

DESCRIPTION

BONDING STRUCTURE

TECHNICAL FIELD

5 [0001]

The present invention relates to a joint configuration.

BACKGROUND ART

[0002]

For instance, a beam end joint between an RC secondary beam or a wall and
10 a primary beam, or between the primary beam and a secondary beam is generally
designed to be a rigid joint or a pinned joint. Taking an example of the primary beam
and the secondary beam, in the case of the rigid joint, flanges of the secondary beam
are welded or bolted to the primary beam and further a web of the secondary beam
is bolted to the primary beam through a fin plate. In the case of the pinned joint, the
15 web of the secondary beam is bolted to a fin plate attached to the primary beam but
the flanges of the secondary beam are not bonded to the primary beam.

[0003]

Meanwhile, Non-Patent Literature 1 describes joints using contact plates
provided that the joints are subject to a hogging moment. This type of joints can be
20 applied to a gravity frame that does not bear a horizontal force, or a moment frame
where antisymmetric bending does not occur because of a small horizontal force.
Each contact plate is interposed in a gap between a supporting member and a small
end surface of a bottom flange of a supported steel beam, and transfers a
compression force at the compressed flange of the steel beam to the supporting
25 member.

[0004]

However, a dimension of the gap between the small end surface of the
bottom flange of the steel beam and the supporting member fluctuates depending on
variations in erection accuracy, tolerance of fabrication or the like. With a thickness
30 of the contact plate that does not correspond to the dimension of the gap, the force
is not transferred and thus the thickness of the contact plate needs to be adjustable.
Specifically, Patent Literature 1 describes a technique where a member equivalent

to the contact plate is configured to be wedge-shaped to cope with a fluctuation in dimension of the gap.

CITATION LIST

PATENT LITERATURE(S)

5 [0005]

Patent Literature 1: JP 2005-282019 A

NON-PATENT LITERATURE(S)

[0006]

Non-Patent Literature 1: EUROPEAN COMMITTEE FOR
10 STANDARDIZATION, "Eurocode 4: Design of Composite Steel and Concrete
Structures Part 1-8: Design of joints", May 2005

SUMMARY OF THE INVENTION

PROBLEM(S) TO BE SOLVED BY THE INVENTION

[0007]

15 However, as in the technique described in Patent Literature 1, in the case
where the member equivalent to the contact plate is wedge-shaped, a contact region
with at least one of the small end surface of the bottom flange of the steel beam or
the supporting member becomes linear or narrower than a plate thickness of the
flange. In this case, since an area of a metal touch portion becomes smaller than a
20 cross-sectional area of the bottom flange, a local compression state is generated,
thereby making it likely that the contact portion is plasticized due to a compression
force acting thereon or designing thereof becomes difficult due to unstable rigidity
and resistance.

[0008]

25 Accordingly, an object of the invention is to provide a novel and improved
joint configuration for members between which a gap fluctuates in dimension, the
joint configuration being capable of reliably securing a contact region of a stable size
regardless of the dimension of the gap.

MEANS FOR SOLVING THE PROBLEM(S)

30 [0009]

According to an aspect of the invention, a joint configuration includes: an H-
section secondary beam including a top flange, a bottom flange and a web; a

supporting member including a supporting surface intersecting with an axial direction of the H-section secondary beam; and a contact member interposed between an end surface of the bottom flange and the supporting surface, in which at least one of the end surface of the bottom flange in the axial direction of the H-section secondary beam or the supporting surface is at least partly beveled with respect to a vertical direction, and the contact member includes a first surface in contact with the supporting surface and a second surface in contact with the end surface of the bottom flange, an angle formed by the first surface and the second surface corresponding to an angle formed by the end surface of the bottom flange and the supporting surface.

[0010]

In the above joint configuration, the contact member may be interposed between the end surface of the bottom flange and the supporting surface at a central portion in a width direction of the bottom flange. In this case, a cutout being adjacent to the bottom flange may be formed at an end portion of the web in the axial direction of the H-section secondary beam, and the contact member may be arranged to traverse the bottom flange in the width direction through the cutout.

[0011]

In the above joint configuration, the contact member may be provided with a groove covering a region of the cutout with respect to the width direction of the bottom flange.

[0012]

The above joint configuration may further include an RC floor slab arranged on and above the H-section secondary beam, the RC floor slab including concrete and rebars embedded in the concrete and extending at least in the axial direction of the H-section secondary beam; and shear connectors bonded to the top flange and embedded in the concrete forming the RC floor slab. In this case, a total length ΣL_{cp} (mm) of the contact member in the width direction of the bottom flange may satisfy a formula (i) below regarding a relationship with a converted plate thickness t_{pl} (mm) of a contact region between the supporting surface and the first surface, a converted plate thickness t_f (mm) of a contact region between the end surface of the bottom flange and the second surface, a yield stress $f_{y,pl}$ (N/mm²) of the supporting member, a yield stress $f_{y,f}$ (N/mm²) of the bottom flange, a yield stress $f_{y,cp}$ (N/mm²) of the

contact member, a total cross-sectional area A_r (mm^2) of the rebars within an effective width of the RC floor slab in a cross section vertical to the axial direction of the H-section secondary beam, and a yield stress $f_{y,r}$ (N/mm^2) of the rebars,

[0013]

5 [Formula 1]

$$\sum L_{cp} \cdot \min(t_{pl}, t_f) \cdot \min(f_{y,pl}, f_{y,f}, f_{y,cp}) \geq A_r \cdot f_{y,r} \quad \cdot \cdot \cdot \quad (i)$$

[0014]

In the above joint configuration, the supporting member may include a first supporting member formed of concrete and a second supporting member bonded to a side surface of the first supporting member to form the supporting surface, and the rebars may be embedded in the concrete forming the first supporting member.

