

## DESCRIPTION

## Title of Invention

CONNECTION STRUCTURE FOR REINFORCED CONCRETE COLUMNS AND  
5 STEEL BEAMS, AND CONNECTING METHOD FOR REINFORCED CONCRETE  
COLUMNS AND STEEL BEAMS

## Technical Field

[0001]

10 The present invention relates to a joint structure of a reinforced concrete column  
and a steel beam and a method of joining a reinforced concrete column and a steel beam.

Priority is claimed on Japanese Patent Application No. 2015-019331, filed on  
February 3, 2015, Japanese Patent Application No. 2015-019332, filed on February 3,  
2015, and Japanese Patent Application No. 2015-237704, filed on December 4, 2015, the  
15 contents of which are incorporated herein by reference.

## Background Art

[0002]

Generally, in a composite structure which configures a main frame by an RC  
20 column (reinforced concrete column) and a steel beam, it is necessary to cause a shear  
reinforcement to penetrate the steel beam at a joint of the RC column and the steel beam.  
However, a work for allowing the shear reinforcement to penetrate the steel beam at the  
work site requires lots of time and labor.

[0003]

25 Accordingly, in many cases, the entire joint including the shear reinforcement or

a member such as a closing plate equivalent to the shear reinforcement is assembled and processed in advance in a factory, is carried to the work site, and is suspended and transported to be installed. A clip construction method is often adopted for arrangement of shear reinforcements (for example, refer to Patent Document 1, Patent Document 2,  
 5 and Patent Document 3).

[0004]

Meanwhile, when a composite structure building configured of an RC column and a steel beam is designed, the design is carried out such that a column-beam joint is assumed as either a rigid joint or a pin joint (for example, refer to Patent Document 1,  
 10 Patent Document 4, Patent Document 5, and Patent Document 6).

[0005]

In addition, as shown in FIGS. 26 to 28, if a case where an equally distributed load acts on a steel beam is considered, a bending moment generated in the steel beam is changed by a fixed state of a column-beam joint.

15 That is, in a case where the joints of both ends of the steel beam are rigid joints, as shown in FIG. 27, a bending moment generated in the steel beam becomes the maximum at the end portion of the steel beam, and a moment  $M_A$  of the end portion of the beam and a moment  $M_C$  of a span center are obtained by the following Expression (1) and Expression (2).  $M_{\max}$  indicates the maximum moment (beam end),  $w$  indicates an  
 20 equally distributed load (N/mm), and  $l$  is the span (mm).

[0006]

$$M_A = \frac{wl^2}{12} = M_{\max} \quad (1)$$

[0007]

$$M_C = \frac{wl^2}{24} \quad (2)$$

[0008]

Meanwhile, in a case where the joints of both ends of the steel beam are pin joints, as shown in FIG. 26, the bending moment generated in the steel beam is

5 maximized at the center portion of the span, and the moment  $M_A$  of the end portion of the beam and the moment  $M_C$  of a span center are obtained by the following Expression (3) and Expression (4).

[0009]

$$M_A = 0 \quad (3)$$

10 [0010]

$$M_C = \frac{wl^2}{8} = M_{\max} \quad (4)$$

## Citation List

### Patent Literature

15 [0011]

[Patent Document 1] Japanese Unexamined Utility Model Application, First Publication No. H05-57107

[Patent Document 2] Japanese Unexamined Patent Application, First Publication No. 2000-319984

20 [Patent Document 3] Japanese Unexamined Patent Application, First Publication No. 2001-193157

[Patent Document 4] Japanese Unexamined Patent Application, First  
Publication No. H08-4111

[Patent Document 5] Japanese Unexamined Patent Application, First  
Publication No. 2001-152550

5 [Patent Document 6] Japanese Unexamined Patent Application, First  
Publication No. 2012-193613

### Summary of Invention

#### Technical Problem

10 [0012]

However, first, in the case where the joint is assembled and processed in advance in a factory or the clip construction method is adopted, processing labor or a special member (clip) is required, which increases costs.

[0013]

15 In addition, in a case where the joint is not assembled and processed in advance in a factory or the clip construction method is not adopted, the shear reinforcement is fixed using a 135° hook or a 90° hook. However, even in this case, it is necessary to carry out a very difficult work of bending the shear reinforcement in a predetermined hook shape after causing the shear reinforcement to penetrate the steel beam at the work  
20 site. A through-hole of the steel beam is machined to be a long hole such that the hook-processed shear reinforcement can easily penetrate the steel beam. However, in this case, cross-sectional defect portions of the steel beam increase.

[0014]

25 Next, if it is possible to adjust a degree of fixation of the steel beam by evaluating the column-beam joint as a semi-rigid joint, it is possible to balance the

bending moment of the end portion of the beam and the bending moment of the span center. Accordingly, compared to the cases of the rigid joint and the pin joint, like the following Expression (5), it is possible to decrease the maximum moment.

[0015]

$$M_A = M_C = \frac{wl^2}{16} = M_{\max} \quad (5)$$

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[0016]

Patent Document 5 or Patent Document 6 is an example in which the column-beam joint is a semi-rigid joint. However, Patent Document 5 and Patent Document 6 are not intended for a composite structure building configured of a PCaRC column and a steel beam, and in Patent Document 5 and Patent Document 6, the configuration of the column-beam joint is complicated. In Patent Document 5 and Patent Document 6, any design method is not disclosed or suggested.

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#### Solution to Problem

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[0017]

The present invention adopts the following aspects in order to solve the above-described problems.

[0018]

(1) According to one aspect of the present invention, there is provided a joint structure of a reinforced concrete column and a steel beam configured to form a recess in a reinforced concrete column, insert an end portion of the steel beam into the recess, and fill the recess with a concrete so as to join the reinforced concrete column and the steel beam, in which a degree of fixation of the steel beam is adjusted by adjusting an

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embedded length of the end portion of the steel beam to the concrete filling the recess, and by adjusting the degree of fixation, the end portion of the steel beam is semi-rigidly joined to the reinforced concrete column, and a bending moment acting on the steel beam and a joint which joints the reinforced concrete column and the steel beam is adjusted.

5 [0019]

(2) In the joint structure of a reinforced concrete column and a steel beam described in (1), a relationship between the degree of fixation and an embedded length ratio which is a ratio between the embedded length and a beam height of the steel beam is obtained, and, based on the relationship between the degree of fixation and the embedded  
10 length ratio, the degree of fixation may be set such that a bending moment at a column face position and a maximum moment in a span of the steel beam balance each other.

[0020]

According to the joint structure of a reinforced concrete column and a steel beam described in (1) or (2), the design of the degree of fixation of the joint which is  
15 difficult in the related art is easily carried out by adjusting the embedded length of the steel beam.

[0021]

In addition, according to the joint structure of a reinforced concrete column and a steel beam described in (1) or (2), it is possible to optimize the generation moment of  
20 the steel beam by designing the degree of fixation of the joint. Accordingly, the size of the cross-section is decreased, and it is possible to reduce costs.

