that the minimum value of the projected anchorage length is 1/2

5 or more times the length D_w . However, in a case where additional tensile stress acts in the up-down direction Z of the walls 11 and 12 due to a horizontal force caused by a wind load or a seismic force, it is preferable that the minimum value of the projected anchorage length is 2/3 or more times the length D_w in order to more reliably obtain the pullout resistance of the anchoring bars 42A and 42B. Meanwhile, it is preferable that

10 at least about 20 mm is secured as a cover thickness from the anchoring portions 42aA and 42aB to a side surface of the wall concrete 14, and it is preferable that the maximum value of the projected anchorage length is $(D_w - 20 \text{ mm})$ or less.

[0040]

The anchoring portions 42aA and 42aB are bundled with each other by the tie

15 wire 44 or the like. The bundling member is not limited to the tie wire 44, and a binding band may be used as the bundling member, or the anchoring portions may be joined to each other by welding. Further, the plurality of bent bar anchorages 38 forming the bundled bars 45 may not be bundled by the bundling member, and other elements for fixing the positions of the bent bar anchorages 38 such that the anchoring

20 portions 42aA and 42aB are close to (in contact with) each other may be used.

The extending portion 42bA and the extending portion 42bB are disposed at positions different from each other in the up-down direction Z. The fact that the extending portion 42bA and the extending portion 42bB are disposed at positions different from each other in the up-down direction Z means that, for example, the central

25 axis of the extending portion 42bA and the central axis of the extending portion 42bB are

disposed at positions different from each other in the up-down direction Z.

[0041]

More specifically, the extending portions 42bA and 42bB are disposed with an interval therebetween in the up-down direction Z. The extending portion 42bA of the first anchoring bar 42A is disposed at the highest position of the extending portions 42bA and 42bB. That is, the extending portion 42bA of the first anchoring bar 42A, which has a small diameter and is disposed at the highest position of the extending portions 42bA and 42bB, is disposed above the extending portion 42bB of the second anchoring bar 42B that has a diameter larger than the diameter of the first anchoring bar.

The plurality of bent bar anchorages 38 are not limited to two layers of the anchoring bars 42A and 42B, and can be used in the same configuration even in the case of three or four layers. In this case, each of the bundled bars 45 is formed of three or four bundled anchoring bars in each case. Further, even in a case where the bundled bar includes three or more bent bar anchorages, it is preferable that the extending portion of at least one anchoring bar having the smallest diameter is disposed at the highest position.

[0042]

According to the configuration shown in FIG. 2, there is an effect of improving failure resistance corresponding to failure modes (FIGS. 4 to 7 to be described later) of the wall concrete (supporting concrete) 14. In FIGS. 4 to 7, for example, a column 100 and a floor concrete 101 having a reinforced concrete structure are connected to each other by the plurality of first anchoring bars 42A. FIGS. 4(B) to 7(B) are cross-sectional views of FIGS. 4(A) to 7(A) viewed from above. The floor concrete 101 is not shown in FIGS. 4(B) to 7(B).

For example, in a case where concrete that resists bearing pressure acting from

the bent portions 42cA and 42cB between the extending portions 42bA and 42bB and the anchoring portions 42aA and 42aB of the anchoring bars 42A and 42B (the plurality of bent bar anchorages 38) is subjected to a raking-out failure (see FIG. 6), an effective area of conical (substantially conical) failure surface of a portion that is raked out is a region R1 surrounded by a solid line in FIG. 2 in the case of the present embodiment (FIG. 2) and is a region R2 surrounded by a solid line in FIG. 9 in the case of a configuration different from the present disclosure to be described later (FIGS. 9 and 10).

[0043]

These conical failure surfaces can be obtained from the following common idea.

First, a conical failure surface (a region R3 shown by a dotted line in FIGS. 2 and 9. However, the regions R1 and R2 form a part of the failure surface in a portion where the solid line and the dotted line overlap with each other) in which a raking-out failure occurs in a case where it is assumed that each of the anchoring bars 42A and 42B (the plurality of bent bar anchorages 38) is present alone, is assumed for each of the anchoring bars 42A and 42B. A region, which is included in both the conical failure surfaces, (the region R1 shown in FIG. 2 and the region R2 shown in FIG. 9) of regions surrounded by the conical failure surfaces is an actual conical failure surface.

As the positions of the bent portions 42cA and 42cB are farther from a beam-side of the wall concrete 14 in the abutting direction X, a conical failure occurs at a position deeper in the abutting direction X. Therefore, an effective area indicated by the region R1 of FIG. 2 is larger than an effective area indicated by the region R2 of FIG. 9, and failure resistance increases.

[0044]

As shown in FIG. 3, a direction orthogonal to a virtual plane S1 parallel to each of the abutting direction X and the up-down direction Z is defined as an orthogonal

direction (crossing direction) Y. The crossing direction may be a direction crossing the virtual plane S1.

The plurality of bundled bars 45 are arranged at intervals in the orthogonal direction Y.

5 The number of the bundled bars 45 included in the floor slab 28 is not limited, and may be one.

Here, an equivalent reinforcing bar diameter $d_{r,eq}$ (mm) of the bundled bars 45 is defined by Equation (5).

[0045]

$$d_{r,eq} = \sqrt{\sum_{i=1}^n (d_{r,i}^2)} \quad \cdot \cdot (5)$$

10

[0046]

Here, $d_{r,i}$ is a diameter (mm) of the i-th bent bar anchorage 38 among n sets of a plurality of bent bar anchorages 38 forming one bundled bar 45. i is a natural number, and n is 2 in the examples of FIGS. 2 and 3.

15 It is preferable that a distance S in the orthogonal direction Y between the bundled bars 45 adjacent to each other in the orthogonal direction Y is six or more times the equivalent reinforcing bar diameter $d_{r,eq}$. The reason for this is that the wall concrete 14 is likely to fail since regions of the wall concrete 14 that resist the drawing force of the bundled bars 45 overlap with each other between the bundled bars adjacent to each other in the orthogonal direction Y in a case where the distance S is less than 6 times the
20 equivalent reinforcing bar diameter $d_{r,eq}$.

