

[Document Type] Specification

[Title of the Invention] REINFORCING MEMBER AND BEAM JOINING
STRUCTURE

[Technical Field of the Invention]

[0001]

The present invention relates to a reinforcing member and a beam joining structure.

Priority is claimed on Japanese Patent Application No. 2017-047881, filed on March 13, 2017, the content of which is incorporated herein by reference.

[Related Art]

[0002]

In the related art, in a beam joining structure in which an end portion of a secondary beam (beam) is joined to a primary beam (support member), a joint portion between the secondary beam and the primary beam is generally designed as a rigid joint or pin joint. The definitions of the rigid joint and pin joint are based on European Design Standards (Eurocode 3-Part 1-8).

At the joint portion of the rigid joint, for example, the flange of the secondary beam is welded to or joined using bolts (hereinafter, referred to as bolted) to the primary beam and the web of the secondary beam is bolted to a shear plate provided in the primary beam. On the other hand, at the joint portion of the pin joint, for example, the web of the secondary beam is bolted to the shear plate provided in the primary beam, whereas the flange of the secondary beam is not joined to the primary beam.

[0003]

For example, as a rigid joint, Patent Document 1 listed below discloses a beam joining structure in which an end portion of a beam is installed in a recessed part

provided in a concrete wall, the beam is bolted to the concrete wall via a substrate, and the recessed part is closed by a filling member. In this beam joining structure, since the recessed part formed in the concrete wall is closed by the filling member, there is a problem that the number of processes for beam joint increases.

On the other hand, in order to reduce the number of processes, Non-Patent Document 1 listed below discloses a beam joining structure under a load condition under which no horizontal force is applied to a support member and a beam, in which a contact plate is installed in a gap between the lower flange of the beam which is an H-section steel and the support member, and compressive stress along the horizontal direction is transmitted from the beam to the support member via the contact plate.

[0004]

In addition, Patent Document 2 listed below discloses a coupling structure of a steel framed secondary beam in which steel framed secondary beams adjacent to each other with a steel framed primary beam interposed therebetween can be made into a continuous beam at a low cost with a simple configuration. In this coupling structure, the lower flanges of the steel framed secondary beams adjacent to each other with the steel framed primary beam are joined to each other with a metal touch via the web of the steel framed primary beam, a flange connection member in contact therewith, and a pair of compression materials with these interposed therebetween.

[Prior Art Document]

[Patent Document]

[0005]

[Patent Document 1] Japanese Unexamined Patent Application, First Publication No. H8-42027

[Patent Document 2] Japanese Unexamined Patent Application, First

Publication No. 2005-282019

[Non-Patent Document]

[0006]

[Non-Patent Document 1] “Eurocode 4: Design of composite steel and concrete structures -Part 1-1: General rules and rules for buildings” EUROPEAN COMMITTEE FOR STANDARDIZATION, December 2004, p. 90

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0007]

However, in a case where the construction accuracy between the support member and the beam is not secured, the size of the gap between the support member and the beam sometimes varies depending on the place. Therefore, in the beam joining structure described in Non-Patent Document 1, there is a problem that it is difficult to properly prepare a contact plate of an appropriate size according to the size of the gap.

In addition, in a case of using the compression materials as disclosed in Patent Document 2, there is concern that the compression materials may move upward due to an influence such as vibration during construction or occurrence of an earthquake and temperature change and an appropriate joint state may not be maintained.

[0008]

The present invention has been made in view of the above problems, and an object thereof is to provide a reinforcing member and a beam joining structure capable of reliably joining a support member and a beam to each other regardless of the size of a gap between the support member and the beam and maintaining the joint state.

[Means for Solving the Problem]

[0009]

The summary of the present invention is as follows.

(1) A first aspect of the present invention is a reinforcing member having a tip end disposed in a gap formed between a support member and a beam having one end side in a member axis direction attached to the support member, the reinforcing member including: a main body portion which has a first contact surface in contact with the support member and a second contact surface in contact with an end surface of the beam facing the support member, and is formed so as to cause a separation distance between the first contact surface and the second contact surface in the member axis direction of the beam to decrease toward the tip end; and a separation prevention mechanism which is configured to limit movement of the main body portion by being locked to at least one of the support member and the beam.

(2) In the reinforcing member according to (1), the separation prevention mechanism may be constituted by a plurality of stages of projections protruding from at least one of the first contact surface and the second contact surface.

(3) In the reinforcing member according to (2), the plurality of stages of projections may be formed so as to cause, in a state where the tip end of the reinforcing member is disposed in the gap, an inclination angle ϕ (rad) between a plane including ridges of the projections adjacent to each other and a plane perpendicular to the member axis direction of the beam to satisfy Formula (1).

$$\phi \leq wl^3 / 24EI \dots (1)$$

E: a Young's modulus (N/mm²) of the beam

I: a second moment of area (mm⁴) of the beam

w: an equally distributed load (kN/m) due to a fixed load supported by the beam

l: a length (mm) of the beam

(4) In the reinforcing member according to (2), the plurality of stages of projections may be formed so as to cause, in a state where the tip end of the reinforcing member is disposed in the gap, an inclination angle ϕ (rad) between a plane including ridges of the projections adjacent to each other and a plane perpendicular to the member axis direction of the beam to satisfy Formula (2).

$$\phi \geq \Delta g_b / (h - t_f) \dots (2)$$

Δg_b : an assumed value (mm) of an error of the gap in the member axis direction of the beam

h: a height (mm) of the reinforcing member in a vertical direction

t_f : a plate thickness of a lower flange of the beam in the vertical direction

(5) In the reinforcing member according to any one of (2) to (4), the first contact surface may extend in a direction perpendicular to the member axis direction of the beam, the second contact surface may extend in a direction intersecting the first contact surface, and the plurality of stages of projections may protrude from the second contact surface.

(6) In the reinforcing member according to (1), the separation prevention mechanism may be constituted by a restriction member, and a restriction member insertion hole which is formed so as to allow the restriction member to be inserted through at least one of the first contact surface and the second contact surface of the main body portion.

(7) In the reinforcing member according to (6), the restriction member insertion hole may be formed to penetrate the first contact surface and the second contact surface.

(8) A second aspect of the present invention is a beam joining structure

including: a support member; a beam supported by the support member; and the reinforcing member according to any one of (1) to (7), in which the reinforcing member is disposed in a gap formed between the support member and the beam.

(9) In the beam joining structure according to (8), the support member may be a primary beam supported by a column, the beam may be a secondary beam supported by the support member, and the support member and the beam may be both H-section steels and have same cross-sectional height.

(10) The beam joining structure according to (8) or (9), may further include: a joint member which joins the support member and the beam to each other in a semi-rigid manner or a pinning manner, in which the reinforcing member may transmit a compressive stress to the support member, the compressive stress being generated from the beam toward the support member.

[Effects of the Invention]

[0010]

According to the reinforcing member and the beam joining structure, the support member and the beam can be reliably joined to each other regardless of the size of the gap between the support member and the beam, and furthermore, the joint state can be maintained.

[Brief Description of the Drawings]

[0011]

FIG. 1 is a schematic front view of a building to which a reinforcing member according to a first embodiment of the present invention is applied.

FIG. 2 is a schematic transverse sectional view of the building shown in FIG. 1.

FIG. 3 is a perspective view of a part B shown in FIG. 2.

FIG. 4 is a front view of a beam joining structure including the reinforcing

member according to the first embodiment of the present invention.

FIG. 5 is a perspective view showing a part of the beam joining structure shown in FIG. 4.

FIG. 6 is a perspective view of the beam joining structure shown in FIG. 5 viewed from below.