[0022]

(3) According to another aspect of the present invention, there is provided a method of joining a reinforced concrete column and a steel beam, including: inserting an  
25 end portion of a steel beam into a recess formed in a reinforced concrete column;

inserting a right angle hook of a shear reinforcement including a semicircular hook or an acute angle hook on one end side and the right angle hook on the other end side into a through-hole formed in a web of the steel beam, and rotating the shear reinforcement at a center of a bent portion of the right angle hook, and installing the shear reinforcement  
5 such that the right angle hook is arranged along the web of the steel beam; fixing the semicircular hook or the acute angle hook on the one side of the shear reinforcement to an auxiliary reinforcement arranged in the recess or a main reinforcement of the reinforced concrete column protruding toward the recess; and placing concrete in the recess.

10 [0023]

(4) According to still another aspect of the present invention, there is provided a joint structure of a reinforced concrete column and a steel beam, in which an end portion of a steel beam is inserted into a recess formed in a reinforced concrete column, a shear reinforcement including a semicircular hook or an acute angle hook on one end side and  
15 a right angle hook on the other end side is installed such that the right angle hook is inserted into a through-hole formed in a web of the steel beam and the right angle hook is arranged along the web of the steel beam, the semicircular hook or the acute angle hook on the one side of the shear reinforcement is fixed to an auxiliary reinforcement arranged in the recess or a main reinforcement of the reinforced concrete column protruding  
20 toward the recess, and concrete is placed in the recess such that the end portion of the steel beam, the shear reinforcement, and the auxiliary reinforcement or the main reinforcement of the reinforced concrete column is embedded in the recess.

[0024]

In the method of joining a reinforced concrete column and a steel beam  
25 described in (3) or the joint structure of a reinforced concrete column and a steel beam

described in (4), a special member such as a clip (that is used in the related art) or the like is not required, and the shear reinforcement can be installed while easily penetrating the steel beam at the work site. In this case, since the shear reinforcement can easily penetrate the through-hole of the steel beam having the size in the related art to be installed, and cross-sectional defects of the steel beam are not increased.

[0025]

(5) According to still another aspect of the present invention, there is provided a joint structure of a reinforced concrete column and a steel beam, in which an end portion of a steel beam is inserted into a recess formed in a reinforced concrete column, a first shear reinforcement which is connected to the steel beam and is arranged in the recess and a second shear reinforcement of the reinforced concrete column which protrudes toward the recess are connected to each other using a coupling member, a concrete is placed in the recess, and the end portion of the steel beam, the first shear reinforcement, the second shear reinforcement, and the coupling member are embedded in the concrete, and the coupling member is a tubular body which is provided to surround outer circumferences of the first shear reinforcement and the second shear reinforcement arranged in the recess and is crimped to each of the first shear reinforcement and the second shear reinforcement.

[0026]

In the joint structure of a reinforced concrete column and a steel beam described in (5), the end portion of the second shear reinforcement of the steel frame concrete column and the end portion of the first shear reinforcement connected to the steel beam and arranged in the recess are inserted into the tubular body, and the shear reinforcements are crimped by the tubular body which surrounds the shear reinforcements. That is, the first shear reinforcement and the second shear reinforcement are joined to each other by

crimping of the tubular body serving as a coupling member. Accordingly, it is possible to easily install the shear reinforcement of the joint of the reinforced concrete column and the steel beam.

[0027]

5 (6) According to still another aspect of the present invention, there is provided a joint structure of a reinforced concrete column and a steel beam, in which in a joint of the reinforced concrete column and the steel beam, a shear reinforcement of the reinforced concrete column is configured of a first shear reinforcement and a second shear reinforcement, and a tubular body in which the first shear reinforcement is inserted from  
10 one end portion and the second shear reinforcement is inserted from the other end portion is provided, the first shear reinforcement is inserted into a hole portion formed in the steel beam, the second shear reinforcement is arranged between the first shear reinforcements adjacent to each other around an axis of the reinforced concrete column, and the tubular body is crimped to the first shear reinforcement and the second shear  
15 reinforcement to surround outer circumferences of the first and second shear reinforcements.

[0028]

(7) According to still another aspect of the present invention, there is provided a method of joining a reinforced concrete column and a steel beam, in which in a joint of  
20 the reinforced concrete column and the steel beam, a shear reinforcement of the reinforced concrete column is configured of a first shear reinforcement and a second shear reinforcement, and a tubular body in which the first shear reinforcement is inserted from one end portion and the second shear reinforcement is inserted from the other end portion is provided, the first shear reinforcement is inserted into a hole portion formed in  
25 the steel beam, and the second shear reinforcement is arranged between the first shear

reinforcements adjacent to each other around an axis of the reinforced concrete column, the method including: a hole portion forming process of forming a hole portion in the steel beam; a first shear reinforcement installation process of inserting the first shear reinforcement into the hole portion; a shear reinforcement tubular body insertion process of inserting the first shear reinforcement into the tubular body from the one end portion and inserting the second shear reinforcement into the tubular body from the other end portion; and a crimping process of crimping the tubular body to the first shear reinforcement and the second shear reinforcement to surround outer circumferences of the first and second shear reinforcements.

10 [0029]

In the joint structure of a reinforced concrete column and a steel beam described in (6) or the method of joining a reinforced concrete column and a steel beam described in (7), the first shear reinforcement inserted into the hole portion of the steel beam and the second shear reinforcement arranged between the first shear reinforcements adjacent to each other around the axes of the steel beam and the reinforced concrete column are inserted into the tubular body, and the tubular body crimps the first shear reinforcement and the second shear reinforcement so as to surround the first shear reinforcement and the second shear reinforcement. That is, the first shear reinforcement and the second shear reinforcement are joined to each other by the crimping of the tubular body with respect to the first shear reinforcement and the second shear reinforcement.

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[0030]

Therefore, according to the joint structure of a reinforced concrete column and a steel beam described in (6) or the method of joining a reinforced concrete column and a steel beam described in (7), since the tubular body is crimped to the first shear reinforcement and the second shear reinforcement inserted into the tubular body so as to

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join the first shear reinforcement and the second shear reinforcement to each other, it is possible to easily install the shear reinforcement of the joint of the reinforced concrete column and the steel beam.

[0031]

5           In addition, according to the joint structure of a reinforced concrete column and a steel beam described in (6) or the method of joining a reinforced concrete column and a steel beam described in (7), since a special member such as a clip for joining the first shear reinforcement and the second shear reinforcement is not required, compared to a case where the special member is used, it is possible to reduce costs.

10           [0032]

          According to the joint structure of a reinforced concrete column and a steel beam described in (6) or the method of joining a reinforced concrete column and a steel beam described in (7), since the hole portion formed in the steel beam may have any shape as long as it has a diameter which is slightly larger than the outer diameter of the first shear reinforcement, it is possible to easily form the hole portion and it is possible to decrease cross-sectional defect portions of the steel beam.

[0033]

          (8) In the joint structure of a reinforced concrete column and a steel beam described in (6), the first shear reinforcement and the second shear reinforcement may be arranged such that tip portions of the first and second shear reinforcements abut on each other inside the tubular body.