The distance S is preferably large from the viewpoint of preventing the failure of the wall concrete 14 at the anchoring portion, and an upper limit of the distance S is not

particularly limited. However, since the number of bent bar anchorages 38 that can be arranged within an effective width of the floor slab 28 is reduced as the distance S is increased, both resistance and stiffness are reduced. Therefore, it is preferable that the upper limit of the distance S is set to about 20 times the equivalent reinforcing bar

diameter $d_{r,eq}$.

[0047]

As shown in FIG. 2, a plurality of headed studs (shear connectors) 48 are fixed to the first flange 31 of the second steel beam 27. The plurality of headed studs 48 are arranged at intervals in the abutting direction X. The plurality of headed studs 48 are embedded in the floor concrete 37 through the deck plate 36 of the floor slab 28.

The deck plate 36 may be divided on the first flange 31. In this case, the plurality of headed studs 48 are directly joined to the first flange 31 and are embedded in the floor concrete 37.

[0048]

As shown in FIGS. 2 and 3, the web 33 of the second steel beam 27 and the shear plate 18 are joined to each other by bolts 51 and nuts 52. More specifically, a shaft portion (of which reference numeral is omitted) of the bolt 51 is inserted into the bolt hole of the shear plate 18 and the bolt hole of the web 33 of the second steel beam 27. A head portion (of which reference numeral is omitted) of the bolt 51 is locked to the shear plate 18 from a side opposite to the web 33.

The nut 52 is locked to the web 33 from a side opposite to the shear plate 18 and is fitted to the shaft portion of the bolt 51. Although not shown, a washer is installed between the head portion of the bolt 51 and the shear plate 18 and between the nut 52 and the web 33.

As shown in FIG. 2, the second flange 32 of the second steel beam 27 and the

baseplate 16 of the first wall 11 are joined to each other by a connecting portion 53. A compression member (contact plate) for transmitting stress may be inserted into the connecting portion 53 by metal touch, or the connecting portion 53 may be joined by welding.

5 [0049]

It is preferable that end portions of the plurality of bent bar anchorages 38 facing the second side X2 extend to a hogging bending region of the second steel beam 27 in the joint configuration 29. That is, in a case where both ends of the second steel beam 27 are supported in the up-down direction Z at some kind of joint portion, a range including
10 the center of the second steel beam 27 in the abutting direction X is a sagging bending region. Since the floor slab 28 in this range is subjected to a compressive force, crack prevention bars only have to be arranged. Therefore, the plurality of first anchoring bars 42A, which are upper-layer bars, are arranged over the entire length of the second steel beam 27 as crack prevention bars, and the plurality of second anchoring bars 42B,
15 which are lower-layer bars, do not need to be arranged in the sagging bending region. The crack prevention bar may be divided into two or more pieces in a length direction, and lap joints may be provided such that the crack prevention bars are arranged continuously with the plurality of first anchoring bars 42A.

Furthermore, in the hogging bending region of the second steel beam 27 facing
20 the first side X1, the plurality of bent bar anchorages 38 only have to be arranged in the vicinity of a joint portion where a tensile force of the floor slab 28 is large. Even in the hogging bending region, the plurality of second anchoring bars 42B do not need to be provided in a range close to the sagging bending region.

[0050]

25 For example, in a case where the length of the second steel beam 27 is denoted

by L_b , the second anchoring bar 42B may be disposed in a range of $0.15L_b$ from the joint portion and may have a shorter length according to the rotational stiffness of the joint portion. However, in order to transmit a tensile force from the headed studs 48 embedded in the floor slab 28 to the plurality of bent bar anchorages 38, it is preferable to secure a length of the second anchoring bar 42B of about 40 times the diameter of each of the plurality of bent bar anchorages 38 in the shortest case.

[0051]

[2. Construction method of joint configuration of Specification 1]

A construction method of the joint configuration 29 of Specification 1 (hereinafter, simply referred to as a construction method) will be described.

In the construction method, for example, before the wall concrete 14 and the floor concrete 37 are cast, the anchoring portions 42aA and 42aB of the anchoring bars 42A and 42B are disposed at the equivalent position in the abutting direction X.

The extending portions 42bA and 42bB are disposed at positions different from each other in the up-down direction Z. More specifically, in the construction method, it is preferable that the extending portions 42bA of the first anchoring bars 42A having a small diameter are disposed at the highest position of the extending portions 42bA and 42bB.

In the construction method, it is preferable to construct the plurality of anchoring bars 42A and 42B such that the minimum value of the projected anchorage lengths of the plurality of anchoring bars 42A and 42B is $1/2$ or more times or $2/3$ or more times the length of the first wall 11 in the abutting direction X.

[0052]

In the construction method, the wall concrete 14 and the floor slab 28 may be constructed to include the plurality of bundled bars 45 arranged in the orthogonal

direction Y. In this case, the bundled bars 45 may be constructed such that a distance in the orthogonal direction Y between the bundled bars 45 adjacent to each other in the orthogonal direction Y is six or more times the equivalent reinforcing bar diameter $d_{r,eq}$.

The baseplate 16 is installed in a state of being provided with a plurality of

5 headed studs 17 before the wall concrete 14 and the floor concrete 37 are cast.

Next, the wall concrete 14 is cast. After the wall concrete 14 is hardened and a formwork is removed, the first steel beam 26 and the second steel beam 27 are joined to the shear plate 18 installed on the baseplate 16 and the floor concrete 37 is cast on the deck plate 36, so that the joint configuration 29 is constructed. The shear plate 18 may
10 be joined to the baseplate 16 after the formwork of the wall concrete 14 is removed. In this case, since the formwork of the wall concrete 14 and the shear plate 18 do not interfere with each other, the formwork of the wall concrete 14 can be easily installed.

The formwork of the wall concrete 14 may be installed in a state where the shear plate 18 is joined to the baseplate 16 in advance. In this case, it is necessary to provide an
15 opening in a part of the formwork in order to avoid interference between the formwork and the shear plate 18, but a step of installing the shear plate 18 after the removal of the formwork can be omitted.