[0015]

In the above joint configuration, the H-section secondary beam may include a first H-section secondary beam and a second H-section secondary beam that are arranged on respective lateral sides of the supporting member, the RC floor slab may be arranged on and above the first H-section secondary beam, the second H-section secondary beam and the supporting member, and the shear connectors may include first shear connectors bonded to a top flange of the first H-section secondary beam, and second shear connectors bonded to a top flange of the second H-section secondary beam.

[0016]

In the above joint configuration, the supporting member may be an H-section primary beam including a support-side top flange, a support-side bottom flange and a support-side web and extending along a direction orthogonal to the axial direction of the H-section secondary beam, the supporting surface may be a side end surface of the support-side bottom flange of the H-section primary beam, and cross-sectional heights of the H-section secondary beam and the H-section primary beam may be equal with each other.

[0017]

The above joint configuration may further include one or more fillet weld portions formed between the H-section secondary beam and the contact member or

between the supporting member and the contact member.

[0018]

In the above joint configuration, an angle θ formed by the first surface and the second surface, a static friction coefficient μ_1 between the supporting surface and the first surface, and a static friction coefficient μ_2 between the end surface of the bottom flange and the second surface may satisfy a relationship: $\tan\theta \leq \mu_1 + \mu_2$.

[0019]

In the above joint configuration, the end surface of the bottom flange and the supporting surface may be non-parallel to each other on a plane including the axial direction of the H-section secondary beam and the width direction of the bottom flange, and the width direction of the bottom flange and a length direction of the contact member may be non-parallel to each other.

[0020]

According to the invention, a contact region of a stable size can be reliably secured regardless of a dimension of a gap in a joint configuration for members between which the gap fluctuates in dimension.

BRIEF DESCRIPTION OF DRAWING(S)

[0021]

Fig. 1 shows a joint configuration according to a first exemplary embodiment of the invention.

Fig. 2 shows a joint configuration according to a second exemplary embodiment of the invention.

Fig. 3 is an enlarged view of the joint configuration shown in Fig. 2.

Fig. 4 is a perspective view of an exemplary contact member used in the joint configuration shown in Figs. 1 to 3.

Fig. 5 is a perspective view showing a modification of the contact member shown in Fig. 4.

Fig. 6 shows a process of interposing the contact member shown in Fig. 5.

Fig. 7 shows a joint configuration according to a third exemplary embodiment of the invention.

Fig. 8 shows a joint configuration according to a fourth exemplary embodiment of the invention.

Fig. 9 shows a joint configuration according to a fifth exemplary embodiment of the invention.

Fig. 10 shows a joint configuration according to a sixth exemplary embodiment of the invention.

5 Fig. 11 is a diagram for explaining an example of absorbing a perpendicularity tolerance of a secondary beam with a contact member in the exemplary embodiments of the invention.

Fig. 12 is a cross-sectional view of the joint configuration taken along a XII-XII line in Fig. 11.

10 Fig. 13 is a graph showing an analysis result of an angle of the contact member in the exemplary embodiments of the invention.

Fig. 14 is a diagram for explaining an analysis result of a length of the contact member in the exemplary embodiments of the invention.

15 Fig. 15 is an enlarged view showing the surroundings of the contact member in Fig. 14.

DESCRIPTION OF EMBODIMENT(S)

[0022]

Exemplary embodiments of the invention will be described below with reference to attached drawings. It should be noted that the same reference numerals
20 will be attached to components having substantially the same structures and functions to omit duplicated explanations therefor in the specification and drawings.

[0023]

Fig. 1 shows a joint configuration according to a first exemplary embodiment of the invention. The joint configuration shown in Fig. 1 includes a secondary beam
25 1, a primary beam 2, a fin plate 31, a rib 32, a contact member 4, an RC floor slab 5 and shear connectors 6. More specifically, the secondary beam 1 is an H-section secondary beam including a top flange 11, a bottom flange 12 and a web 13. The primary beam 2 is an H-section primary beam that extends along a direction orthogonally intersecting with an axial direction of the secondary beam 1 and includes
30 a top flange 21, a bottom flange 22 and a web 23. The RC floor slab 5 includes: concrete 51; rebars 52 embedded in the concrete 51 and extending at least in the axial direction of the secondary beam 1; and a steel deck profile 53.

[0024]

In the above joint configuration, the primary beam 2, the fin plate 31 and the rib 32 form a supporting member that supports the secondary beam 1. Specifically, the fin plate 31 is a plate-shaped member that is orthogonal to the primary beam 2, the fin plate 31 being arranged on each of both sides of the web 23 and welded to the top flange 21, the bottom flange 22 and the web 23. The rib 32 is a plate-shaped member that is parallel to the top flange 21 and the bottom flange 22 of the primary beam 2, the rib 32 being welded to the web 23 and the fin plate 31. An end surface 32E of the rib 32 forms a supporting surface intersecting with the axial direction of the secondary beam 1.

[0025]

The contact member 4 is interposed in the axial direction of the secondary beam 1 between an end surface 12E of the bottom flange 12 and the end surface 32E of the rib 32 serving as the supporting surface. The end surface 12E is at least partly beveled with respect to a vertical direction thereof. As will be described later, the contact member 4 includes: a first surface in contact with the end surface 32E of the rib 32; and a second surface in contact with the end surface 12E of the bottom flange 12. An angle formed by the first surface and the second surface corresponds to an angle between the end surface 12E of the bottom flange 12 and the end surface 32E of the rib 32. With the above arrangement, even if a dimension of a gap between the bottom flange 12 and the rib 32 fluctuates, the contact between the end surface 12E and the end surface 32E is maintained since the contact member 4 moves in the vertical direction. Consequently, contact regions of a sufficient size between the bottom flange 12 and the contact member 4 and between the rib 32 and the contact member 4 are reliably obtainable.