[0034]

          In this case, compared to a case where the first shear reinforcement and the second shear reinforcement are arranged to overlap each other, it is possible to decrease the diameter of a steel pipe.

[0035]

(9) In the joint structure of a reinforced concrete column and a steel beam described in (6), the first shear reinforcement and the second shear reinforcement may be arranged to overlap each other inside the tubular body.

5 [0036]

In this case, since any shape may be adopted as long as the tubular body is crimped to the portion in which the first shear reinforcement and the second shear reinforcement overlap each other, compared to the case where the first shear reinforcement and the second shear reinforcement are arranged such that the tip portions  
10 abut on each other, it is possible to decrease the length (length of the coupling) of the tubular body.

#### Advantageous Effects of Invention

[0037]

15 According to the joint structure of a reinforced concrete column and a steel beam and the method of joining a reinforced concrete column and a steel beam of the present invention, processing of the steel frame is easily carried out, and the joining of the reinforced concrete column and the steel beam can be easily carried out.

[0038]

20 In addition, according to the joint structure of a reinforced concrete column and a steel beam and the method of joining a reinforced concrete column and a steel beam of the present invention, semi-rigid joining is carried out with respect to the column-beam joint, and it is possible to decrease the maximum moment and to rationally (suitably) configure the column-beam joint.

## Brief Description of Drawings

[0039]

FIG. 1 is a longitudinal sectional view showing a joint structure of a reinforced concrete column and a steel beam according to a first embodiment.

5        FIG. 2 is a sectional view taken along line X1-X1 in FIG. 1.

FIG. 3 is a sectional view taken along line X2-X2 in FIG. 1.

FIG. 4 is a longitudinal sectional view showing a lower section RC column of the joint structure of the reinforced concrete column and the steel beam according to the first embodiment.

10       FIG. 5 is a sectional view taken along line X1-X1 in FIG. 4.

FIG. 6 is a sectional view taken along line X2-X2 in FIG. 4.

FIG. 7 is a diagram showing a relationship between a degree of fixation and an embedded length ratio of the joint structure of the reinforced concrete column and the steel beam according to the first embodiment.

15       FIG. 8 is a diagram showing a relationship between the degree of fixation of the joint structure of the reinforced concrete column and the steel beam and the maximum moment of the steel beam according to the first embodiment.

FIG. 9 is a view showing a shear reinforcement used in a method of joining a reinforced concrete column and a steel beam according to a second embodiment.

20       FIG. 10 is a view showing a state where the shear reinforcement penetrates the steel beam so as to be installed in the method of joining the reinforced concrete column and the steel beam according to the second embodiment.

FIG. 11 is a side view (longitudinal sectional) view showing the joint structure of the reinforced concrete column and the steel beam according to the second embodiment.

25       FIG. 12 is a cross-sectional view showing the joint structure of the reinforced

concrete column and the steel beam according to the second embodiment.

FIG. 13 is a front longitudinal sectional view showing the joint structure of the reinforced concrete column and the steel beam according to the second embodiment.

FIG. 14 is a side longitudinal sectional view showing a lower reinforced concrete  
5 column member of the joint structure of the reinforced concrete column and the steel beam according to the second embodiment.

FIG. 15 is a cross-sectional view showing the lower reinforced concrete column member of the joint structure of the reinforced concrete column and the steel beam according to the second embodiment.

10 FIG. 16 is a front longitudinal sectional view showing the lower reinforced concrete column member of the joint structure of the reinforced concrete column and the steel beam according to the second embodiment.

FIG. 17 is a front longitudinal sectional view showing an upper reinforced concrete column member of the joint structure of the reinforced concrete column and the  
15 steel beam according to the second embodiment.

FIG. 18 is a perspective view showing an example of a joint of a reinforced concrete column and a steel beam according to a third embodiment.

FIG. 19 is a sectional view taken along line X1-X1 in FIG. 18.

FIG. 20 is a sectional view taken along line X2-X2 in FIG. 18.

20 FIG. 21 is a view for explaining a steel beam and a first shear reinforcement.

FIG. 22 is a view for explaining a reinforced concrete column before steel frames are arranged.

FIG. 23 is a front view for explaining a joint portion of the first shear reinforcement and a second shear reinforcement.

25 FIG. 24 is a sectional view taken along line X1-X1 in FIG. 23.

FIG. 25 is a view for explaining a state before a tubular body is crimped to the first shear reinforcement and the second shear reinforcement.

FIG. 26 is a diagram showing a bending moment in a case where a column and a beam is joined to each other by a both-end pin joint.

5           FIG. 27 is a diagram showing a bending moment in a case where the column and the beam are joined to each other by a both-end rigid joint.

FIG. 28 is a diagram showing a bending moment in a case where the column and the beam are joined to each other by a both-end semi-rigid joint.

## 10   Description of Embodiments

[0040]

Hereinafter, a joint structure of a reinforced concrete column (hereinafter, referred to as an RC column) and a steel beam according to a first embodiment of the present invention will be described with reference to FIGS. 1 to 8.

15           [0041]

Here, in the joint structure of the RC column and the steel beam of the present embodiment, a column-beam joint is a semi-rigid joint as shown in FIG. 28.

Accordingly, a degree of fixation of the column-beam joint can be adjusted, and the maximum bending moment of the steel beam can be decreased. In addition, the first

20           embodiment relates to a method capable of decreasing the maximum bending moment of the steel beam by the joint structure of the RC column and the steel beam so as to rationally design the column-beam joint (steel beam and RC column).

[0042]

First, a joint structure 100 of the RC column and the steel beam of the present  
25           invention includes an RC column 40 of a lower section PCa, a steel beam 41, an RC

column 42 of an upper section PCa, and a joint concrete 43 as main structural elements. The end portion of the steel beam 41 is embedded in the RC column 40 of the lower section PCa, and the steel beam 41 is fixed to the RC column 40 by filling the embedding portion with the joint concrete 43.

5 [0043]

Specifically, in the joint structure 100 of the RC column and the steel beam of the present embodiment, as shown in FIGS. 1 to 6, the lower section RC column 40 is formed by embedding a plurality of main reinforcements 44 extending in a vertical direction and a plurality of shear reinforcements 45 integrally attached so as to surround  
10 the plurality of main reinforcements 44 in concrete 46. In addition, the main reinforcements 44 are formed to protrude from the upper surface of the lower section RC column 40.

[0044]

In the lower section RC column 40 of the present embodiment, a rectangular  
15 recess (notch) 47 which is open to the upper surface and one side surface is provided at the center in the width direction. Since the end portion of the steel beam 41 is inserted into the recess 47 such that the steel beam 41 is joined, a checkered steel plate 48 is arranged on the inner surface of the recess 47, irregularities are formed on the surface of the checkered steel plate 48, and the checkered steel plate 48 functions as a shear cotta 49  
20 which transfers shear stress into the joint (column-beam joint).

[0045]

Meanwhile, as shown in FIGS. 1 to 3, the steel beam 41 of the present embodiment does not require processing which expects special structural performance, and a required length of the steel beam 41 may be any length as long as it can be  
25 embedded in the lower section RC column 40. Accordingly, it is possible to carry a raw

material from a mill manufacturer to the work site as it is and assemble it, and it is possible to reduce costs by promoting a management without fabrication facility.