[0053]

[3. Configuration of buildings in which joint configurations (Specification 2 to

20 Specification 4) other than that of present disclosure are used]

Next, in order to compare with the joint configuration according to the embodiment of the present disclosure, joint configurations different from the joint configuration according to the embodiment of the present disclosure will be described.

A building 1A shown in FIG. 8 includes a joint configuration 60 of Specification

25 2 instead of the joint configuration 29 in each component of the building 1. The joint

configuration 60 of Specification 2 is a joint configuration different from the joint configuration according to the embodiment of the present disclosure. In the joint configuration 60, the anchoring portion 42aA of the first anchoring bar 42A and the anchoring portion 42aB of the second anchoring bar 42B are not in contact with each other and are disposed at positions different from each other in the abutting direction X. More specifically, the anchoring portion 42aB is disposed closer to the first side X1 than the anchoring portion 42aA.

Meanwhile, the extending portions 42bA and 42bB are disposed at the equivalent position in the up-down direction Z.

A building 1B shown in FIG. 9 includes a joint configuration 65 of Specification 3 instead of the joint configuration 29 in each component of the building 1. The joint configuration 65 of Specification 3 is a joint configuration different from the joint configuration according to the embodiment of the present disclosure. In the joint configuration 65, the anchoring portion 42aA of the first anchoring bar 42A and the anchoring portion 42aB of the second anchoring bar 42B are not in contact with each other and are disposed at positions different from each other in the abutting direction X. Further, the extending portions 42bA and 42bB are disposed at positions different from each other even in the up-down direction Z.

[0054]

In addition, a building 1C shown in FIG. 10 includes a joint configuration 70 of Specification 4 instead of the joint configuration 29 in each component of the building 1. In the joint configuration 70, the first anchoring bars 42A and the second anchoring bars 42B are arranged at intervals in the orthogonal direction Y. That is, as viewed in the abutting direction X, the extending portions 42bA of the first anchoring bars 42A and the extending portions 42bB of the second anchoring bars 42B are not in contact with each

other and are arranged in a staggered manner. The first anchoring bar 42A and the second anchoring bar 42B are not bundled by the tie wire 44. The joint configuration 70 of Specification 4 is also a joint configuration different from the joint configuration according to the embodiment of the present disclosure.

5 [0055]

According to Non Patent Document 1, the calculated anchorage resistance of the bent bar anchorages 38 in the joint configurations 60 (Specification 2) and 65 (Specification 3) is reduced to 0.7 times the calculated anchorage resistance of reinforcing bars arranged in one stage.

10 On the other hand, in the joint configuration 70 (Specification 4), in the example shown in FIG. 10, the interval between the bent bar anchorages 38 in the orthogonal direction Y is the same as the interval between the wall reinforcing bars. Accordingly, the bent bar anchorages and the wall reinforcing bars do not interfere with each other. However, in a case where the interval between the bent bar anchorages 38 is different
15 from the interval between the wall reinforcing bars, the bent bar anchorages and the wall reinforcing bars are likely to interfere with each other unless the larger interval is an integer multiple of the smaller interval. Since the interval between the bent bar anchorages 38 is made uneven in a case where interference with the wall reinforcing bars is avoided, it is difficult to predict the pullout resistance of the anchoring portions.

20 Hereinafter, experimental results of the calculated anchorage resistance of the bent bar anchorages 38 will be described.

[0056]

[4. Experiment using specimen]

As shown in FIGS. 11 and 12, five specimens 75 in which a plurality of bent bar
25 anchorages 38 were anchored to the first wall 11 were used. In FIGS. 11 and 12, tie

wires 44 are not shown.

In FIGS. 11 and 12, dimensions of each component of the specimen 75 are shown in units of “mm”. A numerical value immediately behind “@” indicates a pitch.

The specifications of the specimen 75 are shown in Tables 1 to 4.

5 [0057]

[Table 1]

* Specimen specifications 1

No.	First wall					
	Thickness	Width	Concrete compressive strength	Longitudinal bar	Transverse bar	Distance from tensile reinforcing bar to point of application of compressive reaction force
	Dw	Bw	fck	Diameter@pitch	Diameter@pitch	j
	mm	mm	N/mm ²	mm	mm	mm
1	400	800	59.6	D25@150	D13@200	817
2	400	800	62.6	D25@150	D13@200	817
3	400	800	64.2	D25@150	D13@200	817
4	400	800	47.7	D25@150	D13@200	817
5	300	800	50.5	D25@150	D13@200	817

[0058]

[Table 2]

* Specimen specifications 2

N o.	Details of bent bar anchorage											
	Arrange ment of bent bar anchora ges	Side cover thickn ess	First anchoring bar (upper-layer bar)									
		CO	Diameter@ pitch	Cros s- secti on area	Yield stres s	Num ber of bars	Total cross - secti on area $\Sigma a_r, t$	Bendi ng angle	Bendi ng inner radius	Horizo ntal projecte d anchora ge length Ldh	Assum ed cover thickn ess Drc, t	Leng th of bent exce ss porti on Ldv
-	mm	mm	mm	mm ²	N/m ²	-	mm ²	°	mm	mm	mm	mm
1	Bundled bar	237.0	D10@150	71.3	870	3	213. 9	90	60	347	30	420
2	Bundled bar	238.5	D10@150	71.3	870	3	213. 9	90	60	347	30	420
3	Staggered	216.5	D10@150	71.3	870	3	213. 9	90	60	347	30	420
4	Bundled bar	238.5	D10@100	71.3	870	4	285. 2	90	60	347	30	420
5	Bundled bar	238.5	D10@100	71.3	870	4	285. 2	90	60	247	30	420

[0059]

[Table 3]