[0026]

Here, the beveled end surface 12E of the bottom flange 12 may be obtained by machining the end surface 12E in order to be used for the bonding using the above contact member 4, or may be substituted by, for instance, a groove machined for welding. In other words, in the case where the secondary beam 1 includes the groove for welding formed on the end surface 12E of the bottom flange 12, the above joint configuration can be constructed without additional machining by preparing the

contact member 4 having the second surface formed at an inclination corresponding to an angle of the groove. It should be noted that although in the illustrated example, the entirety of the end surface 12E is beveled, a part of the end surface 12E may not be beveled, for instance, as in a root surface when the above groove is used.

5 [0027]

Meanwhile, although in the illustrated example, the end surface 32E of the rib 32 is a vertical surface opposing the end surface 12E of the bottom flange 12 at an angle, in other examples, the end surface 32E also may be at least partly beveled with respect to the vertical direction. In this case, for instance, the end surface 32E of the rib 32 may be reverse-beveled with respect to the end surface 12E of the bottom flange 12, so that a V-shaped groove may be formed between the end surfaces 12E and 32E. Alternatively, the end surface 32E of the rib 32 may be reverse-beveled with respect to the end surface 12E of the bottom flange 12 shown in Fig. 1 and the end surface 12E may not be beveled, so that a check-mark-shaped groove may be formed between the end surfaces 12E and 32E.

[0028]

Moreover, in the illustrated example, a cutout 13C being adjacent to the bottom flange 12 is formed at an end portion of the web 13 in the axial direction of the secondary beam 1. As shown in Fig. 1, the contact member 4 is arranged to traverse the bottom flange 12 in a width direction thereof through the cutout 13C, thereby avoiding interference between the contact member 4 and the web 13. It should be noted that the contact member 4 may not necessarily traverse the bottom flange 12 across the entire width thereof, or may traverse only a part of the bottom flange 12 including a portion thereof being adjacent to the formed cutout 13C. More specifically, for instance, in the case where the dimension of the gap between the bottom flange 12 and the rib 32 is relatively small, an upper portion of the contact member 4 projects upward from the bottom flange 12 and toward the opposite side to the end surface 12E of the bottom flange 12. In this case, the cutout 13C is formed on a region of the web 13 toward which the contact member 4 projects, thereby avoiding the interference between the contact member 4 and the web 13.

[0029]

With the above arrangement, in the exemplary embodiment, the contact

member 4 can be interposed at a central portion in the width direction of the bottom flange 12 of the secondary beam 1 between the end surface 12E of the bottom flange 12 and the end surface 32E of the rib 32. The end surface 12E and the end surface 32E of the rib 32 are brought into surface contact at the central portion in the width direction of the bottom flange 12, which is also an intersection with a portion of the web 13 where the cutout 13C is not formed, thereby allowing a compression force in the axial direction of the secondary beam 1 to be effectively transferred to the rib 32. It should be noted that for instance, in the case where an end surface in the axial direction of the web 13 is apart from the end surface 12E of the secondary beam 1 toward the opposite side to the primary beam 2, the contact member 4 can be interposed at the central portion in the width direction of the bottom flange 12 without providing the above cutout 13C.

[0030]

Here, the cutout 13C formed on the web 13 may be obtained by machining the web 13 in order to be used for the bonding using the above contact member 4, or may be substituted by, for instance, an access hole or scallop for welding, which is formed by machining the web 13. In other words, in the case where the secondary beam 1 includes the access hole or scallop for welding formed at the end portion of the web 13, the above joint configuration including the cutout 13C can be constructed without additional machining as long as the access hole or the scallop has a size capable of accommodating the projecting portion of the contact member 4.

[0031]

Meanwhile, in the above joint configuration, the fin plate 31 is bonded to the web 13 of the secondary beam 1 using bolts 33. Accordingly, between the secondary beam 1 and the primary beam 2, in addition to the transfer of the compression force by means of the above-described bonding between the bottom flange 12 and the rib 32 via the contact member 4, a compression force and a shear force are transferred by means of bonding between the web 13 and the fin plate 31 via the bolts 33. In other examples, the fin plate 31 may be welded to the web 13.

[0032]

In addition, in the illustrated example, the secondary beam 1 is bonded to the RC floor slab 5 by means of the shear connectors 6. Specifically, the shear

connectors 6 are bonded to the top flange 11 of the secondary beam 1 and embedded in the concrete 51 forming the RC floor slab 5. With the above arrangement, a compression force and a tensile force in the axial direction of the secondary beam 1 are also transferred to the RC floor slab 5, and thus the secondary beam 1 and the RC floor slab 5 can integrally resist a bending moment generated at the secondary beam 1.

[0033]

Additionally, in the illustrated examples: the secondary beam 1 includes a secondary beam 1A (first H-section secondary beam) and a secondary beam 1B (second H-section secondary beam) that are arranged on respective sides of the primary beam 2 serving as the supporting member; the RC floor slab 5 is arranged on and above the secondary beams 1A, 1B and the primary beam 2; and the secondary beams 1A, 1B and the primary beam 2 are bonded to the RC floor slab 5 by means of the shear connectors 6. Specifically, the shear connectors 6 include: shear connectors (first and second shear connectors) bonded to the top flange 11 of the secondary beams 1A, 1B, respectively; and shear connectors each bonded to the top flange 21 of the primary beam 2. The shear connectors 6 are each embedded in the concrete 51. With the above arrangement, the secondary beams 1A, 1B, the primary beam 2 and the RC floor slab 5 can integrally resist a bending moment generated at respective end portions of the secondary beams 1A, 1B.

