

DESCRIPTION

STEEL FRAME MEMBER, JOINT STRUCTURE, COMPOSITE STRUCTURE, AND
METHOD OF CONSTRUCTING COMPOSITE STRUCTURE

Field

[0001] The present invention relates to a steel frame member, a joint structure, a composite structure, and a method of constructing the composite structure.

Background

[0002] As a composite pedestal structure, there is known a composite pedestal structure constructed by using, as main members, a precast outer frame member, a steel frame member, and concrete (see Non-Patent Literature 1). The steel frame member is disposed in the precast outer frame member. The concrete is cast in the precast outer frame member. Patent Literature 1 discloses structure in which integrity with concrete is enhanced by using a steel frame with a protrusion as a steel frame member constituting such a composite pedestal structure.

[0003] The steel frame member disclosed in Patent Literature 1 is vertically extended by vertically joining the steel frame member by a joining method using welding in a site and a friction joining method using a high-strength bolt (see Non-Patent Literature 1).

Citation List

Patent Literature

[0004] Patent Literature 1: JP 2004-204602 A

Non-Patent Literature

[0005] Non-Patent Literature 1: Stripe H, H-shaped steel for bridge pier, Cat. No. D1J-504-05 (JFE Steel Corporation)

Summary

Technical Problem

[0006] Unfortunately, in the above-described conventional

technique, regardless of which method is used, a prolonged period of human-powered work is generated, and a strong work scaffold is required. This leads to an increase in construction time and an increase in costs required for construction. Therefore, there has been a demand for a technique capable of simplifying construction of vertically joining steel frame members performed in site work such as welding and bolt joining and shortening a construction period in a case where a composite pedestal structure is constructed by using steel frame members.

[0007] The present invention has been made in view of the above, and an object thereof is to provide a steel frame member, a joint structure, a composite structure, and a method of constructing the composite structure capable of shortening a construction time by simplifying the construction of vertically joining steel frame members while reducing costs required for the construction.

Solution to Problem

[0008] (1) To solve the above-described problem and achieve the object, a steel frame member according to one aspect of the present invention for a composite structure including concrete and a steel frame member disposed in the concrete, includes: a fixing steel plate to be embedded by the concrete, wherein the fixing steel plate is provided on at least one end of the steel frame member.

[0009] (2) In the above-described steel frame member according to (1), the fixing steel plate is provided on an inner surface side or an outer surface side of the steel frame member.

[0010] (3) In the above-described steel frame member according to (1) or (2), a protrusion is formed on at least a part of a surface of the steel frame member.

[0011] (4) A joint structure according to one aspect of the present invention for a composite structure including concrete

and a steel frame member disposed in the concrete, the joint structure connecting a first steel frame member and a second steel frame member in an axial direction of the composite structure, includes: a first fixing steel plate provided at an end of the first steel frame member, wherein at least one of an outer surface and an inner surface of the second steel frame member is disposed along the first fixing steel plate.

[0012] (5) the above-described joint structure according to claim (4), includes a second fixing steel plate provided at an end of the second steel frame member in a connection portion between the second steel frame member and the first steel frame member.

[0013] (6) A composite structure according to one aspect of the present invention includes: concrete; and a steel frame member disposed in the concrete, wherein a first steel frame member and a second steel frame member are connected by the joint structure according to the above-described invention.

[0014] (7) A method according to one aspect of the present invention of constructing a composite structure including concrete and a plurality of steel frame members disposed in the concrete, includes: a connection step of connecting a second steel frame member on a trailing side to a first steel frame member on a leading side along an axial direction; and a casting step of casting the concrete around the steel frame members after the steel frame members to be connected are connected in the connection step, wherein the connection step includes any one of: a first connection step of disposing a first steel frame member provided with a first fixing steel plate at an end of the first steel frame member such that the end at which the first fixing steel plate is provided is on a connection side and performing connection such that a second steel frame member is fitted to the first fixing steel plate; a second connection step of disposing a second steel frame member provided with a second fixing steel plate at an end of

the second steel frame member to one end of a first steel frame member such that the end at which the second fixing steel plate is provided is on a connection side and performing connection such that the second fixing steel plate of the second steel frame member is fitted to the first steel frame member; and a third connection step of disposing a first steel frame member provided with a first fixing steel plate at an end of the first steel frame member such that the end at which the first fixing steel plate is provided is on a connection side, disposing a second steel frame member provided with a second fixing steel plate at an end of the second steel frame member such that the end at which the second fixing steel plate is provided is on a connection side, and performing connection such that: the first fixing steel plate is fitted to the second steel frame member; and the second fixing steel plate is fitted to the first steel frame member.

Advantageous Effects of Invention

[0015] According to the present invention, a construction time can be shortened while costs required for the construction can be reduced.