* Specimen specifications 3

N o.	Details of bent bar anchorage												
	Second anchoring bar (lower-layer bar)										Interval between n bent bar anchor ages in orthog onal directi on	Interval between n first anchori ng bar and second anchori ng bar	Assum ed slab bar
	Dia meter@pi tch	Cross- section area	Yield stress	Num ber of bars	Total cross- section area $\Sigma a_r, b$	Bend ing angl e	Bend ing inner radiu s	Horiz ontal projec ted ancho rage length L _{dh}	Assu med cover thickn ess D _{rc, b}	Len gth of bent exce ss porti on L _{dv}	sh	sv	Dia meter@pi tch
-	mm	mm ²	N/mm ²	-	mm ²	°	mm	mm	mm	mm	mm	mm	mm
1	D16@ 150	198.6	856	3	595.8	90	96	347	50	400	124.0	10	D10@ 150
2	D13@ 150	126.7	814	3	380.1	90	78	347	50	400	127.0	10	D10@ 150
3	D13@ 150	126.7	814	3	380.1	90	78	347	50	400	63.5	10	D10@ 150
4	D13@ 100	126.7	814	4	506.8	90	78	347	50	400	77.0	10	D10@ 100
5	D13@ 100	126.7	814	4	506.8	90	78	247	50	400	77.0	10	D10@ 100

[0060]

[Table 4]

* Specimen specifications 4

No.	Details of reinforcement bar										
	Width stop bar						Dowel bar				
	Diameter	Cross - section area	Yield stress	Pitch in orthogonal direction	Pitch in up-down direction	Number of bars	Diameter	Cross - section area	Yield stress	Bar arrangement position	Number of bars
-	mm	mm ²	N/mm ²	mm	mm	-	mm	mm ²	N/mm ²	-	-
1	D13	126.7	554	300	200	6	D13	126.7	554	15°, 45° from bending start point of second anchoring bar	2
2	D13	126.7	554	300	200	6	D13	126.7	554	15°, 45° from bending start point of second anchoring bar	2
3	D13	126.7	554	300	200	6	D13	126.7	554	15°, 45° from bending start point of second anchoring bar	2
4	D13	126.7	554	300	200	6	D13	126.7	554	15°, 45° from bending start point of second anchoring bar	2
5	D13	126.7	554	300	200	6	D13	126.7	554	15°, 45° from bending start point of second anchoring bar	2

[0061]

The sizes of all the first walls 11 were set to a width of 800 mm and a height of 2000 mm. The bent bar anchorages (bar anchorages) 38 were shifted in the up-down direction Z (the thickness direction of the floor slab 28) to be arranged in two layers.

- 5 Four specimens 75 of Nos. 1, 2, 4, and 5 in which the anchoring portions 42aA and 42aB in the first wall 11 having the RC structure were bundled by the tie wires 44 and the plurality of bent bar anchorages 38 were arranged were manufactured.

- One specimen 75 of No. 3 in which the bent bar anchorages 38 were shifted in the up-down direction Z to be arranged in two layers and the plurality of bent bar
10 anchorages 38 arranged in the layers were shifted in the orthogonal direction Y to be arranged in a staggered manner was manufactured.

The specimen 75 of No. 3 (staggered arrangement) has the thickness of the first wall 11 and the number of reinforcing bars in the first wall 11, which are the same as those of the specimen 75, No. 2 (bundled bars), and is a specimen for comparison.

- 15 In all of the specimens 75 of Nos. 1 to 5, the bent bar anchorage 38 was a hook bent at an angle of 90° and the bending inner radius thereof was set to 6 times the diameter of the bent bar anchorage 38.

[0062]

- The diameter and pitch of the bent bar anchorages 38 and the thickness of the
20 first wall 11 were set as other experimental parameters. In addition, in a case where concrete was cast for the specimen 75, the specimen 75 was stood such that the height direction of the first wall 11 of the specimen 75 was the same as the up-down direction Z of an actual first wall 11. Accordingly, a direction in which the concrete is cast is the same as that in an actual building.

- 25 [0063]

The specimens 75 of Nos. 1, 2, 4, and 5 correspond to Specification 1. The specimen 75 of No. 3 corresponds to the joint configuration 70 of Specification 4.

In all of the specimens 75, the bent bar anchorage 38 was a hook bent at an angle of 90° and the bending inner radius thereof was set to 6 times the diameter of the bent bar anchorage 38.

[0064]

FIGS. 13 and 14 show a state where the specimen 75 is installed in an experimental device 80.

The experimental device 80 includes a gate-type loading frame 81, a pair of pin roller fulcrums 82, a hydraulic jack 83, and a load cell 84.

The specimen 75 is laid such that a height direction of the first wall 11 is a direction along the horizontal plane. Lower end portions of the plurality (in this example, three) of bent bar anchorages 38 of the specimen 75 are fixed to a loading beam 81a of the gate-type loading frame 81. The pair of pin roller fulcrums 82 supports the first wall 11 such that both end portions of the first wall 11 do not move in the up-down direction. In a case where the hydraulic jack 83 pushes the loading beam 81a downward, the first wall 11 is subjected to so-called three-point bending by the loading beam 81a and the pair of pin roller fulcrums 82. Then, the plurality of bent bar anchorages 38 are drawn downward from the first wall 11.

A drawing force P was applied downward by the hydraulic jack 83 such that the displacement of the first wall 11 was constant. The load cell 84 is connected to the hydraulic jack 83 and measures a compressive load applied by the hydraulic jack 83.

[0065]

It was assumed that the expected maximum load $P_{u,calc}$ of the experiment was determined depending on the smallest resistance among four factors, that is, the

anchoring portion-concrete failure resistance T_u of the bent bar anchorages 38 based on a case where the bent bar anchorages 38 were arranged in one stage (single layer) (see FIG. 4 or 5), raking-out anchorage failure resistance T_{cu} (see FIG. 6), the cross-sectional yield resistance T_{ry} of the bent bar anchorages 38, and the anchoring bar drawing force T_s of the bent bar anchorages 38 of the first wall 11 having the RC structure at the time of shear failure of the joint portion (see FIG. 7). That is, " $P_{u,calc} = \min(T_u, T_{cu}, T_{ry}, T_s)$ " was set.