[0034]

Fig. 2 shows a joint configuration according to a second exemplary embodiment of the invention. In a joint configuration shown in Fig. 2, the bottom flange 12 and the web 13 of the secondary beam 1 extend to a position opposing the web 23 of the primary beam 2. It should be noted that a part of the top flange 11 of the secondary beam 1 and a part of the web 13 to interfere with the top flange 21 of the primary beam 2 are cut. Similarly to the above first exemplary embodiment, the fin plate 31 and the bolts 33 bond the web 13 of the secondary beam 1 to the web 23 of the primary beam 2, but the rib 32 is not provided thereto. In other examples, the web 13 of the secondary beam 1 may be welded to the web 23 of the primary beam 2 without the fin plate 31.

[0035]

In the second exemplary embodiment, the end surface 12E of the bottom flange 12 of the secondary beam 1 opposes a side surface 23S of the web 23 of the primary beam 2. Accordingly, in the second exemplary embodiment, the contact member 4 is interposed between the end surface 12E of the bottom flange 12 and the side surface 23S of the web 23 that forms a supporting surface. Except for the above arrangement, the structure of the second exemplary embodiment is the same as that of the first exemplary embodiment.

[0036]

Fig. 3 is an enlarged view of the joint configuration shown in Fig. 2. As shown in Fig. 3, the contact member 4 includes a first surface 41 in contact with the side surface 23S of the web 23 forming the supporting surface and a second surface 42 in contact with the end surface 12E of the bottom flange 12 of the secondary beam 1. As described above, the end surface 12E is beveled with respect to the vertical direction and thus the second surface 42 of the contact member 4 is formed to have an inclination of an angle θ corresponding to this bevel. Here, the angle θ is an angle with respect to a vertical plane.

[0037]

In addition, in the second exemplary embodiment, a fillet weld portion 43 is formed between the contact member 4 and the side surface 23S of the web 23. The fillet weld portion 43 is formed, for instance, after the contact member 4 is interposed between the end surface 12E of the bottom flange 12 and the side surface 23S of the web 23 to be in secure contact with the respective surfaces. For instance, in the case where vibration or the like after installation may cause a fall off of the contact member 4 because the angle θ is too large for a friction coefficient between the surfaces, the fall off can be prevented by forming the fillet weld portion 43 and fixing the contact member 4.

[0038]

It should be noted that the fillet weld portion 43 may not necessarily be formed between the contact member 4 and the side surface 23S of the web 23, and may be formed between the contact member 4 and an upper surface or a lower surface of the bottom flange 12. Moreover, not only in the illustrated examples but also in other embodiments, one or more fillet weld portions are formed between the

secondary beam 1 serving as an H-section member and the contact member or between the supporting member and the contact member, thereby preventing a fall off of the contact member.

[0039]

5 Fig. 4 is a perspective view of an exemplary contact member used in the joint configuration shown in Figs. 1 to 3. In the example shown in Fig. 4, the contact member 4 is formed to have a uniform cross section with the first surface 41 and the second surface 42. As has already been described, in the above exemplary embodiments, the cutout 13C being adjacent to the bottom flange 12 is formed at the
10 end portion of the web 13 in the axial direction of the secondary beam 1, thereby avoiding the interference between the contact member 4 and the web 13. In this case, a single contact member 4 only needs to be prepared for each joint configuration including the secondary beam 1 (Figs. 1 and 2 each show two joint configurations for the secondary beam 1A and the secondary beam 1B). For instance, separate contact
15 members 4 may be used at both sides of the web 13 without forming the cutout 13C on the web 1. In this case, two contact members 4 are required for each joint configuration. It should be noted that the contact member 4 may not necessarily be integrally formed in a cross-sectional direction and in a longitudinal direction, and may be formed by bonding by various methods such as screwing or welding a
20 plurality of portions.

[0040]

 Fig. 5 is a perspective view showing a modification of the contact member shown in Fig. 4. Fig. 6 shows a process of interposing the contact member shown in Fig. 5. In the illustrated example, a contact member 4A is provided with a groove 44.
25 The groove 44 covers a region of the cutout 13C formed on the web 13 of the secondary beam 1 with respect to an axial direction of the contact member 4A, i.e., the width direction of the bottom flange 12 when the contact member 4A is interposed between the end surface 12E of the bottom flange 12 of the secondary beam 1 and the side surface 23S of the web 23 of the primary beam 2. More specifically, the
30 groove 44 is formed so that a width thereof with respect to this direction (the width direction of the bottom flange 12) is greater than or equal to a thickness of the web 13. As shown in Fig. 5, in the case where the single contact member 4 is used across

both sides of the web 13, the groove 44 is provided around a center in the axial direction of the contact member 4.

[0041]

As shown in Fig. 6, in the case where the contact member 4A is interposed in a state where the end surface 12E of the bottom flange 12 and the side surface 23S of the web 23 forming the supporting surface oppose each other, for instance, the contact member 4A is temporarily placed through the cutout 13C on the upper surface of the bottom flange 12 and subsequently the contact member 4A, while being rotated around an axis thereof, can be fitted from above into a gap between the end surface 12E and the side surface 23S. During this interposition, the upper portion of the contact member 4A temporarily projects more upward from the bottom flange 12 than the upper portion of the interposed contact member 4A. Interference between the contact member 4A and the web 13 during this interposition can be avoided by providing the groove 44 to the contact member 4A. In other words, in the illustrated example, a size of the cutout 13C can be made smaller than a maximum projection amount of the contact member 4A in the interposition process by providing the groove 44.