FIG. 7A is a perspective view of a reinforcing member according to a second embodiment of the present invention.

FIG. 7B is a front view showing a state where the reinforcing member shown in FIG. 7A is disposed in a gap.

FIG. 8A is a perspective view of a reinforcing member according to a first modification example.

FIG. 8B is a front view showing a state where the reinforcing member shown in FIG. 8A is disposed in a gap.

FIG. 9A is a perspective view of a reinforcing member according to a second modification example.

FIG. 9B is a front view showing a state where the reinforcing member shown in FIG. 9A is disposed in a gap.

FIG. 9C is a schematic view showing an inclination angle ϕ of the reinforcing member according to the second modification example.

FIG. 10 is a perspective view showing a beam joining structure according to a third embodiment of the present invention.

FIG. 11 is a supplementary view showing dimensions of a reinforcing member.

FIG. 12 is a supplementary view showing a configuration in a case where a height of a cross section of a primary beam is larger than a height of a cross section of a secondary beam.

[Embodiments of the Invention]

[0012]

(First Embodiment)

A reinforcing member 51 according to a first embodiment of the present invention is applied to a building 1 having a beam joining structure 2 as shown in FIGS. 1 and 2. In FIGS. 1 and 2, only the frame structure of the building 1 is shown, and a core wall 10, which will be described later, is hatched.

[0013]

The building 1 has the core wall 10, columns 11, primary beams (support members) 21, secondary beams (beams) 31, and floor slabs 41.

The core wall 10 is disposed, for example, at the center of the building 1 in a plan view and extends along an up-down direction. For example, in the core wall 10, an elevator, a staircase, and the like (not shown) are disposed. The columns 11 are disposed so as to surround the core wall 10 and extends along the up-down direction. The primary beams (support members) 21 extend from the columns 11 along a horizontal plane. The secondary beams (beams) 31 extend from the primary beams 21 along the horizontal plane. Here, FIG. 3 is a perspective view of a part B indicated by the two-dot chain line in FIG. 2. As shown in FIG. 3, the floor slab 41 is joined to the upper sides of the primary beams 21 and the secondary beams 31. The primary beams 21 and the secondary beams 31 may be inclined with respect to the horizontal plane.

The building 1 is, for example, a high-rise building having a plurality of stories, and the core wall 10 is formed in a rectangular tubular shape having a side length of several tens of meters in the plan view. The core wall 10 is a reinforced concrete (RC) structure formed by disposing reinforcing bars in concrete and the like.

[0014]

As shown in FIG. 3, one end portion of a first shear plate 14 is fixed to the core wall 10. An end portion of the primary beam 21 is joined to the other end portion of the first shear plate 14 by bolts, welding, or the like. Accordingly, the first shear plate 14 joins the primary beam 21 to the core wall 10 in a semi-rigid manner.

[0015]

Here, the semi-rigid joint is a joint type in which the bending moment transmitted between the core wall 10 (support member) and the primary beam 21 (beam) is small and the rotational movement of the primary beam 21 with respect to the core wall 10 is restricted to some extent. In addition, the pin joint refers to a joint type in which there is no or minimal bending moment transmitted between the core wall 10 and the primary beam 21, and the rotational movement of the primary beam 21 with respect to the core wall 10 is not restricted. The definitions of the semi-rigid joint, pin joint, and rigid joint are based on European Design Standards (Eurocode 3-Part 1-8). The rigid joint has infinite rotational stiffness, the pin joint has zero rotational stiffness, and the semi-rigid joint has finite rotational stiffness.

[0016]

The following description is provided focusing on, among the configurations of the building 1, the primary beam 21, the secondary beam 31 having one end side in a member axis direction attached to the primary beam 21, and the floor slab 41 joined to the secondary beam 31.

The beam joining structure 2 is configured to have the primary beam 21, the secondary beam 31, and the floor slab 41. As shown in FIG. 4, the floor slab 41 is produced by placing concrete on a deck plate 42 disposed on the primary beam 21 and the secondary beam 31.

[0017]

As the primary beam 21, for example, H-section steel is used. An upper flange 23 is formed on a web 22 in the primary beam 21. A lower flange 24 is formed under the web 22.

A plurality of the primary beams 21 extend in directions orthogonal to each other along the horizontal plane. Hereinafter, the member axis direction of the primary beam 21 and the following direction are referred to as a first direction X, a substantially horizontal direction orthogonal to the member axis direction of the primary beam 21 and following the direction are referred to as a second direction Y. A direction orthogonal to the first direction X and the second direction Y and the following direction (vertical direction) are referred to as a third direction Z. In the following description, the primary beam 21 extending from the core wall 10 will be mainly described.

[0018]

As shown in FIG. 4, a second shear plate 25 (joint member) is fixed to the primary beam 21 by welding or the like. In the shown example, the second shear plate 25 protrudes from the primary beam 21 in the second direction Y. In the second shear plate 25, a plurality of through-holes 25a are formed in a row along the up-down direction. Each of the through-hole 25a penetrates the second shear plate 25 in the first direction X.

[0019]

As the secondary beam 31, for example, H-section steel is used. An upper flange 33 is formed on a web 32 in the secondary beam 31. A lower flange 34 is formed under the web 32.

The secondary beam 31 is disposed so as to extend along the second direction

Y is in a natural state where a bending moment due to an external force or gravity does not act on the secondary beam 31. When a bending moment due to an external force or gravity acts on the secondary beam 31, the secondary beam 31 bends so as to protrude downward along a reference plane S including the second direction Y and the third direction Z.

[0020]

As shown in FIG. 4, in each end portion of the web 32 of the secondary beam 31, a plurality of bolt holes 36 are arranged side along the up-down direction. These bolt holes 36 are formed at positions corresponding to the through-holes 25a of the second shear plate 25. By disposing bolt or the like (not shown) in the bolt holes 36 and the through-holes 25a, the second shear plate 25 can transmit a shear force and a bending moment generated in a direction from the secondary beam 31 toward the primary beam 21 to the primary beam 21. Accordingly, the second shear plate 25 joins the secondary beam 31 to the primary beam 21 in a semi-rigid manner.

[0021]

In the beam joining structure 2, the cross-sectional heights (beam depths) of the primary beam 21 and the secondary beam 31 are the same. Here, the cross-sectional height represents the dimension in the up-down direction between the outer surface facing upward in the upper flange of the H-section steel and the outer surface facing downward in the lower flange. Since the deck plate 42 is placed on the primary beam 21 and the secondary beam 31, the positions of the outer surfaces of the upper flange 23 of the primary beam 21 and the upper flange 33 of the secondary beam 31 facing upward in the up-down direction are coincident with each other.

[0022]

As shown in FIGS. 3 to 6, in the beam joining structure 2, the reinforcing

member 51 (also referred to as a contact plate) according to this embodiment is provided in a state where the tip end thereof is interposed in a gap K between the primary beam 21 and the secondary beam 31 supported by the primary beam 21.

The reinforcing member 51 is disposed, in the gap K, at a part located below a neutral axis C1 of the cross section of the secondary beam 31 and located between the lower flange 24 of the primary beam 21 and the lower flange 34 of the secondary beam 31. In the shown example, the reinforcing member 51 is interposed in a part located on one side in the first direction X with respect to the second shear plate 25 between the lower flange 24 of the primary beam 21 and the lower flange 34 of the secondary beam 31.

The neutral axis C1 is a neutral axis for compressive load and tensile load acting in the second direction Y direction between the secondary beam 31 and the primary beam 21 when a bending moment generated at the end portion of the secondary beam 31 due to a load acting on the secondary beam 31 is transmitted to the primary beam 21, and in the shown example, is a center line of the secondary beam 31 in the up-down direction as viewed from the first direction X in a front view.