[0046]

In addition, a level adjustment bolt 50 for adjusting a height which is a  
5 temporary member is installed in the lower section RC column 40, and the steel beam 41 includes a triangular rib 51 for preventing out-of-plane deformation of a lower flange when the steel beam 41 receives the own weight through the level adjustment bolt 50. High nuts 52 are welded at four locations of an upper flange, and the steel beam 41 is positioned by adjusting (screwing and unscrewing of the bolt 53) a screwing amount of  
10 the bolt 53. The triangular rib 51 and the high nuts 52 can be installed by on-site welding, and do not require a special management such as ultrasonic flaw detection inspection (UT inspection).

[0047]

The shear reinforcement penetrating the steel beam 41 inside the joint is not  
15 arranged. The shear reinforcements 45 are provided so as to mainly prevent buckling of the main reinforcements 44, and in the present embodiment, U-shaped shear reinforcements 45 are arranged in the joint.

[0048]

Next, the upper section RC column 42 is formed by embedding the plurality of  
20 main reinforcements 44 extending in the vertical direction and the plurality of shear reinforcements 45 integrally attached so as to surround the plurality of main reinforcements 44 in concrete 46.

[0049]

In the upper section RC column 42, sleeves 54 which are attached to the lower  
25 ends of the main reinforcements 44 and are open to the lower end surfaces are embedded

in the concrete 46.

[0050]

The upper section RC column 42 is installed on the lower section RC column 40.

In this case, the main reinforcements 44 protruding from the upper surface of the lower

5 section RC column 40 are inserted into the sleeves 54 of the upper section RC column 42, the insides of the sleeves 54 are filled with grout, and the upper section RC column 42 is integrally joined to the lower section RC column 40. Joint grout is injected a portion between the upper section RC column 42 and the lower section RC column 40.

[0051]

10 Next, at the step where the lower section RC column 40 is installed, the end portion of the steel beam 41 is inserted into the recess 47 of the lower section RC column 40 and the steel beam 41 is arranged. In addition, a formwork is installed and concrete 43 is placed in the recess 47. In this case, the joint concrete 43 can use general concrete which is prepared, the steel beam 41 is installed in the lower section RC column 40, and  
15 the joint concrete 43 is placed at the same time when a floor slab is placed. A gap between the four inner surfaces of the recess 47 and the steel beam 41 is secured to be approximately 100 mm. In FIG. 1, a reference numeral 55 indicates a top end (an upper surface of the floor slab) of the floor slab.

[0052]

20 In this way, the joint A of the RC column and the steel beam 2 of the present embodiment is configured, and it is possible to join the RC column 1 and the steel beam by a semi-rigid joint.

[0053]

Next, a design method of the joint structure 100 of the RC column and the steel  
25 beam of the present embodiment will be described.

[0054]

In the embodiment, the degree of fixation of the joint structure 100 of the RC column and the steel beam realized by a semi-rigid joint is adjusted by an embedded length of the steel beam 41.

5 [0055]

Here, if a moment of a column face position of the column-beam joint is non-dimensionalized by a moment of the end portion in a case of fixed support, the following Expression (6) is obtained. In addition,  $_{rig}M_A$  ( $= M_A$  fixed) indicates a moment when is fixed (a moment at the time of a rigid joint),  $\alpha = 1$ . 0 indicates when is completely fixed, and  $\alpha = 0.0$  indicates when is pin-supported.

[0056]

$$\alpha = \frac{M_A}{_{rig}M_A} \quad (6)$$

[0057]

FIG. 7 indicates a relationship between a degree of fixation  $\alpha$  and an embedded length ratio  $d/H$  ( $d$ : embedded length and  $H$ : beam height) obtained from FEM analysis. From this drawing, it was confirmed that the degree of fixation  $\alpha$  increased as the embedded length ratio  $d/H$  increased.

[0058]

Moreover, the degree of fixation  $\alpha$  of the column-beam joint is given by the following Expression (7) from the result of FIG. 7, and it is possible to obtain the degree of fixation  $\alpha$  when the embedded length ratio  $d/H$  of the steel beam 2 is adjusted, by Expression (7). In addition,  $N/N_0$  is an axial force ratio.

[0059]

$$\alpha = \left( 0.30 \frac{d}{H} + 0.55 \right) \cdot \left( 0.52 \frac{N}{N_0} + 0.90 \right) \quad (7)$$

[0060]

Next, FIG. 8 indicates a relationship between the degree of fixation  $\alpha$  and the maximum moment ( $M_{\max}$  ( $M_A$ ,  $M_0$ )) of the beam 41. As shown in FIG. 8,  $M_A = M_0$  when the degree of fixation  $\alpha = 0.69$ , and the maximum moment is the minimum value. That is, according to the joint structure 100 of the RC column and the steel beam of the present embodiment, it was confirmed that the moment for the design of the beam could be made 0.69 times as compared to the case where the column is rigidly joined.

[0061]

Next, a flow of optimum design of a steel beam cross-section is shown.

[0062]

First, design conditions such as the span  $l$ , the load  $w$ , the axial force ratio, or a material to be used of the steel beam 41 are set.

[0063]

Next, from the following Expressions (8), (9), and (10), an end portion moment when the end portion is fixed is calculated and a provisional section is determined. A central moment and maximum deformation are calculated.  $E$  is Young's modulus of the steel beam and  $I$  is a cross-sectional secondary moment of the steel beam.

[0064]

$${}_{rig} M_A = -\frac{1}{8} w l^2 \quad (8)$$

[0065]

$${}_{rig} M_0 = \frac{9}{128} w l^2 \quad (9)$$

[0066]

$${}_{rig} \delta_{\max} = 0.00541 \frac{w l^4}{EI} \quad (10)$$

[0067]

5           Next, the degree of fixation  $\alpha$  of the joint A at the time of the semi-rigid joint is determined, and the embedded length  $d$  is determined. In this case, the optimum value of the degree of fixation  $\alpha$  is 0.69, and in a case where  $N/N_0 = 0.2$ , the embedded length ratio  $d/H = (\alpha - 0.55) / (0.52 \times 0.20 + 0.90) \div 0.30 = 0.46$ , and it is preferable when the embedded length  $d$  which is approximately half of the beam height  $H$  is secured.

10           [0068]

Next, the end portion moment, the central moment, and the maximum deformation when the degree of fixation is  $\alpha$  are calculated by the following Expressions (11), (12), and (13), and the cross-section is determined.

[0069]

$$M_A = \alpha * {}_{rig} M_A \quad (11)$$

[0070]

$$M_0 = (1.00 - 0.44\alpha) * {}_{rig} M_0 \quad (12)$$

[0071]

$$\delta_{\max} = (2.41 - 1.41\alpha) * {}_{rig} \delta_{\max} \quad (13)$$

20           [0072]

Moreover, the joint strength of the embedded portion is confirmed, and when OK (good) is determined, the design is completed. In a case where NG (bad) is determined, the degree of fixation  $\alpha$  of the semi-rigid joint is changed, the embedded length  $d$  is changed, and calculation is carried out again.