[0042]

Fig. 7 shows a joint configuration according to a third exemplary embodiment of the invention. In a joint configuration shown in Fig. 7, cross-sectional heights of the secondary beam 1 and the primary beam 2 are equal with each other. In other words, in the illustrated example, heights of an upper surface of the top flange 11 of the secondary beam 1 and an upper surface of the top flange 21 (support-side top flange) of the primary beam 2 are equal with each other in design and heights of the lower surface of the bottom flange 12 of the secondary beam 1 and a lower surface of the bottom flange 22 (support-side bottom flange) of the primary beam 2 are equal with each other in design. It should be noted that a thickness of each of the top flange 11 and the bottom flange 12 of the secondary beam 1 may be different from a thickness of each of the top flange 21 and the bottom flange 22 of the primary beam 2. In the illustrated example, the thickness of each of the top flange 21 and the bottom flange 22 of the primary beam 2 is larger than the thickness of each of the top flange 11 and the bottom flange 12 of the secondary beam 1.

[0043]

In the third exemplary embodiment, similarly to the above first exemplary embodiment, the fin plate 31 and the bolts 33 are bonded to the web 13 of the secondary beam 1 and the web 23 (support-side web) of the primary beam 2 without the rib 32 and the end surface 12E of the bottom flange 12 of the secondary beam 1 opposes a side end surface 22E of the bottom flange 22 of the primary beam 2. Accordingly, in the third exemplary embodiment, the side end surface 22E of the bottom flange 22 of the primary beam 2 forms a supporting surface, and the contact member 4 is interposed between the end surface 12E of the bottom flange 12 of the secondary beam 1 and the side end surface 22E of the bottom flange 22 of the primary beam 2. Except for the above arrangement, the structure of the third exemplary embodiment is the same as that of the first exemplary embodiment.

[0044]

Fig. 8 shows a joint configuration according to a fourth exemplary embodiment of the invention. In a joint configuration shown in Fig. 8, an RC primary beam 7, a base plate 81 and a fin plate 82 form a supporting member that supports the secondary beam 1. The RC primary beam 7 includes concrete 71 and rebar 72 embedded in the concrete 71. The rebar 72 includes longitudinal reinforcements 72A extending in a direction orthogonal to the secondary beam 1, and stirrups 72B. The base plate 81 is bonded to the RC primary beam 7 by embedding, in the concrete 71, anchors 84 bonded to the base plate 81. The fin plate 82 is a plate-shaped member that is orthogonal to the RC primary beam 7 and the base plate 81, the fin plate 82 being welded to a plate surface 81S of the base plate 81 and being bonded to the web 13 of the secondary beam 1 using bolts 83. In other examples, the web 13 of the secondary beam 1 may be welded to the base plate 81 without the fin plate 82.

[0045]

In the fourth exemplary embodiment, the end surface 12E of the bottom flange 12 of the secondary beam 1 opposes the plate surface 81S of the base plate 81 bonded to the side surface of the RC primary beam 7. Accordingly, in the fourth exemplary embodiment, the plate surface 81S of the base plate 81 forms a supporting surface, and the contact member 4 is interposed between the end surface 12E of the bottom flange 12 and the plate surface 81S of the base plate 81.

[0046]

Moreover, in the fourth exemplary embodiment, the RC floor slab 5 is also arranged on and above the secondary beams 1A, 1B and the RC primary beam 7. The secondary beams 1A, 1B are bonded to the RC floor slab 5 by means of the shear connectors, whereas the RC primary beam 7 is bonded to the RC floor slab 5 by placing the concrete 71 in the rebar 72 while a portion of the rebar 72 extending beyond upper surfaces of the secondary beams 1A, 1B is kept exposed, and subsequently placing the concrete 51 of the RC floor slab 5 over the rebar 72 to embed the rebar 72 in the concrete 51. Except for the above arrangement, the structure of the fourth exemplary embodiment is the same as that of the first exemplary embodiment.

[0047]

Fig. 9 shows a joint configuration according to a fifth exemplary embodiment of the invention. In a joint configuration shown in Fig. 9, an RC column 9A (first supporting member), a base plate 81A (second supporting member) and a fin plate 82A form a supporting member at one end of the secondary beam 1, and an RC wall 9B (first supporting member), a base plate 81B (second supporting member) and a fin plate 82B form a supporting member at the other end thereof. The base plates 81A, 81B and the fin plates 82A, 82B are configured in a similar manner to the base plate 81 described in the above fourth exemplary embodiment. Accordingly, the structure of the fifth exemplary embodiment is in common with that of the above the fourth exemplary embodiment in that the plate surface 81S of the base plate 81 forms the supporting surface and the contact member 4 is interposed between the end surface 12E of the bottom flange 12 and the plate surface 81S of the base plate 81.

[0048]

Meanwhile, the RC column 9A and the RC wall 9B are connected to the RC floor slab 5 by embedding the rebars 52 of the RC floor slab 5 via respective extensions 52E (starter bars) in respective concretes of the RC column 9A and the RC wall 9B each forming the supporting member. Specifically, for instance, the concrete 51 of the RC floor slab 5 may be placed after: placing the concretes of the RC column 9A and the RC wall 9B while the extensions 52E project from a side surface of the RC wall 9B, or while the side surface of the RC wall 9B for a fitting hole

for a coupler is exposed, the coupler being provided to an end portion of each of the extensions 52E facing the side surface of the RC wall 9B; and subsequently bonding the extensions 52E to the respective rebars 52. With the above arrangement, the tensile force transferred to the RC floor slab 5 by means of a bending moment generated at end portions of the secondary beam 1 can be effectively transferred to the RC column 9A and the RC wall 9B each forming the supporting member.