[0023]

As shown in FIG. 4, the reinforcing member 51 has a main body portion 511 and a separation prevention mechanism (a restriction member 54A and a restriction member insertion hole 54B). The material of the reinforcing member 51 is not particularly limited, and a metal such as steel is exemplified.

[0024]

The main body portion 511 has a first contact surface 511a which is in contact with the primary beam 21 (support member) and a second contact surface 511b which is in contact with the end surface of the secondary beam 31 (beam) facing the primary

beam 21.

The main body portion 511 has a base end surface 511c and a tip end surface 511d which connect the end edges of the first contact surface 511a and the second contact surface 511b in the third direction Z to each other. In a state where the reinforcing member 51 is installed in the gap K, the dimension of the base end surface 511c in the second direction Y is larger than the dimension of the tip end surface 511d in the second direction Y.

In the following description, with reference to the gap K in which the reinforcing member 51 is installed, the side on which the base end surface 511c is located is referred to as a base end side, and the opposite side thereof is referred to as a tip end side.

[0025]

The main body portion 511 is formed so that the separation distance in the second direction Y between the first contact surface 511a and the second contact surface 511b on the base end side is larger than the separation distance in the second direction Y between the first contact surface 511a and the second contact surface 511b on the tip end side.

More specifically, the main body portion 511 has a tapered shape such that the separation distance between the first contact surface 511a and the second contact surface 511b gradually decreases in the second direction Y from the base end side toward the tip end side. That is, the main body portion 511 is formed such that the separation distance in the second direction Y (width direction) gradually decreases from the base end surface 511c toward the tip end side.

[0026]

Therefore, in the main body portion 511 of the reinforcing member 51, the

second contact surface 511b is a wedge surface inclined with respect to the extension direction of the first contact surface 511a. In the main body portion 511, the first contact surface 511a extends in the vertical direction in a state of being disposed in the gap K of the main body portion 511.

[0027]

Here, in a state where the reinforcing member 51 is disposed in the gap K, an inclination angle ϕ between the second contact surface 511b and a plane perpendicular to the second direction Y is preferably more than 0 (rad) and is more preferably $\Delta g_b / (h - t_f)$ or more.

Here, Δg_b is an assumed value (mm) of the error of the length (gap dimension) in the direction along the second direction Y of the gap K caused by construction error. As shown in FIG. 11, h is the height (mm) of the reinforcing member 51 in the direction along the third direction Z, and t_f is the dimension (plate thickness) of the lower flange 34 of the secondary beam 31 in the Z direction. In FIG. 11, the lower flange of the beam is indicated by the two-dot chain lines.

For example, Δg_b is a construction error which can occur at the joint portion between the secondary beam 31 and the second shear plate 25 and is equal to the difference in diameter between the bolt hole 36 and the shaft portion (not shown) of the bolt, or the difference in diameter between the through-hole 25a and the shaft portion (not shown) of the bolt. Given that the position of the primary beam 21 is the reference and the gap dimension when the center of the bolt hole 36 in the direction along the second direction Y and the center of the shaft portion (not shown) of the bolt are coincident with each other is defined as the standard gap dimension, there is a possibility that the gap dimension varies within a range of the standard gap dimension $\pm \Delta g_b/2$ due to construction error.

The difference between the length of the surface 511c of the reinforcing member 51 on the base end side and the length of the surface 511d on the tip end side in the direction along the second direction Y is at least $\Delta g_b + \phi \times t_f$, and when the length of the surface 511d on the tip end side in the direction along the second direction Y is the same as the assumed minimum value of the gap dimension (standard gap dimension - $\Delta g_b/2$), even in a case where the gap dimension varies within a range of the standard gap dimension $\pm \Delta g_b/2$ due to the construction error, transmission of compressive force through contact is possible. This is because by adjusting the insertion amount of the reinforcing member 51 into the gap K in the third direction Z, both the contact between the first contact surface 511a of the reinforcing member 51 and the lower flange 24 of the primary beam 21 and the contact between the second contact surface 511b of the reinforcing member 51 and the lower flange 34 of the secondary beam 31 can be reliably achieved.

That is, when ϕ is at least $\Delta g_b / (h - t_f)$, even in a case where the gap dimension varies, it is possible to transmit compressive force by disposing the reinforcing member 51. Hereinafter, $\Delta g_b / (h - t_f)$ is referred to as a recommended lower limit value $\phi_{l,req}$ (rad) of the inclination angle of the wedge surface of the reinforcing member.

[0028]

The separation prevention mechanism is a mechanism for suppressing movement of the main body portion 511 in a direction from the tip end side toward the base end side. As shown in FIGS. 4 and 6, the separation prevention mechanism of the beam joining structure 2 according to this embodiment includes the restriction member 54A and the restriction member insertion hole 54B which is formed in the main body portion 511 so as to allow the restriction member 54A to be inserted

therethrough.

[0029]

The restriction member 54A is a wedge-shaped plate material having front and rear surfaces directed in the up-down direction and having a lower surface inclined with respect to the lower surfaces of the lower flanges 24 and 34 of the primary beam 21 and the secondary beam 31. The restriction member 54A is inserted through the restriction member insertion hole 54B in a state where the main body portion 511 is disposed in the gap K, and both end portions thereof protruding from the openings of the restriction member insertion hole 54B are locked to the lower surface of the lower flange 24 of the primary beam 21 and the lower surface of the lower flange 34 of the secondary beam 31 from above. That is, both end portions of the restriction member 54A in the second direction Y protrude from the restriction member insertion hole 54B toward both sides in the second direction Y, and the both end portions are respectively locked to the primary beam 21 and the secondary beam 31. Accordingly, the separation of the main body portion 511 from the gap K is suppressed.

[0030]

The restriction member insertion hole 54B is formed so as to penetrate the first contact surface 511a and the second contact surface 511b of the main body portion 511 and has an upper surface 54B1 and a lower surface 54B2.

The upper surface 54B1 of the restriction member insertion hole 54B is formed so as to be disposed above (on the base end side) the lower surface of the lower flange 34 of the secondary beam 31 in a state where the main body portion 511 is disposed in the gap K.

The lower surface 54B2 of the restriction member insertion hole 54B is formed so as to be disposed below (on the tip end side) the lower surface of the lower

flange 34 of the secondary beam 31 in a state where the main body portion 511 is disposed in the gap K.

According to the restriction member insertion hole 54B formed as described above, by adjusting the inclination angle and insertion amount of the lower surface of the wedge-shaped restriction member 54A, it becomes possible to reliably join the primary beam 21 and the secondary beam 31 to each other and maintain the joint state regardless of the distance of the gap K.

[0031]

In the reinforcing member 51 according to this embodiment, both ends of the restriction member 54A protruding from the openings of the restriction member insertion hole 54B are locked to the primary beam 21 and the secondary beam 31. However, only one end of the restriction member 54A may protrude from the opening and be locked to any one of the primary beam 21 and the secondary beam 31.

In the reinforcing member 51 according to this embodiment, the restriction member insertion hole 54B is formed so as to penetrate the first contact surface 511a and the second contact surface 511b. However, the restriction member insertion hole 54B may not necessarily penetrate the main body portion 511 as long as the restriction member 54A is locked to any of the support member (primary beam 21) and the beam (secondary beam 31).

That is, a restriction member insertion hole which is formed so as to allow the restriction member 54A to be inserted through any one of the first contact surface 511a and the second contact surface 511b may be formed.