5 [0073]

Accordingly, in the joint structure 100 of the RC column and the steel beam of the present embodiment, the design of the degree of fixation  $\alpha$  of the joint which is difficult in the related art is easily carried out by adjusting the embedded length  $d$  of the steel beam 41.

10 [0074]

Moreover, it is possible to optimize the generation moment of the steel beam 41 by designing the degree of fixation  $\alpha$  of the joint A. Accordingly, the size of the cross-section is decreased, and it is possible to reduce costs.

[0075]

15 Hereinbefore, the first embodiments of the joint structure of the reinforced concrete column and the steel beam according to the present invention are described. However, the present invention is not limited to the first embodiments and can be appropriately modified within a scope which does not depart from the gist.

[0076]

20 Next, a joint structure of an RC column (reinforced concrete column) and a steel beam and a method of joining an RC column and a steel beam according to a second embodiment of the present invention will be described with reference to FIGS. 9 to 17. Here, the method of joining the RC column and the steel beam according to the second embodiment relates a method of joining the RC column and the steel beam while  
25 allowing a shear reinforcement to penetrate the steel beam at the work site so as to fix the

shear reinforcement to the steel beam.

[0077]

In the method of joining the RC column and the steel beam and a joint structure 200 of the RC column and the steel beam according to the second embodiment, as shown  
5 in FIG. 9, a used shear reinforcement 1 is formed to include a semicircular hook ( $180^\circ$  hook) (or acute angle hook) 2 on one end side and a right angle hook ( $90^\circ$  hook) 3 on the other end side.

[0078]

Moreover, as shown in FIGS. 9 and 10, a folding radius (an inner diameter of a  
10 bent portion)  $d$  of the right angle hook 3 is equal to or more than a plate thickness  $t_w$  of a web 4a of a penetrated steel beam 4. In addition, a diameter  $R$  of a through-hole 4b of the steel beam 4 through which the shear reinforcement 1 penetrates is equal to or more than an outermost diameter  $D$  of the shear reinforcement 1.

[0079]

Moreover, when the shear reinforcement 1 is installed, as shown in FIG. 10, the  
15 other end on the right angle hook 3 side is inserted into the through-hole 4b of the steel beam 4, rotates with a bent portion of a base end of the right angle hook 3 as a rotation center, and the shear reinforcement rotates by  $90^\circ$  around the through-hole 4b along the folding radius  $d$  of the bent portion. Accordingly, the shear reinforcement 1 penetrates  
20 the through-hole 4b of the steel beam 4, and it is possible to install the shear reinforcement 1 such that the right angle hook 3 is arranged along the web 4a of the steel beam 4. In this way, if the semicircular hook 2 on the one side of the shear reinforcement 1 arranged to penetrate the steel beam 4 is fixed to the column main reinforcement or the like, the installation work of the shear reinforcement 1 is completed.

25 [0080]

Here, as an example of an embedding type joint structure 200 of an RC column 5 of PCa and the steel beam 4 shown in FIGS. 11 to 13, the method of joining the RC column 5 and the steel beam 4 according to the first embodiment will be more specifically described.

5 [0081]

First, the RC column 5 of PCa of the joint structure 200 is configured by integrally joining the upper RC column member 5a and the lower RC column member 5b. In addition, as shown in FIGS. 11 to 16, the lower RC column member 5b is formed by embedding a plurality of main reinforcements 6 extending in a vertical direction and a  
10 plurality of shear reinforcements 7 integrally attached so as to surround the plurality of main reinforcements 6 in concrete 8. In addition, a joint plate (end plate) 10 for connecting (bolt-joining) the RC columns 5 of PCa adjacent to each other in the vertical direction is integrally attached to the lower end of the lower RC column member 5b. The main reinforcements 6 are formed to protrude from the surface of the lower RC  
15 column member 5b.

[0082]

In the lower RC column member 5b, a rectangular recess (notch) 11 which is open to the upper surface and the side surfaces is provided at the center in the width direction. The recess 11 is configured such that the end portion of the steel beam 4 is  
20 inserted into the recess 11 and the steel beam 4 is joined to the recess 11, and a shear cotta (checkered steel plate) 12 is formed to be integrated with the concrete 8.

[0083]

As shown in FIGS. 11 to 13 and FIG. 17, the upper RC column member 5a is formed by embedding the plurality of main reinforcements 6 extending in a vertical  
25 direction and the plurality of shear reinforcements 7 integrally attached so as to surround

the plurality of main reinforcements 6 in the concrete 8, and the joint plate (end plate) 10 for connecting (bolt-joining) the RC columns 5 of PCa adjacent to each other in the vertical direction is integrally attached to the upper end of the upper RC column member 5a.

5 [0084]

In the upper RC column member 5a, sleeves 13 which are attached to the lower ends of the main reinforcements 6 and are open to the lower end surfaces are embedded in the concrete 8.

[0085]

10 In addition, as shown in FIGS. 11 to 13, in the upper RC column member 5a and the lower RC column member 5b configured as described above, the lower RC column member 5b is placed on the upper end joint plate 10 of the lower RC column 5 of PCa, and the mutual joint plates 10 are bolt-joined. Next, the upper RC column member 5a is installed on the lower RC column member 5b. In this case, the main reinforcements 6  
15 protruding from the upper surface of the lower RC column member 5b are inserted into and connected to the sleeves 13 of the upper RC column member 5a, and the upper RC column member 5a is integrally joined to the lower RC column member 5b. Accordingly, the RC column 5 of PCa is formed on each of the upper end and the lower end.

20 [0086]

Meanwhile, in the method of joining the RC column 5 and the steel beam 4 according to the second embodiment, at a step where the lower RC column member 5b is installed, the end portion of the steel beam 4 is inserted into the recess 11 of the lower RC column member 5b and the steel beam 4 is arranged.

25 [0087]

As shown in FIGS. 9, 10, and 11 to 13, the right angle hook 3 is inserted into the through-hole 4b formed in the steel beam 4, the shear reinforcement 1 rotates by 90° around the through-hole 4b along the folding radius d of the right angle hook 3 so as to be installed. The semicircular hook 2 of the shear reinforcement 1 arranged to penetrate the steel beam 4 is fixed to an auxiliary reinforcement 14 which is inserted into the recess 11 after the shear reinforcement 1 is inserted.

In addition, the main reinforcement 6 of the lower RC column member 5b may protrude toward the recess 11 so as to fix the semicircular hook (or acute angle hook) 2 of the shear reinforcement 1 to the main reinforcement 6.

10 [0088]

As described above, at the step where the steel beam 4, the shear reinforcement 1, or the like is installed, the upper RC column member 5a is installed. Moreover, a formwork is installed, the concrete 8 is placed in the recess 11, the end portion of the steel beam 4, the shear reinforcement 1, and the auxiliary reinforcement 14 (or main reinforcement 6) are embedded in the concrete 8, and the RC column 5 and the steel beam 4 are integrally joined to each other.