[0049]

Fig. 10 shows a joint configuration according to a sixth exemplary embodiment of the invention. In a joint configuration shown in Fig. 10, the RC primary beam 7, the base plate 81 and the fin plate 82 form a supporting member at one end of the secondary beam 1, and the RC wall 9B, the base plate 81 and the fin plate 82 form a supporting member at the other end thereof. The sixth exemplary embodiment is described as an embodiment in which the RC column 9A is replaced with the RC primary beam 7 in the above fifth exemplary embodiment. The extensions 52E (starter bars) of the respective rebars 52 of the RC floor slab 5 are embedded in the respective concretes of the RC primary beam 7 and the RC wall 9B each forming the supporting member.

[0050]

Figs. 11 and 12 are each a diagram for explaining an example of absorbing a perpendicularity tolerance of the secondary beam with the contact member in the exemplary embodiments of the invention. Fig. 11 is a cross-sectional view of the joint configuration on a plane including the axial direction of the secondary beam 1 and the width direction of the bottom flange 12. Fig. 12 is a cross-sectional view of the joint configuration taken along a XII-XII line in Fig. 11. Constituent elements of the illustrated joint configuration are the same as those in the example described above in reference to Fig. 1. In the illustrated example, for a perpendicularity tolerance of the secondary beam 1 or the fin plate 31, the secondary beam 1 is not arranged at a right angle to the primary beam 2 and the end surface 12E of the bottom flange 12 is non-parallel to the end surface 32E of the rib 32 (i.e., has an angle ϕ) on the plane (horizontal cross section) including the axial direction of the secondary beam 1 and the width direction of the bottom flange 12. In this case, gaps between the end surface 12E and the end surface 32E are different on respective sides in the width

direction of the bottom flange 12 (the gaps are shown as a gap g_1 and gap g_2).

[0051]

In this regard, in the above example, as shown in Fig. 12, the contact member 4 is interposed between the end surface 12E and the end surface 32E so that the width direction of the bottom flange 12 is non-parallel to the a length direction of the contact member 4 (i.e., has an angle ψ). With the above arrangement, the contact member 4 is fitted between the end surface 12E and the end surface 32E to be inserted more deeply at a side with the larger gap (gap g_1) between the end surface 12E and the end surface 32E and to be inserted more shallowly at a side with the smaller gap (gap g_2) therebetween, thereby maintaining surface contact between the first surface 41 and the end surface 32E and between the second surface 42 and the end surface 12E according to a fluctuation in a size of the gap. In other words, in the above examples, the perpendicularity tolerance of the secondary beam 1 is absorbed using the contact member 4.

[0052]

Fig. 13 is a graph showing an analysis result of an angle of the contact member in the exemplary embodiments of the invention. An ordinate axis in Fig. 13 shows the angle θ (deg), i.e., an angle formed by the first surface 41 and the second surface 42 of the contact member 4, and an abscissa axis shows a slip coefficient (static friction coefficient) μ . In each of the exemplary embodiments described above, magnitude of the compression force that is transferred from the bottom flange 12 of the secondary beam 1 to the supporting surface is defined as F . Between the supporting surface that is not beveled and the first surface 41 of the contact member 4, in theory, a component of force in a direction along a contact surface is not generated but a force F in a vertical direction to the contact surface is generated. In contrast, between the end surface 12E of the bottom flange 12 that is beveled at the angle θ and the second surface 42 of the contact member 4, components of force $F\sin\theta$ and $F\cos\theta$ are generated in the direction along the contact surface and in the vertical direction to the contact surface, respectively.

[0053]

Accordingly, in order for the contact member 4 not to fall off because of sliding, the component of force $F\sin\theta$ generated on the second surface 42 and acting in the

direction along the contact surface (force acting in a direction of the contact surface falling off) only needs not to exceed a resultant force of a component of force $\mu_1 F \cos \theta$ of a maximum static friction force $\mu_1 F$ generated on the contact surface with the first surface 41 and acting in the same direction as that of the above component of force and a component of force $\mu_2 F \cos \theta$ of a maximum static friction force generated on the contact surface with the second surface 42. Here, μ_1 is a static friction coefficient between the supporting surface and the first surface 41 and μ_2 is a static friction coefficient between the end surface 12E and the second surface 42. The above conditions are expressed in a formula: $F \sin \theta \leq \mu_1 F \cos \theta + \mu_2 F \cos \theta$, i.e., $\tan \theta \leq \mu_1 + \mu_2$. If $\mu_1 = \mu_2 = \mu$, the condition is $\tan \theta \leq 2\mu$.

[0054]

Here, in the case where the end surface 12E of the bottom flange 12, the first surface 41 and the second surface 42 of the contact member 4, and the supporting surface remain covered with a mill scale (mill scale), the slip coefficient (equivalent to the static friction coefficient μ in this case) is in a range from 0.2 to 0.35 (Architectural Institute of Japan, "Guidebook on Design and Fabrication of High Strength Bolted Connections", the second edition, May 2016). According to the above literature, in the case where the end surface 12E of the bottom flange 12, the first surface 41 and the second surface 42 of the contact member 4, and the supporting surface are blasted, the slip coefficient is in a range from 0.4 to 0.7. Fig. 13 shows a maximum value of the angle θ (approximately 31 degrees) in the case where the slip coefficient is set to be 0.25 and a maximum value of the angle θ (approximately 72 degrees) in the case where the slip coefficient is set to be 0.45.