The restriction member 54A does not necessarily need to have a wedge shape, and various shapes such as a flat plate shape or a straight bar shape, a bolt, and the like can be used as long as the restriction member 54A is locked to the support member

(primary beam 21) or the beam (secondary beam 31) in a state of being inserted into the restriction member insertion hole 54B.

[0032]

The beam joining structure 2 using the reinforcing member 51 according to this embodiment is constructed by performing the following steps.

First, an operator disposes the secondary beam 31 so as to extend from the primary beam 21 along the horizontal plane (secondary beam disposing step).

Next, by inserting bolts or the like into the through-holes 25a formed in the primary beam 21 and the bolt holes 36 formed in the secondary beam 31, the end portions of the primary beam 21 and the secondary beam 31 are joined to each other (joining step).

Next, the main body portion 511 of the reinforcing member 51 is inserted into the gap K between the primary beam 21 and the secondary beam 31 from the upper side toward the lower side (main body portion insertion step).

Next, the restriction member 54A is inserted into the restriction member insertion hole 54B formed in the main body portion 511 (restriction member insertion step).

Then, the deck plate 42 is disposed on the primary beam 21 and the secondary beam 31 and concrete is placed on the deck plate 42, thereby forming the floor slab 41 on the secondary beam 31 (floor slab placing step).

By performing the above steps, the beam joining structure 2 is constructed.

[0033]

When a bending moment acts on the secondary beam 31 as the load of the floor slab 41 of the beam joining structure 2 configured as described above is applied to the secondary beam 31, the secondary beam 31 is bent to protrude downward on the

reference plane S. This bending moment is a bending moment around the axis along the first direction X.

At this time, in a part located above the neutral axis C1 in the joint part between the secondary beam 31 and the primary beam 21, a tensile stress is generated to pull the primary beam 21 from both ends toward the center side in the second direction Y (member axis direction, longitudinal direction). In a part located below the neutral axis C1 in the joint part between the secondary beam 31 and the primary beam 21, a compressive stress is generated to compress the primary beam 21 from the center toward both end sides in the second direction Y. Furthermore, a tensile stress is transmitted from the secondary beam 31 to the primary beam 21 by the floor slab 41. In addition, by the reinforcing member 51 disposed between the primary beam 21 and the secondary beam 31, a compressive stress is transmitted from the secondary beam 31 to the primary beam 21.

[0034]

As described above, according to the beam joining structure 2 of this embodiment, since the tip end of the reinforcing member 51 is disposed in the gap K between the primary beam 21 and the secondary beam 31, the joint between the primary beam 21 and the secondary beam 31 can be reinforced and the rotational stiffness thereof can be increased. In addition, in the reinforcing member 51, since the separation distance between the first contact surface and the second contact surface on the base end side is larger than the separation distance between the first contact surface and the second contact surface on the tip end side, even in a case where the construction accuracy of the primary beam 21 is low and the size of the gap K between the primary beam 21 and the secondary beam 31 varies depending on the place, by adjusting the insertion amount of the reinforcing member 51 into the gap K, the size of

the main body portion 511 of the reinforcing member 51 in the second direction Y can be changed according to the size of the gap K. In a case where the reinforcing member 51 has a tapered shape having a size gradually decreasing in the second direction Y from the base end side toward the tip end side, the effect can be more reliably obtained.

As described above, regardless of the size of the gap K between the primary beam 21 and the secondary beam 31, the primary beam 21 and the secondary beam 31 can be reliably joined to each other.

Then, the reinforcing member 51 disposed in the gap K, even if an external force is applied to the primary beam 21 and the secondary beam 31, the compressive stress can be reliably transmitted from the secondary beam 31 to the primary beam 21 via the reinforcing member 51.

[0035]

Furthermore, in a case where the reinforcing member 51 is inserted from above with respect to the gap K, even if an external force is applied to the primary beam 21 and the secondary beam 31 and the gap K between the primary beam 21 and the secondary beam 31 greatly changes, the main body portion 511 of the reinforcing member 51 moves downward due to the self-weight. Accordingly, the gap K between the primary beam 21 and the secondary beam 31 can be appropriately filled, so that the compressive stress from the secondary beam 31 can be reliably transmitted to the primary beam 21 via the reinforcing member 51.

[0036]

The separation prevention mechanism that limits the separation of the main body portion 511 from the gap K is realized by inserting the restriction member 54A into the restriction member insertion hole 54B formed in the main body portion 511.

Therefore, even if an external force is applied to the reinforcing member 51 in a direction to be separated from the gap K by the external force applied to the primary beam 21 and the secondary beam 31, the separation of the main body portion 511 of the reinforcing member 51 from the gap K can be suppressed by the separation prevention mechanism. Therefore, the joint between the primary beam 21 and the secondary beam 31 can be maintained.

In particular, in a case where the restriction member 54A is locked to both the primary beam 21 and the secondary beam 31, it is possible to more reliably restrict the movement of the reinforcing member 51 in a direction so as to be separated from the gap K. Therefore, the separation of the reinforcing member 51 from the gap K can be reliably suppressed.

Furthermore, the restriction member 54A is a wedge-shaped plate material in which, when the restriction member 54A is disposed so that the front and rear surfaces are directed in the up-down direction and the upper surface is parallel to the lower surfaces of the lower flanges 24 and 34 of the primary beam 21 and the secondary beam 31, the lower surface is inclined with respect to the lower surfaces of the lower flanges 24 and 34 of the primary beam 21 and the secondary beam 31. Therefore, the insertion amount of the reinforcing member 51 can be adjusted by the insertion amount in the second direction Y (member axis direction, longitudinal direction), and the gap K between the lower flanges 24 and 34 of the primary beam 21 and the secondary beam 31 can be reliably filled with the reinforcing member 51. Therefore, the compressive stress from the secondary beam 31 can be reliably transmitted to the primary beam 21 via the reinforcing member 51.

[0037]

Since both the primary beam 21 and the secondary beam 31 are H-section

steels and have the same cross-sectional height, for example, in a case where the primary beam 21 and the secondary beam 31 are joined to each other so that the height positions of the upper surfaces of the upper flanges 23 and 33 are flush with each other, when the gap K is provided between the respective lower flanges 24 and 34 of the primary beam 21 and the secondary beam 31, the lower flanges 24 and 34 can be caused to face each other with the gap K interposed therebetween. Therefore, by disposing the reinforcing member 51 in the gap K between the lower flanges 24 and 34 facing each other as described above, the primary beam 21 and the secondary beam 31 can be reliably joined to each other.

[0038]

In addition, since the compressive stress generated from the secondary beam 31 toward the primary beam 21 can be transmitted to the primary beam 21 by the reinforcing member 51, the rotational stiffness against the moment generated by the load received by the secondary beam 31 can be increased, and the joint between the primary beam 21 and the secondary beam 31 can be brought close to a rigid joint state.

[0039]

(Second Embodiment)

Next, a reinforcing member 52 according to a second embodiment of the present invention will be described with reference to FIGS. 7A to 9C.

[0040]

Like the reinforcing member 51 according to the first embodiment, the reinforcing member 52 according to this embodiment is applied to the building 1 having the beam joining structure 2 as shown in FIGS. 1 and 2. A main body portion 521 of the reinforcing member 52 includes a first contact surface 521a extending along a plane perpendicular to the second direction Y, a second contact surface 521b

extending in a direction intersecting the plane perpendicular to the second direction Y. That is, the main body portion 521 is formed so that the distance between the first contact surface 521a and the second contact surface 521b on the base end side is larger than the distance between the first contact surface 521a and the second contact surface 521b on the tip end side.