[0089]

Therefore, according to the joint structure 200 of the RC column and the steel beam and the method of joining the RC column and the steel beam of the second embodiment, a special member such as a clip (that is used in the related art) or the like is not required, and the shear reinforcement 1 can be installed while easily penetrating the steel beam 4 at the work site. In this case, since the shear reinforcement 1 can easily penetrate the through-hole 4b of the steel beam 4 having the size in the related art to be installed, and cross-sectional defects of the steel beam 4 are not increased.

25 [0090]

Hereinbefore, the second embodiments of the joint structure of the RC column and the steel beam and the method of joining the RC column and the steel beam according to the present invention are described. However, the present invention is not limited to the second embodiments and can be appropriately modified within a scope which does not depart from the gist.

[0091]

For example, in the second embodiment, the shear reinforcement 1 is formed to include the semicircular hook or the acute angle hook 2 on one end side and the right angle hook 3 on the other end side.

[0092]

Meanwhile, a straight bar-shaped shear reinforcement (first shear reinforcement) 1 which does not include a circular hook, the acute angle hook 2, or the right angle hook 3 may be used, and the first shear reinforcement 1 may be connected to the shear reinforcement (second shear reinforcement) of the RC column 5, which protrudes from the RC column 5 to the recess 11, using a crimp coupler (coupling member).

[0093]

In addition, a tubular body 30 described in detail later (shown in a third embodiment) may be used as the coupling member of the crimp coupler. In this case, a second shear reinforcement (23: refer to FIGS. 22 and 23) and the first shear reinforcement 1 which are integrally embedded in the RC column 5 and include end portions protruding toward the recess 11 are inserted into the tubular body 30, and the first shear reinforcement 1 and the second shear reinforcement (24) can be crimped by the tubular body 30. In this way, since the first shear reinforcement 1 and the second shear reinforcement (24) are joined by the crimping of the tubular body 30 serving as the coupling member, it is possible to easily install the shear reinforcement of the joint of the

RC column 5 and the steel beam 4, and as a result, it is possible to suitably join the RC column 5 and the steel beam 4.

[0094]

Next, a joint structure of an RC column (reinforced concrete column) and a steel beam and a method of joining an RC column and a steel beam according to a third embodiment of the present invention will be described with reference to FIG. 18 to 25.

[0095]

As shown in FIGS. 18 to 20, a joint structure 300 of an RC column and a steel beam according to the third embodiment has a structure of a joint 22 in which steel beams 21 are joined to an RC column 20 having an approximately square cross-sectional shape from four sides. Moreover, in FIG. 18, the first shear reinforcement 23 and the second shear reinforcement 24 of the joint 22 of the RC column 20 and the steel beams 21 are omitted.

[0096]

As shown in FIGS. 19 to 21, for example, in the case of which each of the steel beams 21 is an H-shaped steel, the steel beams 21 are jointed at the joint 22 that connects the RC column 20 and the steel beams 21 so that one steel beam 21 extending in a horizontal direction and the other steel beam 21 extending in a direction orthogonal to the horizontal direction are joined to be orthogonal to each other. In each steel beam 21, hole portions 26 into which the first shear reinforcement 23 of the RC column 20 is inserted are formed in the webs 25 of the portions embedded in the RC column 20.

[0097]

A plurality of column main reinforcements 27, the plurality of first shear reinforcements 23 inserted into the steel beams 21, and the plurality of second shear reinforcements 24 which are not inserted into the steel beams 21, are respectively

arranged between the adjacent first shear reinforcements 23 around the axis of the RC column 20, and are joined to the first shear reinforcements 23 are embedded in the joint 22 of the RC column 20 and the steel beam 21. In the third embodiment, each of the plurality of first shear reinforcements 23 shown in FIGS. 19 to 21 is formed in a linear shape. In addition, each of the plurality of second shear reinforcements 24 shown in FIGS. 19 to 21 is formed to be bent to have an approximately L shape.

[0098]

In the third embodiment, as shown in FIG. 19, four first shear reinforcements 23 and four second shear reinforcements 24 are alternately arranged one by one at the same height around the axis of the RC column 20 and are arranged to draw an approximately square shape in a plan view. A plurality of shear reinforcements configured of four first shear reinforcements 23 and four second shear reinforcements 24 arranged to draw an approximately square shape in a plan view are arranged in the height direction.

For each of the plurality of first shear reinforcements 23 and the plurality of second shear reinforcements 24, a deformed reinforcement such as D10 (SD345) is used.

[0099]

As shown in FIGS. 23 and 24, in the joint portion of the first shear reinforcement 23 and the second shear reinforcement 24, a tip portion 28 of the first shear reinforcement 23 and a tip portion 29 of the second shear reinforcement 24 are inserted into the tubular body 30, and the tubular body 30 is crimped to the tip portion 28 and the tip portion 29.

[0100]

For example, for the tubular body 30, a carbon steel pipe for pressure piping of STPG 370 or the like is used. The tip portion 28 of the first shear reinforcement 23 is inserted into the tubular body 30 from one side in an axial direction and the tip portion 29

of the second shear reinforcement 24 is inserted into the tubular body 30 from the other side in the axial direction. The tip portion 28 of the first shear reinforcement 23 and the tip portion 29 of the second shear reinforcement 24 inserted into the tubular body 30 coaxially abut on each other.

5 [0101]

As shown in FIG. 25, the tubular body 30 is formed in a cylindrical shape when the tubular body 30 is manufactured, and as shown in FIGS. 23 and 24, the tubular body 30 is deformed when the tubular body 30 is crimped to the tip portion 28 of the first shear reinforcement 23 and the tip portion 29 of the second shear reinforcement 24.

10 In the third embodiment, the crimping of the tubular body 30 with respect to the tip portion 28 of the first shear reinforcement 23 and the tip portion 29 of the second shear reinforcement 24 is carried out by a crimping tool having a hexagonal compression dice which can press the tubular body 30 in a state where the tubular body 30 is interposed by the compression dice in a direction orthogonal to the axis.

15 [0102]

The tubular body 30 is crimped to the tip portion 28 of the first shear reinforcement 23 and the tip portion 29 of the second shear reinforcement 24 so as to surround the outer circumferences of the first and second shear reinforcements 23 and 24 by pressing the tubular body 30 using the crimping tool.

20 [0103]

Since the tubular body 30 is crimped to the tip portion 28 of the first shear reinforcement 23 and the tip portion 29 of the second shear reinforcement 24, a node 31 of the first shear reinforcement 23 and a node 32 of the second shear reinforcement 24 are embedded into the tubular body 30.

25 [0104]

In this way, since the tubular body 30 is crimped to the tip portion 28 of the first shear reinforcement 23 and the tip portion 29 of the second shear reinforcement 24, the first shear reinforcement 23 and the second shear reinforcement 24 are joined to each other.

5 [0105]

Since the tubular body 30 is crimped to the tip portion 28 of the first shear reinforcement 23 and the tip portion 29 of the second shear reinforcement 24 using the crimping tool having a hexagonal compression dice, the tubular body 30 is pressed by an approximately uniform compression force in the entire circumferential direction.