[0055]

Figs. 14 and 15 are each a diagram for explaining an analysis result of a length of the contact member in the exemplary embodiments of the invention. Fig. 14 is a perspective view of the same joint configuration as that of the example described above in reference to Fig. 1, where constituent elements of the RC floor slab 5 other than the rebars 52 extending in the axial direction of the secondary beam 1 are not illustrated for convenience of explanation. Fig. 15 is an enlarged view showing the surroundings of the contact member in Fig. 14. A total length ΣL_{cp} (mm) of the contact member 4 shown in Fig. 15 satisfies a formula (i) below regarding a relationship with

a converted plate thickness t_{pl} (mm) of a contact region between the end surface 32E of the rib 32 and the first surface 41, a converted plate thickness t_f (mm) of a contact region between the end surface 12E of the bottom flange 12 and the second surface 42, a yield stress $f_{y,pl}$ (N/mm²) of the rib 32, a yield stress $f_{y,f}$ (N/mm²) of the bottom flange 12, a yield stress $f_{y,cp}$ (N/mm²) of the contact member 4, a total cross-sectional area A_r (mm²) of the rebars 52 within an effective width of the RC floor slab 5 in a cross section vertical to the axial direction of the secondary beam 1, and a yield stress $f_{y,r}$ (N/mm²) of the rebars 52.

[0056]

10 [Formula 2]

$$\sum L_{cp} \cdot \min(t_{pl}, t_f) \cdot \min(f_{y,pl}, f_{y,f}, f_{y,cp}) \geq A_r \cdot f_{y,r} \quad \cdot \cdot \cdot \quad (i)$$

[0057]

Here, the total length ΣL_{cp} of the contact member 4 is the length of the contact member 4, i.e., a total dimension in the longitudinal direction thereof. In the case where the single contact member 4 is arranged as in the illustrated example, the length of the contact member 4 is the total length ΣL_{cp} . In the case where a plurality of contact members 4 are arranged at, for instance, both sides of the web 13, a sum of lengths of the respective contact members 4 is the total length ΣL_{cp} . The converted plate thickness t_{pl} of the contact region between the end surface 32E of the rib 32 and the first surface 41 is a projection length of the contact region between the end surface 32E and the first surface 41 in the plate thickness direction of the rib 32. As in the illustrated example, in the case where the first surface 41 of the contact member 4 is in contact with the entirety of the end surface 32E in a vertical cross section, the converted plate thickness t_{pl} is equal to the thickness of the rib 32. As in the examples shown in Figs. 2, 8, 9 and 10, in the case where the entirety of the first surface of the contact member 4 is in contact with the supporting surface of the supporting member in the vertical cross section, the converted plate thickness t_{pl} is equal to the dimension in the vertical direction of the first surface of the contact member 4.

30 [0058]

The converted plate thickness t_f of the contact region between the end

surface 12E of the bottom flange 12 and the second surface 42 is a projection length of the contact region between the end surface 12E and the second surface 42 in the plate thickness direction of the bottom flange 12. As in the illustrated examples, in the case where the entirety of the end surface 12E is beveled and the second surface 42 of the contact member 4 is in contact with the entirety of the end surface 12E in the vertical cross section, the converted plate thickness t_r is equal to the thickness of the bottom flange 12. In the case where a part of the end surface 12E is not beveled and the second surface 42 of the contact member 4 is in contact only with a portion of the end surface 12E being beveled as in the case where a groove with a root surface is formed at the bottom flange 12, the converted plate thickness t_r is obtained by subtracting a thickness corresponding to the root surface from the plate thickness of the end surface 12E of the bottom flange 12.

[0059]

The yield stresses $f_{y,pl}$, $f_{y,f}$, $f_{y,cp}$, and $f_{y,r}$ of the respective members can be identified based on, for instance, strength test results of materials for the respective members. The effective width of the RC floor slab 5 can be identified based on, for instance, EUROPEAN COMMITTEE FOR STANDARDIZATION, "Eurocode 4: Design of composite steel and concrete structures Part 1-1: General rules and rules for buildings" (May 2005), or Architectural Institute of Japan, "Design Recommendations for Composite Constructions" (November 2010). As shown in Fig. 14, the total cross-sectional area A_r is a sum of cross-sectional areas of the rebars 52 disposed within a range of the above effective width.

[0060]

In the above formula (i), it is defined that an upper limit of a compression load that can be transferred from the bottom flange 12 to the rib 32 via the contact member 4 (the left side) is greater than or equal to an upper limit of a tensile load that the rebars 52 can transfer (the right side). For instance, assuming that a maximum transfer load from the secondary beam 1 to the primary beam 2 is generated at the time of earthquake, the compression load transferred from the bottom flange 12 to the rib 32 via the contact member 4 is equal to the tensile load transferred by the rebars 52. In other words, if a maximum value of a transferable tensile load is generated without causing the rebars 52 to yield and if the bottom flange 12, the

contact member 4 and the rib 32 do not yield under a compression load of the same magnitude, the length of the contact member 4 is necessary and sufficient for transferring the compression load.

[0061]

5 It should be noted that the above analysis result is exemplary and the contact member 4 may be formed to have a length shorter than the total length ΣL_{cp} (mm) defined in the above formula (i) by considering an estimated value of a load that is actually generated, a safety factor and the like. Although the analysis result has been described above with respect to the same joint configuration as that of the example
10 described in reference to Fig. 1, the length of the contact member can be defined under the same conditions in the other examples.

[0062]

Exemplary embodiments of the invention have been described in detail with reference to attached drawings. However, the scope of the invention is not limited to
15 the above exemplary embodiments. It is apparent that a person having ordinary skill in the art to which the invention pertains can arrive at various alterations and modifications within the scope of the technical idea recited in the appended claims, and it is understood that such alterations and modifications naturally fall within the technical scope of the invention.