Furthermore, the main body portion 521 has a base end surface 521c and a tip end surface 521d which connect the end edges of the first contact surface 521a and the second contact surface 521b in the third direction Z to each other.

In the reinforcing member 52 according to this embodiment, the configuration of the separation prevention mechanism is different from that of the reinforcing member 51 described above. In the following description, like members or portions having the same configuration are denoted by like reference numerals, and overlapping descriptions will be omitted.

[0041]

As shown in FIGS. 7A and 7B, the separation prevention mechanism of the reinforcing member 52 according to this embodiment is constituted by projections 55 protruding from the second contact surface 521b of the main body portion 521 in a plurality of stages on. The projections 55 are continuously formed linearly along the first direction X. Further, the plurality of stages of projections 55 protrude so as to form a plurality of steps from the base end side toward the tip end side.

The projections 55 of the adjacent stages form recessed grooves that are recessed toward the inner side of the reinforcing member 52 in the second direction Y (the main body portion 521 side). Therefore, in a case where the projections 55 are formed over n stages, (n - 1) recessed grooves are formed along the first direction X.

The projections 55 may be formed along a direction intersecting the first

direction X at a predetermined angle, or may be formed intermittently.

[0042]

The plurality of stages of projections 55 protrude from the second contact surface 521b of the main body portion 521 and as shown in FIG. 7B, are locked to the secondary beam 31 to suppress movement of the main body portion 521 toward the base end side.

[0043]

As shown in FIG. 7B, the plurality of stages of projections 55 protruding from the second contact surface 521b are locked to the secondary beam 31 in a state where the main body portion 521 is disposed in the gap K. Accordingly, the separation of the main body portion 521 from the gap K between the primary beam 21 and the secondary beam 31 is suppressed.

[0044]

Each of the projections 55 has a base end side contact surface 55a which obliquely faces the base end side of the reinforcing member 52, and a tip end side contact surface 55b which faces the tip end side of the reinforcing member 52.

In the reinforcing member 52, when viewed in the first direction X, the base end side contact surface 55a is formed to be inclined with respect to the third direction Z, and the tip end side contact surface 55b is formed along the second direction Y.

The base end side contact surface 55a is a surface with which the ridge between the lower surface and the side surface of the lower flange 34 of the secondary beam 31 comes into contact, the surface extending from the tip end side toward the base end side gradually inward in the second direction Y (toward the inner side of the main body portion 521).

The tip end side contact surface 55b is a surface with which the upper surface

of the lower flange 34 of the secondary beam 31 comes into contact, the surface being connected to the base end side contact surface 55a via the ridge. The tip end side contact surface 55b may face the upper surface of the lower flange 34 with a gap therebetween.

[0045]

As described above, the base end side contact surface 55a is the surface with which the boundary line between the lower surface and the side surface of the lower flange 34 of the secondary beam 31 comes into contact, and the tip end side contact surface 55b is the surface with which the upper surface of the lower flange 34 of the secondary beam 31 comes into contact. Therefore, the separation distance between the ridges of the projections 55 of adjacent stages in the third direction Z is set to be larger than the plate thickness of the lower flange 34.

[0046]

According to the reinforcing member 52 configured as described above, when an external force is applied to the main body portion 521 so as to cause the main body portion 521 to be moved upward and separated from the gap K, the base end side contact surface 55a is caught on and locked to the end edge of the lower flange 34. Therefore, the separation of the main body portion 521 from the gap K between the primary beam 21 and the secondary beam 31 can be suppressed by the projection 55 on the second contact surface 521b side.

[0047]

In a case where the reinforcing member 52 is inserted from above with respect to the gap K, even if an external force is applied to the primary beam 21 and the secondary beam 31 and the gap K between the primary beam 21 and the secondary beam 31 greatly changes, the main body portion 521 of the reinforcing member 52

moves downward due to the self-weight. Accordingly, the gap K between the primary beam 21 and the secondary beam 31 can be appropriately filled with the projection 55 of the base end side stage of the reinforcing member 52, so that the compressive stress from the secondary beam 31 can be reliably transmitted to the primary beam 21 via the reinforcing member 52.

[0048]

As described above, since the reinforcing member 52 according to this embodiment has the projections 55 on the second contact surface 521b side as the separation prevention mechanism, an increase in the number of components can be suppressed, for example, compared to a configuration using a member other than the main body portion for separation prevention, so that a simple configuration can be achieved.

In this embodiment, as the separation prevention mechanism, only the projections 55 on the second contact surface 521b side, which protrude from the second contact surface 521b of the main body portion 521 and are locked to the secondary beam 31 to suppress the movement of the main body portion 521 toward the base end side are provided. However, instead of the projections on the second contact surface 521b side, only projections on the first contact surface 521a side, which protrude from the first contact surface 521a of the main body portion 521 and are locked to the primary beam 21 to suppress the movement of the main body portion 521 toward the base end side may be provided. Alternatively, both the projections on the first contact surface 521a side and the projections on the second contact surface 521b side may be provided.

[0049]

(First Modification Example)

FIGS. 8A and 8B show a first modification example of the reinforcing member 52 according to the second embodiment. In the first modification example, the separation prevention mechanism is constituted by a plurality of stages of projections 56 protruding from the second contact surface 521b of the main body portion 521.

Each of the projections 56 has a base end side contact surface 56a which obliquely faces the base end side of the reinforcing member 52, and a tip end side contact surface 56b which faces the tip end side of the reinforcing member 52.

[0050]

In the reinforcing member 52 according to the first modification example, when viewed in the first direction X, the base end side contact surface 56a is formed along the second direction Y, and the tip end side contact surface 55b is formed to be inclined with respect to the third direction Z.

The base end side contact surface 56a is a surface with which the lower surface of the lower flange 34 of the secondary beam 31 comes into contact, the surface being connected to the tip end side contact surface 56b via the ridge.

The tip end side contact surface 56b is a surface with which the boundary line between the upper surface and the side surface of the lower flange 34 of the secondary beam 31 comes into contact, the surface extending from the base end side toward the tip end side gradually inward in the second direction Y (toward the inner side of the main body portion 521). The tip end side contact surface 56b may face the upper surface of the lower flange 34 with a gap therebetween.

[0051]

According to the reinforcing member 52 according to the first modification example, when an external force is applied to the main body portion 521 so as to cause

the main body portion 521 to be moved upward and separated from the gap K, the base end side contact surface 56a is caught on and locked to the lower surface of the lower flange 34. Therefore, the separation of the main body portion 521 from the gap K between the primary beam 21 and the secondary beam 31 can be suppressed by the projection 56 on the second contact surface 521b side.

[0052]

(Second Modification Example)

FIGS. 9A to 9C show a second modification example of the reinforcing member 52 according to the second modification example. In the second modification example, the separation prevention mechanism is constituted by a plurality of stages of projections 57 protruding from the second contact surface 521b of the main body portion 521.

Like the projections 55 of the reinforcing member 52 according to the second embodiment, each of the projections 57 has a base end side contact surface 57a which obliquely faces the base end side of the reinforcing member 52, and a tip end side contact surface 57b which faces the tip end side of the reinforcing member 52.

In the reinforcing member 52 according to the second modification example, the separation distance between the tip ends of the projections 57 of adjacent stages in the third direction Z is set to be smaller than the plate thickness of the lower flange 34.

In the reinforcing member 52 according to the second modification example, when viewed in the first direction X, the base end side contact surface 57a is formed to be inclined with respect to the third direction Z, and the tip end side contact surface 57b is formed along the second direction Y.