10 Accordingly, it is possible to prevent the tubular body 30 from being deformed to be bent. In addition, when a stopper function by which a load is removed if a predetermined load is applied to the crimping tool is provided, a compression load by which the tubular body 6 is pressed is easily managed constantly, and a quality of the joint 22 of the RC column 20 and the steel beam 21 is easily managed.

15 In the third embodiment, the tubular body 30 is crimped (pressed) by the crimping tool at a plurality of locations with gaps in a length direction of the tubular body 30.

[0106]

20 Next, the method of joining the RC column and the steel beam according to the third embodiment will be described.

First, a hole portion forming process of forming hole portions 26 through which the first shear reinforcements 23 are inserted into the webs 25 of the steel beams 21 is performed. In addition, a steel beam joining process of joining the steel beams 21 in a state where the steel beams 21 are orthogonal to each other is also performed before or  
25 after the hole portion forming process.

[0107]

In the method of joining the RC column and the steel beams according to the third embodiment, the hole portion forming process is performed at a factory or the like, and the steel beams 21 in which the hole portions 26 are formed are carried to the work site. In addition to the hole portion forming process, the steel beam joining process may be also performed at a factory or the like, and the steel beams 21 to which the hole portions 26 are formed and which are joined to be orthogonal to each other may be carried to the work site.

[0108]

10 A steel beam installation process of installing the steel beams 21, which include the hole portions 26 formed on the webs 25 and are joined to be orthogonal to each other, on the joint 22 is performed.

[0109]

15 A first shear reinforcement installation process of inserting the first shear reinforcements 23 into the hole portions 26 of the web 25 is performed. In the steel beam installation process and the first shear reinforcement installation process, the first shear reinforcement installation process may be performed first, and the steel beam installation process may be performed after the first shear reinforcements 4 are temporarily set to the steel frame.

20 [0110]

A shear reinforcement insertion process of inserting the tip portions 28 of the first shear reinforcement 23 into the tubular bodies 30 and inserting the tip portions 29 of the second shear reinforcements 24 into the tubular bodies 30 is performed.

[0111]

25 A crimping process of causing the tubular bodies 30 to crimp the tip portions 28

of the first shear reinforcements 23 and the tip portions 29 of the second shear reinforcements 24 to surround the outer circumferences of the first and second shear reinforcements is performed.

[0112]

5           In the crimping process, the tubular bodies 30 are crimped to the tip portions 28 of the first shear reinforcements 23 and the tip portions 29 of the second shear reinforcements 24 using the crimping tool having a hexagonal compression dice. Each of the tubular bodies 30 is crimped (pressed) by the crimping tool in a plurality of locations with gaps in the length direction of the tubular body 30.

10           In this way, the first shear reinforcements 23 and the second shear reinforcements 24 are joined to each other.

[0113]

Next, the formwork of the joint 22 is installed, and a concrete material is placed inside the formwork and is hardened. In this way, the RC column 20 and the steel  
15   beams 21 are joined to each other.

[0114]

Hereinafter, effects of the joint structure 300 of the RC column and the steel beam and the method of joining the RC column and the steel beam according to the third embodiment will be described with reference to the drawings.

20           [0115]

In the joint structure 300 of the RC column and the steel beam and the method of joining the RC column and the steel beam according to the third embodiment, if the tip portions 28 of the first shear reinforcements 23 and the tip portions 29 of the second shear reinforcements 24 are inserted into the tubular bodies 30 and the tubular bodies 30  
25   are crimped to the first shear reinforcements 23 and the second shear reinforcements 24

inserted into the tubular bodies. Therefore, the first shear reinforcements 23 and the second shear reinforcements 24 are joined to each other. Accordingly, it is possible to easily install the shear reinforcements of the joint 22 of the RC column 20 and the steel beams 21, and it is possible to easily construct the joint 22 of the RC column 20 and the steel beams 21.

[0116]

In addition, since a special member such as a clip for joining the first shear reinforcement 23 and the second shear reinforcement 24 is not required, compared to a case where the special member is used, it is possible to reduce costs.

[0117]

In addition, since each of the hole portions 26 formed in the web 25 of each steel beam 21 may have any shape as long as it has a diameter which is slightly larger than the outer diameter of the first shear reinforcement 23, it is possible to easily form the hole portions 26 and it is possible to decrease cross-sectional defect portions of the steel beams 21.

[0118]

Since the first shear reinforcement 23 and the second shear reinforcement 24 are arranged such that the tip portions thereof abut on each other inside the tubular body 30, compared to a case where the first shear reinforcement 23 and the second shear reinforcement 24 are arranged to overlap each other, it is possible to decrease the diameter of the tubular body 30.

[0119]

Hereinbefore, the third embodiments of the joint structure of the RC column and the steel beam and the method of joining the RC column and the steel beam according to the present invention are described. However, the present invention is not limited to the

third embodiments and can be appropriately modified within a scope which does not depart from the gist.

[0120]

For example, in the third embodiment, the steel beams 21 are joined to be  
5 orthogonal to each other. However, the steel beams 21 may extend in only one direction and may be joined to intersect each other unlike to the case of being orthogonal to each other.

[0121]

In the third embodiment, the tubular bodies 30 are crimped to the tip portions 28  
10 of the first shear reinforcements 23 and the tip portions 29 of the second shear reinforcements 24 using the crimping tool having a hexagonal compression dice. However, the tubular bodies 30 may be crimped to the tip portions 28 of the first shear reinforcements 23 and the tip portions 29 of the second shear reinforcements 24 using other crimping tools.

15 [0122]

In the third embodiment, the first shear reinforcements 23 and the second shear reinforcements 24 are arranged such that the tip portions 28 of the first shear reinforcements 23 and the tip portions 29 of the second shear reinforcements 24 abut on each other inside the tubular bodies 30. However, the first shear reinforcements 23 and  
20 the second shear reinforcements 24 may be arranged such that the tip portions 28 of the first shear reinforcements 23 and the tip portions 29 of the second shear reinforcements 24 overlap each other inside the tubular bodies 30. Moreover, the tip portions 28 of the first shear reinforcements 23 and the tip portions 29 of the second shear reinforcements 24 overlap each other inside the tubular bodies 30, and the vicinities of the tip portions 28  
25 of the first shear reinforcements 23 and the vicinities of the tip portions 29 of the second

shear reinforcements 24 may protrude from sides opposites to the sides inserted into the tubular bodies 30.

#### Industrial Applicability

5 [0123]

According to the joint structure of a reinforced concrete column and a steel beam and the method of joining a reinforced concrete column and a steel beam of the present invention, processing of the steel frame is easily carried out, and the joining of the reinforced concrete column and the steel beam can be easily carried out. In addition, according to the joint structure of a reinforced concrete column and a steel beam and the method of joining a reinforced concrete column and a steel beam of the present invention, the column-beam joint is carried out by semi-rigid joining, and it is possible to decrease the maximum moment and to rationally (suitably) configure the column-beam joint.