20 EXPLANATION OF CODE(S)

[0063]

1, 1A, 1B...secondary beam, 11...top flange, 12...bottom flange, 12E...end surface, 13...web, 13C...cutout, 2...primary beam, 21...top flange, 22...bottom flange, 22E...side end surface, 23...web, 23S...side surface, 31...fin plate, 32...rib,
25 32E...end surface, 33...bolt, 4, 4A...contact member, 41...first surface, 42...second surface, 43...fillet weld portion, 44...groove, 5...RC floor slab, 51...concrete, 52...rebar, 52E...extension, 53...steel deck profile, 6...shear connector, 7...RC primary beam, 71...concrete, 72...rebar, 72A...longitudinal reinforcement, 72B...stirrup, 81, 81A, 81B...base plate, 81S...plate surface, 82, 82A, 82B...fin plate,
30 83...bolt, 84...anchor, 9A...RC column, 9B...RC wall.

CLAIM(S)

1. A joint configuration comprising:

an H-section secondary beam comprising a top flange, a bottom flange and a web;

5 a supporting member comprising a supporting surface intersecting with an axial direction of the H-section secondary beam; and

a contact member interposed between an end surface of the bottom flange and the supporting surface, wherein

10 at least one of the end surface of the bottom flange in the axial direction of the H-section secondary beam or the supporting surface is at least partly beveled with respect to a vertical direction, and

the contact member comprises a first surface in contact with the supporting surface and a second surface in contact with the end surface of the bottom flange, an angle formed by the first surface and the second surface corresponding to an angle formed by the end surface of the bottom flange and the supporting surface.

2. The joint configuration according to claim 1, wherein the contact member is interposed between the end surface of the bottom flange and the supporting surface at a central portion in a width direction of the bottom flange.

3. The joint configuration according to claim 2, wherein

20 a cutout being adjacent to the bottom flange is formed at an end portion of the web in the axial direction of the H-section secondary beam, and

the contact member is arranged to traverse the bottom flange in the width direction through the cutout.

4. The joint configuration according to claim 3, wherein the contact member is provided with a groove covering a region of the cutout with respect to the width direction of the bottom flange.

5. The joint configuration according to any one of claims 1 to 4, further comprising:

30 an RC floor slab arranged on and above the H-section secondary beam, the RC floor slab comprising concrete and rebars embedded in the concrete and extending at least in the axial direction of the H-section secondary beam; and

shear connectors bonded to the top flange and embedded in the concrete

forming the RC floor slab.

6. The joint configuration according to claim 5, wherein a total length ΣL_{cp} (mm) of the contact member in the width direction of the bottom flange satisfies a formula (i) below regarding a relationship with a converted plate thickness t_{pl} (mm) of a contact region between the supporting surface and the first surface, a converted plate thickness t_f (mm) of a contact region between the end surface of the bottom flange and the second surface, a yield stress $f_{y,pl}$ (N/mm²) of the supporting member, a yield stress $f_{y,f}$ (N/mm²) of the bottom flange, a yield stress $f_{y,cp}$ (N/mm²) of the contact member, a total cross-sectional area A_r (mm²) of the rebars within an effective width of the RC floor slab in a cross section vertical to the axial direction of the H-section secondary beam, and a yield stress $f_{y,r}$ (N/mm²) of the rebars,

[Formula 1]

$$\sum L_{cp} \cdot \min(t_{pl}, t_f) \cdot \min(f_{y,pl}, f_{y,f}, f_{y,cp}) \geq A_r \cdot f_{y,r} \quad \cdot \cdot \cdot \quad (i)$$

7. The joint configuration according to claim 5 or 6, wherein

the supporting member comprises a first supporting member formed of concrete and a second supporting member bonded to a side surface of the first supporting member to form the supporting surface, and

the rebars are embedded in the concrete forming the first supporting member.

8. The joint configuration according to claim 5 or 6, wherein

the H-section secondary beam comprises a first H-section secondary beam and a second H-section secondary beam that are arranged on respective lateral sides of the supporting member,

the RC floor slab is arranged on and above the first H-section secondary beam, the second H-section secondary beam and the supporting member, and

the shear connectors comprise first shear connectors bonded to a top flange of the first H-section secondary beam and second shear connectors bonded to a top flange of the second H-section secondary beam.

9. The joint configuration according to any one of claims 1 to 6 and 8, wherein

the supporting member is an H-section primary beam comprising a support-side top flange, a support-side bottom flange and a support-side web and extending along a direction orthogonal to the axial direction of the H-section secondary beam,

the supporting surface is a side end surface of the support-side bottom flange of the H-section primary beam, and

cross-sectional heights of the H-section secondary beam and the H-section primary beam are equal with each other.

5 10. The joint configuration according to any one of claims 1 to 9, further comprising: one or more fillet weld portions formed between the H-section secondary beam and the contact member or between the supporting member and the contact member.

11. The joint configuration according to any one of claims 1 to 10, wherein an
10 angle θ formed by the first surface and the second surface, a static friction coefficient μ_1 between the supporting surface and the first surface, and a static friction coefficient μ_2 between the end surface of the bottom flange and the second surface satisfy a relationship: $\tan\theta \leq \mu_1 + \mu_2$.

12. The joint configuration according to any one of claims 1 to 11, wherein
15 the end surface of the bottom flange and the supporting surface are non-parallel to each other on a plane including the axial direction of the H-section secondary beam and the width direction of the bottom flange, and
the width direction of the bottom flange and a length direction of the contact member are non-parallel to each other.

20