As shown in FIG. 9C, the base end side contact surface 57a is a portion with which the boundary line between the lower surface and the side surface of the lower

flange 34 of the secondary beam 31 comes into contact when deflection occurs in the secondary beam 31 due to the self-weight or an external force applied in the vertical direction. The base end side contact surface 57a extends from the tip end side toward the base end side gradually inward in the second direction Y (toward the inner side of the main body portion 521).

The tip end side contact surface 57b is a surface with which the upper surface of the lower flange 34 of the secondary beam 31 comes into contact, the surface being connected to the base end side contact surface 55a via the ridge. The tip end side contact surface 57b may face the upper surface of the lower flange 34 with a gap therebetween. As shown in FIG. 9C, the tip end side contact surface 57b is also a surface with which the boundary line between the upper surface and the side surface of the secondary beam 31 comes into contact when deflection occurs in the secondary beam 31 due to the self-weight or an external force applied in the vertical direction.

[0053]

In addition, as shown in FIG. 9C, when deflection occurs in the secondary beam 31 due to the self-weight or an external force applied in the vertical direction, the ridge between the base end side contact surface 57a and the tip end side contact surface 57b is deformed so as to be crushed in a direction toward the inside of the main body portion 521.

[0054]

According to the reinforcing member 52 according to the second modification example, when deflection occurs in the secondary beam 31 due to the self-weight or an external force applied in the vertical direction, the base end side contact surface 57a is caught on and locked to the end edge of the lower flange 34. Therefore, the separation of the main body portion 521 from the gap K between the primary beam 21

and the secondary beam 31 can be suppressed by the projections 57 on the second contact surface 521b side.

[0055]

It is preferable that the plurality of stages of projections 57 are formed so that in a state where the reinforcing member 52 is disposed in the gap K, an inclination angle ϕ (rad) between a plane including the ridges of the plurality of stages of projections and a plane perpendicular to the member axis direction of the secondary beam 31 satisfies Formula (1).

$$\phi \leq wl^3 / 24EI \dots (1)$$

Here, E is the Young's modulus (N/mm²) of the secondary beam 31, I is the second moment of area (mm⁴) of the secondary beam 31, w is the equally distributed load (kN/m) due to a fixed load supported by the secondary beam 31, and l is the length (mm) of the secondary beam 31. w is an equally distributed load due to a fixed load shared by the secondary beams 31. For example, in a case where a secondary beam 31A in FIG. 2 is targeted, the region A indicated by the one-dot chain line in FIG. 2 is taken as a dominated area shared by the secondary beam 31A, the masses of the secondary beam 31A, the deck plate 42, the floor slab 41, reinforcing bars (not shown) in the floor slab, and finishing materials (not shown) in the region A are calculated, and a value obtained by dividing the product of the total mass and the gravitational acceleration by the dominated area is used. The region A is a region surrounded by boundaries which are the middle portions between the secondary beams 31 adjacent to the secondary beam 31A and the edge of the floor slab. The mass is obtained by obtaining the volume (m³) of each of the secondary beam 31A, the deck plate 42, the floor slab 41, the reinforcing bars (not shown) in the floor slab, and the finishing materials (not shown) in the region A and multiplying the volume by the density

(kg/m³) of the corresponding material.

[0056]

Before the concrete of the floor slab 41 is hardened, the joint portion is pinned. Therefore, the rotation angle of the joint portion of the pinned secondary beam is obtained by $wl^3/24EI$. Therefore, in a case where the inclination angle ϕ is $wl^3/24EI$ (rad) or less, as shown in FIG. 9C, when deflection occurs in the secondary beam 31 due to the self-weight or an external force applied in the vertical direction, the base end side contact surface 57a can be reliably caught on and locked to the end edge of the lower flange 34. Therefore, by forming the plurality of stages of projections 57 so as to satisfy Formula (1), the separation of the main body portion 521 from the gap K between the primary beam 21 and the secondary beam 31 can be suppressed. Hereinafter, $wl^3/24EI$ is referred to as a recommended upper limit value $\phi_{u,req}$ (rad) of the inclination angle of the wedge surface of the reinforcing member.

The recommended upper limit value $\phi_{u,req}$ (rad) indicates the upper limit of a desirable inclination angle for locking the projection to the lower flange, and is an index independent from the recommended lower limit value $\phi_{l,req}$ (rad). Therefore, the recommended upper limit value $\phi_{u,req}$ (rad) is not necessarily larger than the recommended lower limit value $\phi_{l,req}$ (rad).

[0057]

Regarding the inclination angle ϕ of the reinforcing member 52 according to this embodiment, the inclination angle between the second contact surface 511b and the plane perpendicular to the second direction Y is preferably more than 0 (rad), and more preferably satisfy Formula (2).

$$\phi \geq \Delta g_b / (h - t_f) \dots (2)$$

Here, Δg_b is an assumed error (mm) of the gap caused by construction error.

In addition, h is the height of the reinforcing member in the Z direction (the distance between the surface 511c on the base end side and the surface 511d on the tip end side). For example, Δg_b is a construction error which can occur at the joint portion between the secondary beam 31 and the second shear plate 25 and is equal to the difference in diameter between the bolt hole 36 and the shaft portion (not shown) of the bolt, or the difference in diameter between the through-hole 25a and the shaft portion (not shown) of the bolt.

Even in a case where the gap dimension varies within a range of the standard gap dimension $\pm \Delta g_b/2$ due to the construction error, by adjusting the insertion amount of the reinforcing member 51 into the gap K in the third direction Z , both the contact between the first contact surface 511a of the reinforcing member 51 and the lower flange 24 of the primary beam 21 and the contact between the second contact surface 511b of the reinforcing member 51 and the lower flange 34 of the secondary beam 31 can be reliably achieved, so that transmission of compressive force through contact is possible. Therefore, the recommended lower limit value $\phi_{l,req}$ (rad) of the inclination angle of the wedge surface of the reinforcing member can be set to $\Delta g_b / (h-t_f)$.

[0058]

(Third Embodiment)

Next, a beam joining structure 2' according to a third embodiment of the present invention will be described with reference to FIG. 10. In this embodiment, like members or portions described in the first embodiment and the second embodiment described above are denoted by like reference numerals, the descriptions thereof will be omitted, and only differences will be described.

[0059]

As shown in FIG. 10, in the beam joining structure 2' according to this

embodiment, the primary beam 21 as a beam is joined to the column 11 as a support member. The column 11 is a reinforced concrete (RC) structure. The column 11 and the primary beam 21 are joined to each other in a semi-rigid manner via the first shear plate 14 (see FIG. 4, not shown in FIG. 10) as described above. A reinforcing member 53 is disposed in the gap K between the core wall 10 and the primary beam 21. The reinforcing member 53 is disposed, in the gap K, at a part located below a neutral axis C2 of the primary beam 21 and located between the lower flange 24 of the primary beam 21 and the column 11.

Further, the surface of the column 11 to which the primary beam is attached extends in the up-down direction (substantially vertical direction) as a whole, and the surface thereof is formed in a substantially flat shape.

[0060]

In the third embodiment, a main body portion 531 of the reinforcing member 53 has a shape in which a first contact surface 531a in contact with the column 11, which is the support member, extends along the up-down direction, and a second contact surface 531b in contact with the end surface of the primary beam 21, which is the beam, in the member axis direction extends in a direction which intersects the up-down direction and becomes close to the first contact surface 531a toward the tip end side (downward direction in this case) of the up-down direction. In addition, the first contact surface 531a is formed in a substantially flat shape, the second contact surface 531b is inclined with respect to the first contact surface 531a.