The cross-sectional yield resistance T_{ry} was defined as a product of the yield strength of the reinforcing bars used in the experiment and a total cross-section area.

The anchoring portion-concrete failure resistance T_u , the raking-out anchorage failure resistance T_{cu} , and the anchoring bar drawing force T_s at the time of shear failure of the joint portion were calculated according to a calculation method disclosed in Document 1.

Document 1: Architectural Institute of Japan, "Seismic Design Guidelines for Reinforced Concrete Building for Toughness Guaranteed and Commentary on the Guidelines", Maruzen Co., Ltd., 2001 [0066]

The anchoring bar drawing force T_s at the time of shear failure of the joint portion was defined as the drawing force of the bent bar anchorages 38 in a case where a shear force acting on the first wall 11 is equal to a larger strength of shear crack strength V_c and shear trust strength V_u disclosed in Document 1 ($T_s = 2 \times (\max(V_c, V_u))$). The anchoring portion-concrete failure resistance T_u was defined as the value of a product of the total cross-section area of anchoring bars and bending anchorage strength f_u that was disclosed in Document 1 and was calculated using an equivalent reinforcing bar diameter $d_{r,eq}$ of the bundled bars 45 defined by Equation (5) in a state where the bundled bars 45 were regarded as one equivalent reinforcing bar.

The anchoring portion-concrete failure resistance T_u in the case of the staggered arrangement was treated as resistance obtained in a case where the bent bar anchorages 38 having the equivalent reinforcing bar diameter $d_{r,eq}$ (mm) calculated from Equation (8) were arranged in one layer by the same number as the total number of the first anchoring bars 42A as upper-layer bars and the second anchoring bars 42B as lower-layer bars. An interval between the bent bar anchorages 38 in the orthogonal direction Y was set to an interval between the first anchoring bar 42A and the second anchoring bar 42B in the orthogonal direction Y.

[0067]

$$d_{r,eq} = \sqrt{\frac{n_l \cdot d_{r,l}^2 + n_b \cdot d_{r,b}^2}{n_l + n_b}} \quad \cdot \cdot (8)$$

[0068]

Here, n_l denotes the number of the first anchoring bars 42A. $d_{r,l}$ denotes the nominal diameter (mm) of the first anchoring bar 42A, n_b denotes the number of the second anchoring bars 42B, and $d_{r,b}$ denotes the nominal diameter (mm) of the second anchoring bar 42B. In the calculation of any of the anchoring portion-concrete failure resistance T_u , the raking-out anchorage failure resistance T_{cu} , and the anchoring bar drawing force T_s at the time of shear failure of the joint portion, actual compressive strength and split tensile strength on the day of the experiment were used as concrete strength.

[0069]

An expected maximum load $P_{u,calc}$, calculated resistances T_u , T_{cu} , T_{ry} , and T_s corresponding to various failure modes, an expected failure mode, the maximum resistance obtained in the experiment, and a failure mode generated in the experiment are

shown in Table 5.

[0070]

[Table 5]

* Calculated resistance and experimental resistance

N o.	Prediction using design equation							Experimental result			Maxim um resistan ce in experim ent / expecte d maximu m resistan ce
	Anchor ing portion - concret e failure resistan ce	Raking -out anchor age failure resista nce	Cross- section al yield resista nce of bent bar anchor age	Anchor ing bar pullout resistan ce at time of shear failure of joint portion	Expect ed maxim um load	Reinfor cing bar stress at time of expecte d maximu m load	Expect ed failure mode	Maxim um resista nce	Averag e stress of bent bar anchor age	Failure mode	
	Tu	Tcu	Try	Ts	Pu,calc	fu,calc		Tmax	fu,exp		
-	kN	kN	kN	kN	kN	N/mm ²	-	kN	N/mm ²	-	-
1	648	1728	696	714	648	801	Anchor ing portion - concret e	700	865	Anchor ing portion - concret e	1.08
2	517	1776	496	720	496	834	Yield of bent bar anchor age	563	948	Fractur e of bent bar anchor age	1.14
3	523	1801	496	723	496	834	Yield of bent bar anchor age	572	962	Fractur e of bent bar anchor age	1.15
4	619	1518	661	604	604	762	Shear of joint portion	675	853	Shear of joint portion + Anchor ing portion - concret e	1.12
5	589	1105	661	383	383	483	Shear of joint portion	381	481	Shear of joint portion	1.00

[0071]

FIG. 15 shows a result of comparison between a reinforcing bar stress $f_{u,calc}$ at the time of an expected maximum load that is obtained by dividing the expected maximum load (calculated anchorage resistance) $P_{u,calc}$ by the sum of the cross-section areas of the plurality of bent bar anchorages 38 and an average stress $f_{u,exp}$ of the bent bar anchorages 38 that is obtained by dividing the maximum load T_{max} of the experiment by the sum of the cross-section areas of the plurality of bent bar anchorages 38. In FIG. 15, a case where there is a mark $\circ$ on a line L1 means that the average stress $f_{u,exp}$ was not reduced to 0.7 times the reinforcing bar stress $f_{u,calc}$ at the time of the expected maximum load based on a case where the bent bar anchorages 38 were arranged in one stage (single layer), and resistance equivalent to resistance obtained in a case where the bent bar anchorages were arranged in one stage (single layer) and used for a column-to-beam joint portion was obtained.

In any of the specimens 75, $f_{u,exp}$ showed a value substantially equivalent to $f_{u,calc}$. That is, it was confirmed that T_{max} has resistance equivalent to the expected maximum load $P_{u,calc}$ and anchorage resistance can be accurately expected by a proposed method used here. Further, from the results of the specimens 75 of Nos. 2 and 3, it was confirmed that the bundled bars had resistance equivalent to the resistance of the bars arranged in a staggered manner as long as the configuration of the present disclosure was adopted. That is, according to the configuration of the present disclosure, the bent bar anchorages 38 are less likely to interfere with the wall reinforcing bars 15. Therefore, it is easier to perform construction than in the case of the staggered arrangement, and the same resistance as in the case of the staggered arrangement can be obtained.