Brief Description of Drawings

[0016] FIG. 1 is a front view illustrating an example of a steel frame member according to a first embodiment of the present invention.

FIG. 2 is a cross-sectional view taken along line II-II of the steel frame member according to the first embodiment in FIG. 1.

FIG. 3 includes a cross-sectional view and a plan view illustrating a portion of a hole of a fixing steel plate according to the first embodiment of the present invention.

FIG. 4 includes a cross-sectional view and a plan view illustrating the portion of the hole of the fixing steel plate according to the first embodiment of the present invention.

FIG. 5 is a perspective view illustrating an example of a

steel frame member before the fixing steel plate according to the first embodiment of the present invention is attached.

FIG. 6 is a front view illustrating a vertical joint structure of two steel frame members according to the first embodiment of the present invention.

FIG. 7 is a top view illustrating a composite structure according to the first embodiment.

FIG. 8 is a front view illustrating an example of a steel frame member according to a second embodiment of the present invention.

FIG. 9 is a cross-sectional view taken along line IX-IX of the steel frame member according to the second embodiment in FIG. 8.

FIG. 10 is a front view illustrating a vertical joint structure of two steel frame members according to the second embodiment of the present invention.

FIG. 11 is a cross-sectional view taken along line XI-XI of the vertical joint structure of the steel frame members in FIG. 10.

FIG. 12 is a front view illustrating an example of a steel frame member according to a third embodiment of the present invention.

FIG. 13 is a cross-sectional view taken along line XIII-XIII of the steel frame member in FIG. 12.

FIG. 14 is a front view illustrating an example of a steel frame member according to a fourth embodiment of the present invention.

FIG. 15 is a front view illustrating a steel frame member and a vertical joint structure according to a fifth embodiment of the present invention.

FIG. 16 is a front view corresponding to FIG. 1 of a steel frame member according to a first variation of the embodiments of the present invention.

FIG. 17 is a cross-sectional view taken along line XVII-

XVII of the steel frame member in FIG. 16.

FIG. 18 is a cross-sectional view corresponding to FIG. 2 of a steel frame member according to a second variation of the embodiments of the present invention.

Description of Embodiments

[0017] Hereinafter, embodiments of the present invention will be described with reference to the drawings. Note that, in all the figures of the following embodiments, the same or corresponding parts are denoted by the same reference signs. Furthermore, the present invention is not limited by the embodiments to be described below.

[0018] (First Embodiment)

First, a steel frame member according to a first embodiment of the present invention will be described. In the first embodiment, a fixing steel plate such as a perforated steel plate is preliminarily attached to the steel frame member. The steel frame member according to the present embodiment is used in a composite structure including concrete and a steel frame member disposed in the concrete.

[0019] FIG. 1 illustrates an example of a steel frame member 10 according to the first embodiment. FIG. 2 is a cross-sectional view taken along line II-II of the steel frame member 10 in FIG. 1. As illustrated in FIGS. 1 and 2, fixing steel plates 13 are provided on an inner surface side of the steel frame member 10. Specifically, the steel frame member 10 according to the first embodiment includes a web 11, flanges 12, and the fixing steel plates 13. The flanges 12 are provided on both sides of the web 11. A fixing steel plate 13, which is a member for fixation with concrete, is joined to a joint portion 14 on an inner surface side of a flange 12 of the steel frame member 10 at an end of the steel frame member 10, that is, an end of the flange 12.

[0020] In the present embodiment, the fixing steel plate 13 is embedded by concrete constituting the above-described

composite structure in which the steel frame member 10 is disposed. A fixing function is exerted between the fixing steel plate 13 and concrete by the fixing steel plate 13 being embedded by the concrete. Here, although details will be described later, examples of the composite structure include a composite structure 100, and examples of the concrete include concrete 102.

[0021] For example, four fixing steel plates 13 are joined so as to protrude to the inner surface side of the flanges 12. In the example in FIGS. 1 and 2, the fixing steel plates 13 are provided substantially in parallel to a surface of the web 11, and are preferably provided at symmetric positions with respect to a plane along the surface of the web 11. The fixing steel plates 13 may be symmetric with respect to the line of the web 11 or symmetric with respect to the point of the center of the web 11 in a surface perpendicular to the longitudinal direction (also referred to as axial direction) of the steel frame member 10 in FIG. 2. Note that the number and positions of the fixing steel plates 13 are not necessarily limited to these number and positions. In particular, one or a plurality of fixing steel plates 13 may be provided. Also in this case, the fixing steel plates 13 can be arranged at more preferred positions as described above by providing a plurality of fixing steel plates 13, particularly an even number of fixing steel plates 13.