A plurality of stages of projections 58 are formed on the second contact surface 531b as separation prevention portions. The projection 58 may be the projection as described in the second embodiment, and the description thereof is omitted.

Here, in the outer surfaces of the main body portion 531 in the reinforcing member 53, the contact area of the first contact surface 531a in contact with the column 11 is set to be larger than the contact area of the second contact surface 531b in contact with the primary beam 21. That is, the first contact surface 531a is in contact with the column 11 over almost the entire area of the first contact surface 531a (in particular, in the case of the third embodiment, the first contact surface 531a and the surface of the column 11 are in surface contact with each other over the entire surface of the first contact surface 531a). On the other hand, since the second contact surface 531b is a surface inclined with respect to the first contact surface 531a, the second contact surface 531b is in contact with the entirety or a portion of the end surface of the lower flange 24 of the primary beam 21.

[0061]

As described above, according to the reinforcing member 53 of this embodiment, in the contact surfaces of the main body portion 531 of the reinforcing member 53 with the column 11 and the primary beam 21, the first contact surface 531a in contact with the concrete material of the column 11 having a smaller proof stress against compressive stress than steel is set so that the contact area thereof with the concrete material of the column 11 is as large as possible and is made larger than the contact area of the second contact surface 531b in contact with the primary beam 21 which is steel, whereby, when compressive stress is applied to the reinforcing member 53, it is possible to reduce the contact pressure generated in the concrete material and limit damage to the surface of the concrete material.

[0062]

While the present invention has been described in detail based on the first to third embodiments, the specific configuration is not limited to the embodiments, and

changes, combinations, omissions, and the like of the configurations are included without departing from the gist of the present invention. Furthermore, the respective configurations of the embodiments may be appropriately combined.

[0063]

For example, in the first embodiment and the second embodiment, the configuration in which the support member is the primary beam 21 and the beam is the secondary beam 31 is described, but the aspect is not limited thereto. A configuration in which the support member is the core wall 10 or the column 11 and the beam is the primary beam 21 may be adopted.

In the third embodiment, the configuration in which the support member is the column 11 and the beam is the primary beam 21 is described, but the aspect is not limited thereto. The support member may be the core wall 10 or the primary beam 21, and the beam may be the secondary beam 31.

[0064]

In the first embodiment and the second embodiment, the configuration in which the secondary beam 31 is joined to the primary beam 21 by the second shear plate 25 in a semi-rigid manner, but the aspect is not limited thereto. The secondary beam 31 may be pinned to the primary beam 21.

In the third embodiment, the configuration in which the primary beam 21 is joined to the column 11 by the first shear plate 14 in a semi-rigid manner, but the aspect is not limited thereto. The primary beam 21 may be pinned to the column 11.

[0065]

In addition, the configuration in which the through-hole 25a is formed in the second shear plate 25 of the primary beam 21, the bolt hole 36 is formed in the web 32 of the secondary beam 31, and the bolt is disposed in the through-hole 25a and the bolt

hole 36 is described, but the aspect is not limited thereto. A configuration in which a bolt hole is formed in the web 22 of the primary beam 21, a shear plate having a through-hole is fixed to the secondary beam 31, and a bolt is disposed in the through-hole and the bolt hole may be adopted.

[0066]

Furthermore, the configuration in which the through-hole 25a is formed in the second shear plate 25 of the primary beam 21 is described, but the aspect is not limited thereto. A through-hole may be formed in the web 22 of the primary beam 21, a shear plate may be disposed on the web 32 of the secondary beam 31, and the shear plate may be joined to the web 22 of the primary beam 21.

The configuration in which the reinforcing member 51 is disposed in the gap K formed by the lower flange 24 of the primary beam 21 and the lower flange 34 of the secondary beam 31 is described, but the aspect is not limited thereto. For example, in a case where the height of the cross section of the primary beam 21 (beam depth) is larger than the height (beam depth) of the cross section of the secondary beam 31, the upper flange 23 of the primary beam 21 and the upper flange 33 of the secondary beam 31 may be disposed at positions at the same height in the third direction Z, a rib may be provided in the web 22 of the primary beam 21 at a position at the same height as that of the lower flange of the secondary beam 31 in the third direction Z, and the reinforcing member 51 may be disposed in the gap K formed by the rib and the lower flange 34 of the secondary beam 31.

Similarly, in a case where the height (beam depth) of the cross section of the primary beam 21 is larger than the height (beam depth) of the cross section of the secondary beam 31, the configuration shown in FIG. 12 may be adopted. In the configuration shown in FIG. 12, the upper flange 23 of the primary beam 21 and the

upper flange 33 of the secondary beam 31 are disposed at positions at the same height in the third direction Z. In addition, a notch is formed in portions of the upper flange 33 and the web 32 of the secondary beam 31 so as to cause the upper flange 33 of the secondary beam 31 to be shorter than the lower flange 34 in the second direction Y, the lower flange 34 of the secondary beam 31 is caused to directly face the web 22 of the primary beam 21, and the reinforcing member 51 is disposed in the gap K formed by the lower flange 34 of the secondary beam 31 and the web 22 of the primary beam 21.

[0067]

(Examples)

Hereinafter, examples of the present invention will be described.

As Experimental Examples 1 to 7, based on the joining structure between the column and the beam as shown in FIG. 10 described in the third embodiment, the beam joining structure was modeled using the specification of the beam shown in Table 1 and the construction conditions and the specification of the reinforcing member shown in Table 2. The gap between the column and the beam was set to 10 mm.

Experimental examples 1 to 5 are invention examples, in which the reinforcing member (contact plate) as shown in FIG. 10, that is, a reinforcing member having a plurality of stages of projections formed as separation prevention portions on a contact surface to be in contact with the end portion of the secondary beam was used. The protruding height of the projection in the second direction Y was set to 1 mm.

Experimental Examples 6 and 7 are comparative examples, and a reinforcing member in a form in which the projections were removed from the reinforcing member as shown in FIG. 10 was used.

[0068]

Table 3 shows, as the evaluation of functionality regarding Experimental

Examples 1 to 7,

(a) upper limit value Δg (mm) of variation in the gap dimension in which the reinforcing member can be constructed,

(b) recommended upper limit value $\phi_{u,req}$ (rad) of the inclination angle of the wedge surface of the reinforcing member,

(c) recommended lower limit value $\phi_{l,req}$ (rad) of the inclination angle of the wedge surface of the reinforcing member,

(d) constructability against variation in the gap dimension,

(e) a separation prevention function by the projections, and

(f) overall evaluation.

Each evaluation will be described below.

[0069]

(a) Upper Limit Value Δg (mm) of Variation in Gap Dimension in which Reinforcing Member Can Be Constructed

Regarding the reinforcing member used in each of the experimental examples, the upper limit value Δg (mm) of variation in the gap dimension in which the reinforcing member can be constructed is shown. Δg can be calculated by the following formula.

$$\Delta g = (h - t_f) \times \phi \dots (3)$$

[0070]

(b) Recommended Upper Limit Value $\phi_{u,req}$ (rad) of Inclination Angle of Wedge Surface of Reinforcing Member

The recommended upper limit value $\phi_{u,req}$ (rad) of the inclination angle of the wedge surface of the reinforcing member for functioning separation prevention by catching (locking) of the projections is shown.

[0071]

(c) Recommended Lower Limit Value $\phi_{l,req}$ (rad) of Inclination Angle of Wedge Surface of Reinforcing Member

The recommended lower limit value $\phi_{l,req}$ (rad) of the inclination angle of the wedge surface of the reinforcing member when a construction error (Δg_b) of 2 mm due to the gap of the bolt is assumed is shown.