[0072]

[5. Experiment for confirming calculated anchorage resistance]

- The specimens 75 of Nos. 1 and 2 were set as bases (examples), cases where the projected anchorage length of each of the second anchoring bars 42B was made shorter than the projected anchorage length of the first anchoring bar 42A were set as comparative examples (No. 1' and No. 2' shown in Table 6), and the calculated anchorage resistances of a total of four cases were obtained from calculation. The calculation mentioned here is based on the findings of Non Patent Document 1.

[0073]

[Table 6]

No.	Thickness of first wall	First anchoring bar			Second anchoring bar			Calculated anchorage resistance	Example or comparative example
		Diameter	Pitch	Anchorage length	Diameter	Pitch	Anchorage length		
		Dw	d1	Ldh,max	d2		Ldh,min	Tu	
	mm	mm	mm	mm	mm	mm	mm	kN	
1	400	D10	@150	347	D16	@150	347	507.91	Example
1'	400	D10	@150	347	D16	@150	270	334.55	Comparative example
2	400	D10	@150	347	D13	@100	347	618.83	Example
2'	400	D10	@150	347	D13	@100	280	420.12	Comparative example

[0074]

- 10 Obtained results are shown in FIG. 16.

It can be seen that the calculated anchorage resistances of No. 1' and No. 2' as comparative examples are lower than those of No. 1 and No. 2 as examples of the present disclosure.

[0075]

- 15 [6. Effects of present embodiment]

As described above, in the joint configuration 29 and the construction method according to the present embodiment, the inventors have intensively studied the positions

of the anchoring portions 42aA and 42aB and the extending portions 42bA and 42bB of the anchoring bars 42A and 42B forming the bundled bars 45 in the floor concrete 37 of the floor slab 28. As a result, it was found that, in a case where the extending portions 42bA and 42bB are disposed at positions different from each other in the up-down direction Z and the anchoring portion 42aA of the first anchoring bar 42A and the anchoring portion 42aB of the second anchoring bar 42B are disposed in a state of being in contact with each other, the anchoring bars 42A and 42B exhibit pullout resistance substantially equivalent to the pullout resistance of bent bar anchorages arranged in one stage (single layer) and used for a column-to-beam joint portion.

Therefore, the joint configuration 29 can include the anchoring bars 42A and 42B that are arranged in multiple layers and have a pullout resistance substantially equivalent to the pullout resistance of bent bar anchorages arranged in a single layer. Further, in the construction method, it is possible to construct the joint configuration 29 including the anchoring bars 42A and 42B that are arranged in multiple layers and have pullout resistance substantially equivalent to the pullout resistance of bent bar anchorages arranged in a single layer and used for a column-to-beam joint portion. Furthermore, since the anchoring bars 42A and 42B are disposed as the bundled bars 45 in which the anchoring bars 42A and 42B are bundled, the wall reinforcing bars 15 and the anchoring bars 42A and 42B of the first wall 11 can be made less likely to interfere with each other.

[0076]

The anchoring portions 42aA and 42aB are disposed at the equivalent position in the abutting direction X (in the construction method, the anchoring portions 42aA and 42aB are disposed at the equivalent position in the abutting direction X). Accordingly, for example, even in a case where the length of the first wall 11 in the abutting direction X is relatively short, the anchoring portions 42aA and 42aB can be disposed in the wall

concrete 14 of the first wall 11.

Furthermore, in a case where a reinforcing bar having the smallest diameter is used for the first anchoring bar 42A among the bent bar anchorages 38 arranged in multiple layers, the extending portion 42bA of the first anchoring bar 42A is disposed at the highest position of the extending portions 42bA and 42bB (in the construction method, the extending portion 42bA of the first anchoring bar 42A is disposed at the highest position of the extending portions 42bA and 42bB). Therefore, it is possible to suppress the occurrence of cracks in the floor concrete 37.

[0077]

The minimum value of the projected anchorage lengths of the anchoring bars 42A and 42B may be $1/2$ or more times or $2/3$ or more times the length of the first wall 11 in the abutting direction X (in the construction method, the plurality of anchoring bars 42A and 42B are constructed such that the minimum value of the projected anchorage lengths of the anchoring bars 42A and 42B is $1/2$ or more times or $2/3$ or more times the length of the first wall 11 in the abutting direction X). Accordingly, even in a case where additional tensile stress acts in the up-down direction Z of the walls 11 and 12 due to a horizontal force caused by a wind load or a seismic force, the plurality of bent bar anchorages 38 can be more reliably anchored to the first wall 11, and the plurality of bent bar anchorages 38 can be caused to yield prior to the concrete failure of the anchoring portion, so that ductile failure caused by the elongation and deformation of the plurality of bent bar anchorages 38 can be induced.

A distance in the orthogonal direction Y between the bundled bars 45 adjacent to each other in the orthogonal direction Y may be six or more times the equivalent reinforcing bar diameter $d_{r,eq}$ (in the construction method, the bundled bars 45 may be constructed such that a distance in the orthogonal direction Y between the bundled bars

adjacent to each other in the orthogonal direction Y is six or more times the equivalent reinforcing bar diameter $d_{r,eq}$). In this case, the plurality of bent bar anchorages 38 can be more reliably anchored to the first wall 11. In addition, for example, a design equation in the related art (an equation assuming a column-to-beam joint portion) disclosed in Document 1 or the like can be easily applied to the joint configuration.

[0078]

[7. Supplementary note]

In the present embodiment, it is desirable to satisfy the following conditions.