#### 15 Reference Signs List

[0124]

1: shear reinforcement

2: semicircular hook (or acute angle hook)

3: right angle hook

20 4: steel beam

4a: web

4b: through-hole

5: RC column (reinforced concrete column)

5a: upper RC column member

25 5b: lower RC column member

|    |                                            |
|----|--------------------------------------------|
|    | 6: main reinforcement                      |
|    | 7: shear reinforcement                     |
|    | 8: concrete                                |
|    | 10: end plate                              |
| 5  | 11: recess (notch)                         |
|    | 12: shear cotta (checkered steel plate)    |
|    | 13: sleeve                                 |
|    | 14: auxiliary reinforcement                |
|    | 20: RC column (reinforced concrete column) |
| 10 | 21: steel beam                             |
|    | 22: joint                                  |
|    | 23: first shear reinforcement              |
|    | 24: second shear reinforcement             |
|    | 25: web                                    |
| 15 | 26: hole portion                           |
|    | 30: tubular body                           |
|    | 40: lower section RC column                |
|    | 41: steel beam                             |
|    | 42: upper section RC column                |
| 20 | 43: joint concrete                         |
|    | 44: main reinforcement                     |
|    | 45: shear reinforcement                    |
|    | 46: concrete                               |
|    | 47: recess (notch)                         |
| 25 | 48: checkered steel plate                  |

49: shear cotta

50: level adjustment bolt

51: triangular rib

52: high nut

5

53: bolt

54: sleeve

100: joint structure of RC column and steel beam

200: joint structure of RC column and steel beam

300: joint structure of RC column and steel beam

10

## CLAIMS

What is claimed is:

1. A joint structure of a reinforced concrete column and a steel beam,  
wherein the reinforced concrete column and the steel beam is configured to  
5 insert an end portion of the steel beam into a recess formed in the reinforced concrete  
column and fill the recess with a concrete so as to join the reinforced concrete column  
and the steel beam,  
wherein a degree of fixation of the steel beam is adjusted by adjusting an  
embedded length of the end portion of the steel beam to the concrete filling the recess,  
10 and  
wherein, by adjusting the degree of fixation, the end portion of the steel beam is  
semi-rigidly joined to the reinforced concrete column, and a bending moment acting on  
the steel beam and a joint which joints the reinforced concrete column and the steel beam  
is adjusted.
- 15 2. The joint structure of a reinforced concrete column and a steel beam  
according to claim 1,  
wherein a relationship between the degree of fixation and an embedded length  
ratio which is a ratio between the embedded length and a beam height of the steel beam is  
obtained, and  
20 wherein, based on the relationship between the degree of fixation and the  
embedded length ratio, the degree of fixation is set such that a bending moment at a  
column face position and a maximum moment in a span of the steel beam balance each  
other.
- 25 3. A method of joining a reinforced concrete column and a steel beam,  
comprising:

inserting an end portion of the steel beam into a recess formed in the reinforced concrete column;

inserting a right angle hook of a shear reinforcement including a semicircular hook or an acute angle hook on one end side and the right angle hook on the other end side into a through-hole formed in a web of the steel beam, rotating the shear reinforcement at a center of a bent portion of the right angle hook, and installing the shear reinforcement such that the right angle hook is arranged along the web of the steel beam;

fixing the semicircular hook or the acute angle hook on the one side of the shear reinforcement to an auxiliary reinforcement arranged in the recess or a main reinforcement of the reinforced concrete column protruding toward the recess; and placing concrete in the recess.

4. A joint structure of a reinforced concrete column and a steel beam, wherein an end portion of a steel beam is inserted into a recess formed in a reinforced concrete column,

wherein a shear reinforcement including a semicircular hook or an acute angle hook on one end side and a right angle hook on the other end side is installed such that the right angle hook is inserted into a through-hole formed in a web of the steel beam and the right angle hook is arranged along the web of the steel beam,

wherein the semicircular hook or the acute angle hook on the one side of the shear reinforcement is fixed to an auxiliary reinforcement arranged in the recess or a main reinforcement of the reinforced concrete column protruding toward the recess, and

wherein concrete is placed in the recess such that the end portion of the steel beam, the shear reinforcement, and the auxiliary reinforcement or the main reinforcement of the reinforced concrete column is embedded in the recess.

5. A joint structure of a reinforced concrete column and a steel beam,  
 wherein an end portion of a steel beam is inserted into a recess formed in a  
 reinforced concrete column,

wherein a first shear reinforcement which is connected to the steel beam and is  
 5 arranged in the recess and a second shear reinforcement of the reinforced concrete  
 column which protrudes toward the recess are connected to each other using a coupling  
 member,

wherein a concrete is placed in the recess, and the end portion of the steel beam,  
 the first shear reinforcement, the second shear reinforcement, and the coupling member  
 10 are embedded in the concrete, and

wherein the coupling member is a tubular body which is provided to surround  
 outer circumferences of the first shear reinforcement and the second shear reinforcement  
 arranged in the recess and is crimped to each of the first shear reinforcement and the  
 second shear reinforcement.

15 6. A joint structure of a reinforced concrete column and a steel beam,  
 wherein, in a joint of the reinforced concrete column and the steel beam, a shear  
 reinforcement of the reinforced concrete column is configured of a first shear  
 reinforcement and a second shear reinforcement, and a tubular body in which the first  
 shear reinforcement is inserted from one end portion and the second shear reinforcement  
 20 is inserted from the other end portion is provided,

wherein the first shear reinforcement is inserted into a hole portion formed in the  
 steel beam,

wherein the second shear reinforcement is arranged between the first shear  
 reinforcements adjacent to each other around an axis of the reinforced concrete column,  
 25 and

wherein the tubular body is crimped to the first shear reinforcement and the second shear reinforcement to surround outer circumferences of the first and second shear reinforcements.

7. The joint structure of a reinforced concrete column and a steel beam  
5 according to claim 6,

wherein the first shear reinforcement and the second shear reinforcement are arranged such that tip portions of the first and second shear reinforcements abut on each other inside the tubular body.

8. The joint structure of a reinforced concrete column and a steel beam  
10 according to claim 6,

wherein the first shear reinforcement and the second shear reinforcement are arranged to overlap each other inside the tubular body.

9. A method of joining a reinforced concrete column and a steel beam,  
wherein, in a joint of the reinforced concrete column and the steel beam, a shear  
15 reinforcement of the reinforced concrete column is configured of a first shear reinforcement and a second shear reinforcement, and a tubular body in which the first shear reinforcement is inserted from one end portion and the second shear reinforcement is inserted from the other end portion is provided,

wherein the first shear reinforcement is inserted into the hole portion formed in  
20 the steel beam, and

wherein the second shear reinforcement is arranged between the first shear reinforcements adjacent to each other around an axis of the reinforced concrete column,

the method comprising:

a hole portion forming process of forming a hole portion in the steel beam;

25 a first shear reinforcement installation process of inserting the first shear

reinforcement into the hole portion;

a shear reinforcement tubular body insertion process of inserting the first shear reinforcement into the tubular body from the one end portion and inserting the second shear reinforcement into the tubular body from the other end portion; and

- 5 a crimping process of crimping the tubular body to the first shear reinforcement and the second shear reinforcement to surround outer circumferences of the first and second shear reinforcements.