[0072]

(d) Constructability against Variation in Gap Dimension

A case of $\phi \geq \phi_{l,req}$ was evaluated as A, and a case of $\phi < \phi_{l,req}$ was evaluated as C.

[0073]

(e) Separation Prevention Function by Projections

A case where both the separation prevention function by the friction between the end portion of the secondary beam in contact with the reinforcing member in the gap and the projection of the reinforcing member and the separation prevention function by the locking of the projection were exhibited was evaluated as A. A case where the separation prevention function only by the friction between the end portion of the secondary beam and the projection of the reinforcing member was exhibited was evaluated as B. A case where any of the separation prevention functions was not exhibited was evaluated as D. When the protruding height of the projection is larger than 0 and $\phi \leq \phi_{u,req}$ is satisfied, the separation prevention function by the locking of the projection is exhibited.

[0074]

(f) Overall Evaluation

As the overall evaluation, a case where both “constructability against

variation in the gap dimension” and “separation prevention function” were evaluated as A was evaluated as A (invention example), a case where either one was evaluated as B or C was evaluated as B (invention example), and a case where there was no separation prevention function was evaluated as D (comparative example).

[0075]

[Table 1]

No.	Specification of beam						
	Depth	Flange width	Web plate thickness	Flange plate thickness	Length of beam	Young's modulus	Second moment of area (about strong axis)
	H	B _f	t _w	t _f	l	E	I
	mm	mm	mm	mm	m	N/mm ²	mm ⁴
1	700	200	9	12	16.8	210000	831000000
2	700	200	9	12	16.8	210000	831000000
3	700	200	9	12	16.8	210000	831000000
4	700	200	9	12	16.8	210000	831000000
5	700	200	9	12	16.8	210000	831000000
6	700	200	9	12	16.8	210000	831000000
7	700	200	9	12	16.8	210000	831000000

[0076]

[Table 2]

No.	Construction conditions	Specification of reinforcing member		
	Equally distributed load due to self-weight	Inclination angle of wedge surface of reinforcing member	Height of reinforcing member	Protruding height of projection
	w	ϕ	h	-
	kN/m	rad	mm	mm
1	11.16	0.0139	150	1
2	11.16	0.0120	150	1
3	11.16	0.0120	180	1
4	15.64	0.0195	150	1
5	15.64	0.0159	150	1
6	11.16	0.0139	150	0
7	15.64	0.0159	150	0

[0077]

[Table 3]

No.	Evaluation of functionality						Classification
	Upper limit value of variation in gap dimension in which reinforcing member can be constructed	Recommended upper limit value of inclination angle of wedge surface of reinforcing member	Recommended lower limit value of inclination angle of wedge surface of reinforcing member	Constructability against variation in gap dimension	Separation prevention function by projections	Overall evaluation	
		$\phi_{u, req}$	$\phi_{l, req}$				
		rad	rad				
		mm					
1	1.92	0.0126	0.0145	C	B	B	Invention Example
2	1.66	0.0126	0.0145	C	A	B	Invention Example
3	2.02	0.0126	0.0119	A	A	A	Invention Example
4	2.69	0.0177	0.0145	A	B	B	Invention Example
5	2.20	0.0177	0.0145	A	A	A	Invention Example
6	1.92	0.0126	0.0145	C	D	C	Comparative Example
7	2.20	0.0177	0.0145	A	D	C	Comparative Example

[0078]

From the above examples, it could be confirmed that according to the present invention having the separation prevention mechanism, the support member and the beam can be reliably joined to each other regardless of the size of the gap between the support member and the beam, and furthermore, the joint state can be maintained.

Furthermore, in Invention Examples 1, 2, and 3, it could be confirmed that in a case where the inclination angle ϕ is 0.0119 (rad) or more and less than 0.0126 (rad) and the height of the reinforcing member is 180 mm, it is possible to stably obtain the separation prevention effect of the reinforcing member and the effect of securing constructability against variation in the gap dimension. In addition, in Invention Examples 4 and 5, it could be confirmed that in a case where the inclination angle ϕ is 0.0145 (rad) or more and less than 0.0177 (rad), it is possible to stably obtain the separation prevention effect of the reinforcing member and the effect of securing constructability against variation in the gap dimension.

In Comparative Examples 6 and 7, since no projection is provided, a separation prevention function is not provided regardless of the inclination angle. Therefore, the compressive force acting in a normal direction of the inclined wedge surface has a component of force which is directed upward in the vertical direction, and by this force, the reinforcing member is moved in a direction to be separated. Therefore, the function as the reinforcing member cannot be stably obtained.

[Industrial Applicability]

[0079]

According to the present invention, a support member and a beam can be reliably joined to each other regardless of the size of the gap between the support member and the beam, and furthermore, the joint state can be maintained.

[Brief Description of the Reference Symbols]

[0080]

1: building

2: beam joining structure

21: primary beam (support member)

31: secondary beam (beam)

51, 52, 53: reinforcing member

511, 521, 531: main body portion

511a, 521a, 531a: first contact surface

511b, 521b, 531b: second contact surface

54A: restriction member

54B: restriction member insertion hole

55, 56, 57, 58: projection

C1, C2: neutral axis

K: gap

CLAIMS

[Document Type]

1. A beam joining structure comprising:

a support member;

a beam which has one end side in a member axis direction attached to the support member and which is supported by the support member; and

a reinforcing member having a tip end disposed in a gap formed between the support member and the beam,

wherein the reinforcing member is disposed in the gap formed between the support member and the beam,

wherein the reinforcing member comprises:

a main body portion which has a first contact surface in contact with the support member and a second contact surface in contact with an end surface of the beam facing the support member, and is formed so as to cause a separation distance between the first contact surface and the second contact surface in the member axis direction of the beam to decrease toward the tip end; and

a separation prevention mechanism which is configured to limit movement of the main body portion by being locked to at least one of the support member and the beam,

wherein the separation prevention mechanism is constituted by a plurality of stages of projections protruding from at least one of the first contact surface and the second contact surface, and

wherein the plurality of stages of projections are formed so as to cause, in a state where the tip end of the reinforcing member is disposed in the gap, an inclination angle ϕ (rad) between a plane including ridges of the projections adjacent to each other and a plane

perpendicular to the member axis direction of the beam to satisfy Formula (1) or Formula (2).

$$\phi \leq wl^3 / 24EI \dots (1)$$

E: a Young's modulus (N/mm²) of the beam

I: a second moment of area (mm⁴) of the beam

w: an equally distributed load (kN/m) due to a fixed load supported by the beam

l: a length (mm) of the beam

$$\phi \geq \Delta g_b / (h - t_f) \dots (2)$$

Δg_b : an assumed value (mm) of an error of the gap in the member axis direction of the beam

h: a height (mm) of the reinforcing member in a vertical direction

t_f : a plate thickness of a lower flange of the beam in the vertical direction

2. The beam joining structure according to claim 1,

wherein the support member is a primary beam supported by a column,

the beam is a secondary beam supported by the support member, and

the support member and the beam are both H-section steels and have same cross-sectional height.

3. The beam joining structure according to claim 1 or 2, further comprising:

a joint member which joins the support member and the beam to each other in a semi-rigid manner or a pinning manner,

wherein the reinforcing member is configured to transmit a compressive stress to the support member, the compressive stress being generated from the beam toward the support member.

4. The beam joining structure according to any one of claims 1 to 3, wherein
the first contact surface extends in a direction perpendicular to the member axis
direction of the beam,
the second contact surface extends in a direction intersecting the first contact surface,
and
the plurality of stages of projections protrude from the second contact surface.