In order to prevent cracks in the floor slab 28, it is desirable to reduce the maximum value of the diameter of the bent bar anchorage 38 and to arrange a plurality of bent bar anchorages 38 having a small diameter in a bundled manner. For example, the maximum value of the diameter of the bent bar anchorage 38 is desirably 19 mm or less and more desirably 16 mm or less. Further, from the viewpoint of suppressing cracks and dispersing cracks into a large number of fine cracks to prevent the corrosion of the bent bar anchorages 38, it is desirable that the bent bar anchorages 38 of the highest layer (hereinafter, referred to as the bent bar anchorages 38 of the uppermost layer) have a minimum diameter of 6 mm or more and 13 mm or less and an interval between the bent bar anchorages 38 is set to 200 mm or less. Furthermore, it is desirable that the bent bar anchorages 38 of the uppermost layer are formed of a mesh bar in which the transverse bars are crossed.

[0079]

The diameter and arrangement of the bent bar anchorages 38 other than the bent bar anchorages 38 of the uppermost layer are not particularly limited. However, it is desirable that the bent bar anchorages 38 other than the bent bar anchorages 38 of the uppermost layer have a diameter equivalent to or larger than the diameter of the bent bar

anchorage 38 of the uppermost layer and are arranged at intervals equivalent to or larger than the intervals thereof. For example, a method of forming the bent bar anchorage 38 of the uppermost layer with a 100 mm square-mesh bar using round steel bars of $\phi 6$ and arranging bent bar anchorage 38 of D16 at a pitch of 150 mm in a layer below the uppermost layer is conceivable.

In this case, the round steel bars of $\phi 6$, which are the bent bar anchorage 38 of the uppermost layer, and the bent bar anchorage 38 of D16 are anchored while forming bundled bars at intervals of 300 mm, which is the least common multiple. The round steel bars of $\phi 6$, which are the remaining bent bar anchorage 38 of the uppermost layer, may be anchored to the supporting member (the wall concrete or the like) alone or may not be anchored thereto.

[0080]

It is preferable that two or more times the diameter of the bent bar anchorage 38 of the uppermost layer is secured as the cover thickness of a concrete on the floor slab 28. For example, in a case where the bent bar anchorage 38 provided outdoors or the like are exposed to a harsh environment, it is preferable that about three times the diameter of the bent bar anchorage 38 is secured as the cover thickness of the concrete on the floor slab 28. For example, in an indoor composite beam 25, in a case where the bent bar anchorage 38 of the uppermost layer are formed of a 200 mm square-mesh bar using deformed reinforcing bars of D10 and deformed reinforcing bars of D16 are arranged at a pitch of 200 mm in a layer below the uppermost layer, the cover thickness of a concrete of 20 mm is secured from an outer periphery of the deformed reinforcing bars of D10 of the bent bar anchorage 38 of the uppermost layer to an upper portion. That is, a spacer is disposed below the floor slab 28 at a depth of 25 mm from an upper surface of the floor slab 28 at the center of the diameter of the deformed reinforcing bars

of D10 of the bent bar anchorages 38 of the uppermost layer to secure a cover thickness.

[0081]

In addition, the bent bar anchorages 38 of the lower layer need to be accommodated in the thickness of the floor slab 28. For this reason, an upper limit of the depth of the bent bar anchorages 38 of the lower layer (a distance from the bent bar anchorages 38 of the uppermost layer) is naturally determined by parameters of the thickness of the floor slab 28 and the thickness (height) of the deck plate 36.

Furthermore, it is preferable that the transverse bars are disposed to transmit a shear force from the headed studs (shear connectors) 48 installed on the first flange 31 of the second steel beam 27 to the bent bar anchorages 38 far from the second steel beam 27 among the bent bar anchorages 38 extending along the abutting direction X.

In order to appropriately transmit a force from the transverse bars to the bent bar anchorages 38, it is preferable that not only the bent bar anchorages 38 of the lower layer but also the bent bar anchorages 38 of the uppermost layer are not too far away from the transverse bars. Specifically, with regard to the transverse bars, it is preferable that the transverse bars are arranged within 2 to 3 times the diameter of each of the bent bar anchorage 38 of the uppermost layer or the bent bar anchorage 38 of the lower layer in the up-down direction Z (the thickness direction of the floor slab 28).

[0082]

For example, in a case where the floor slab 28 is a deck composite slab having a thickness of 150 mm and the peak height of the deck plate 36 is 50 mm, the minimum value of the thickness of the floor concrete 37 of the floor slab 28 is 100 mm. A 200 mm square-mesh bar using deformed reinforcing bars of D13 is disposed in the outermost layer of the floor slab 28, and deformed reinforcing bar of D16 are arranged at a pitch of 200 mm in a layer below the outermost layer. In this case, a cover thickness

of the floor concrete 37 of 26 mm is secured from the outer periphery of the deformed reinforcing bars of D13 of the outermost layer to an upper portion.

Further, in a case where a mesh bar is disposed such that the transverse bars of D13 are immediately below D13 of the outermost layer, “a cover thickness of 26 mm +
 5 the diameter of the bar of the outermost layer of 13 mm + the diameter of the transverse bar of 13 mm = 52 mm” is satisfied. Therefore, the thickness of the floor concrete 37 immediately below the transverse bars is 48 mm ($= 100 \text{ mm} - 52 \text{ mm}$) at a minimum. Furthermore, in a case where the bent bar anchorages 38 of the lower layer of D16 are disposed immediately above the peak of the deck plate 36, an interval between the bent
 10 bar anchorage 38 of the lower layer and the transverse bar in the up-down direction Z is 32 mm ($= 48 \text{ mm} - 16 \text{ mm}$). Since 32 mm is two times the diameter of the bent bar anchorage 38 of the lower layer, this satisfies the above-described preferable conditions.
 [0083]

Although the bent bar anchorage 38 is a hook bent at an angle of 90° in the
 15 examples, this bending angle may be set to any angle in a range of 90° to 180° . In any case, in order to prevent failure caused by the drawing of the bent bar anchorages 38, it is preferable that a length L_{dv} of a bent excess portion of a leading end portion of the bent portion (anchoring portion) is set to a length 10 or more times the diameter of each bent bar anchorage 38. From the viewpoint of preventing the local compression failure of
 20 the concrete, it is preferable that the inner diameter of the bent portion is set to six or more times the diameter of the bent bar anchorage 38.

[0084]

Although one embodiment of the present disclosure has been described in detail above with reference to the drawings, specific configurations are not limited to the
 25 embodiment, and modifications, combinations, deletions, and the like in the

configurations may be made without departing from the gist of the present disclosure.

For example, in the embodiment, the supporting member is assumed to be the first wall 11 having the RC structure. However, the supporting member is not limited thereto, and may be a column having the RC structure or a beam having the RC structure.

5 The plurality of floor reinforcing bars may be arranged in three or more layers.

 The composite beam 25 may not include the deck plate 36.

INDUSTRIAL APPLICABILITY

[0085]

 A joint configuration can include bent bar anchorages, which have pullout
10 resistance substantially equivalent to the pullout resistance of bent bar anchorages
 arranged in a single layer and used for a column-to-beam joint portion, using bundled
 bars or bent bar anchorages of reinforcing bars arranged in multiple layers. Further, a
 joint configuration including bent bar anchorages, which have pullout resistance
 substantially equivalent to the pullout resistance of bent bar anchorages arranged in a
15 single layer and used for a column-to-beam joint portion, can be constructed in a
 construction method of a joint configuration. Therefore, great industrial applicability is
 achieved.

REFERENCE SIGNS LIST

[0086]

20	11 First wall (supporting member)
	12 Second wall (supporting member)
	14 Wall concrete (supporting concrete)
	28 Floor slab
	29 Joint configuration
25	37 Floor concrete

38 Bent bar anchorage

42aA, 42aB Anchoring portion

42bA, 42bB Extending portion

45 Bundled bar

5

S1 Virtual plane

X Abutting direction

Y Orthogonal direction (crossing direction)

Z Up-down direction

CLAIMS

[Claim 1] A joint configuration comprising:

a supporting member having an RC structure; and

a floor slab that is abutted against and joined to the supporting member in an

5 abutting direction,

wherein the supporting member includes a supporting concrete,

the floor slab includes

a floor concrete, and

a plurality of bent bar anchorages that are embedded in the supporting concrete

10 and the floor concrete,

each of the bent bar anchorages includes

an anchoring portion that extends along an up-down direction in the supporting concrete, and

an extending portion that extends from an upper end portion of the anchoring

15 portion along the abutting direction in the supporting concrete and the floor concrete,

two or more bent bar anchorages of the plurality of bent bar anchorages form a bundled bar in which the anchoring portions of the two or more bent bar anchorages are disposed in contact with each other, and

one extending portion and another extending portion among the extending

20 portions of the two or more bent bar anchorages forming the bundled bar are disposed at positions different from each other in the up-down direction.

[Claim 2] The joint configuration according to Claim 1,

wherein the anchoring portions of the two or more bent bar anchorages forming the bundled bar are disposed at an equivalent position in the abutting direction.

25 [Claim 3] The joint configuration according to Claim 1 or 2,

wherein the extending portion of the bent bar anchorage, which has a smallest diameter, among the two or more bent bar anchorages forming the bundled bar is disposed at a highest position among the extending portions of the two or more bent bar anchorages.

5 [Claim 4] The joint configuration according to Claim 1 or 2,

wherein a plurality of the bundled bars are provided at intervals in a crossing direction crossing a virtual plane parallel to each of the abutting direction and the up-down direction, and

10 in a case where an equivalent reinforcing bar diameter $d_{r,eq}$ of the bundled bars is defined by Equation (1), a distance in the crossing direction between the bundled bars adjacent to each other in the crossing direction is six or more times the equivalent reinforcing bar diameter $d_{r,eq}$,

here, $d_{r,i}$ is a diameter of an i-th bent bar anchorage among n sets of the two or more bent bar anchorages forming one bundled bar.

15
$$d_{r,eq} = \sqrt{\sum_{i=1}^n (d_{r,i}^2)} \quad \cdot \cdot (1)$$

[Claim 5] A construction method of a joint configuration for constructing a joint configuration including a supporting member having an RC structure, and a floor slab that is abutted against and joined to the supporting member in an abutting direction,

20 wherein the supporting member includes a supporting concrete,
the floor slab includes
a floor concrete, and
a plurality of bent bar anchorages that are embedded in the supporting concrete and the floor concrete,

each of the bent bar anchorages includes

an anchoring portion that extends along an up-down direction in the supporting concrete, and

an extending portion that extends from an upper end portion of the anchoring
5 portion along the abutting direction in the supporting concrete and the floor concrete,

two or more bent bar anchorages of the plurality of bent bar anchorages form a bundled bar in which the anchoring portions of the two or more bent bar anchorages are disposed in contact with each other, and

one extending portion and another extending portion among the extending
10 portions of the two or more bent bar anchorages forming the bundled bar are disposed at positions different from each other in the up-down direction.

[Claim 6] The construction method of a joint configuration according to Claim 5,

wherein the anchoring portions of the plurality of bent bar anchorages forming the bundled bar are disposed at an equivalent position in the abutting direction.

15 [Claim 7] The construction method of a joint configuration according to Claim 5 or 6,

wherein the extending portion of the bent bar anchorage, which has a smallest diameter, among the two or more bent bar anchorages forming the bundled bar is disposed at a highest position among the extending portions of the two or more bent bar anchorages.

20 [Claim 8] The construction method of a joint configuration according to Claim 5 or 6,

wherein a plurality of the bundled bars are constructed to be provided at intervals in a crossing direction crossing a virtual plane parallel to each of the abutting direction and the up-down direction, and

in a case where an equivalent reinforcing bar diameter $d_{r,eq}$ of the bundled bars is
25 defined by Equation (2), the bundled bars are constructed such that a distance in the

crossing direction between the bundled bars adjacent to each other in the crossing direction is six or more times the equivalent reinforcing bar diameter $d_{r,eq}$,

here, $d_{r,i}$ is a diameter of an i -th bent bar anchorage among n sets of the two or more bent bar anchorages forming one bundled bar.

$$d_{r,eq} = \sqrt{\sum_{i=1}^n (d_{r,i}^2)} \quad \cdot \cdot (2)$$

5