[0022] The fixing steel plate 13 includes, for example, a perforated steel plate whose longitudinal direction is substantially parallel to the longitudinal direction of the steel frame member 10. At least one hole 13a is formed in the fixing steel plate 13. In the example in FIG. 1, for example, five holes 13a are formed in one fixing steel plate 13. Note that, when the fixing steel plate 13 includes a perforated steel plate, at least one hole 13a is required to be provided, and the number of holes 13a to be formed is not limited.

[0023] FIGS. 3 and 4 illustrate examples of the hole 13a of the fixing steel plate 13. FIGS. 3 and 4 both include a cross-sectional view and a plan view illustrating a portion of the hole 13a of the fixing steel plate 13. The fixing steel plate 13 in FIG. 3 is a perforated steel plate dowel. The hole 13a including a dowel hole is obtained by forming the hole 13a in a flat plate. The fixing steel plate 13 in FIG. 4 is a perforated steel plate dowel, and is obtained by raising a side portion 13aa of the hole 13a by performing burring press working on a steel plate. Raising the side portion 13aa can improve fixability with concrete to be cast as compared with that of the perforated steel plate dowel in FIG. 3. Note that any of the fixing steel plates 13 in FIGS. 3 and 4 may be adopted as the perforated steel plate dowel used in the fixing steel plate 13.

[0024] FIG. 5 is a perspective view illustrating an example of a steel frame member before the fixing steel plate 13 is attached. As illustrated in FIG. 5, a protrusion 12a is formed on the surface of the flange 12 of the steel frame member 10 in a shape of a stripe perpendicular to the longitudinal direction of the steel frame member 10, that is, a horizontal stripe shape. Providing the protrusion 12a on the surface of the flange 12 in this way can improve fixability with concrete to be cast around the steel frame member 10. The protrusion 12a may have various shapes such as a protrusion of a vertical stripe shape and a checker rib in addition to the horizontal stripe shape in FIG. 5. Furthermore, as for the shape of the protrusion 12a on the surface of the steel frame member 10, a function similar to that of the protrusion 12a can be obtained by further welding a deformed reinforcing bar or a steel piece. Furthermore, the protrusion 12a desirably has a height of 2 mm or more to secure the fixability with the surrounding concrete 102, and desirably 3 mm or less in terms of formation. Moreover, the protrusion 12a may be located in an

inner surface portion of the flange 12 or a surface of the web 11 in addition to an outer surface of the steel frame member 10 including H-shaped steel in FIG. 5, that is, an outer surface of the flange 12. The protrusion 12a may be formed at various positions as long as the protrusion 12a is provided at a portion that may be in contact with the concrete 102 on an outer surface of the steel frame member 10. Note that formation of the protrusion 12a is not a limitation. The protrusion 12a is not required to be provided.

[0025] (Vertical Joint Structure of Steel Frame Members)

Next, a vertical joint structure serving as a joint structure of steel frame members configured as described above will be described. FIG. 6 is a front view illustrating a vertical joint structure of two steel frame members according to the first embodiment. Furthermore, FIG. 6 illustrates a connection step corresponding to a first connection step.

[0026] As illustrated in FIG. 6, the fixing steel plate 13 serving as a first fixing steel plate is joined only to an end of one steel frame member 10 among a pair of steel frame members 10 and 10A, which are vertically joined along the longitudinal direction (axial direction) of the steel frame member 10. In other words, the fixing steel plate 13 is joined at the joint portion 14 to an end of the steel frame member 10 serving as one first steel frame member on the side of the steel frame member 10A serving as the other second steel frame member among the pair of steel frame members 10 and 10A. In contrast, as illustrated in FIG. 5, the fixing steel plate 13 is not provided at an end of the steel frame member 10A on the side of the steel frame member 10.

[0027] When these steel frame members 10 and 10A are vertically joined, the shapes of a web 11A and a flange 12A at a lower end of the steel frame member 10A on a trailing side are matched with the shapes of the web 11 and the flange 12 at an upper end of the steel frame member 10 on a leading side.

Thereafter, the web 11A and the flange 12A are disposed along the fixing steel plate 13, and are vertically joined to upper ends of the web 11 and the flange 12. Here, the steel frame members 10 and 10A are connected such that the fixing steel plate 13 is inserted between the flanges 12A of the steel frame member 10A. This causes a vertical joint structure 5 to be constructed in a connection portion between the steel frame members in the composite structure. Moreover, the fixing steel plate 13 is joined at the upper end of the steel frame member 10A on the trailing side. The steel frame member 10A is regarded as the above-described steel frame member 10. A connection step of vertically connecting, in a further upper layer, a steel frame member having a lower end similar to that of the steel frame member 10A is repeated as many times as necessary. Thereby, each of a plurality of steel frame members in the composite structure extends upward via the vertical joint structure 5.

[0028] Note that the leading sides and the trailing sides of the steel frame members 10 and 10A can be reversed. In this case, the connection step corresponds to a second connection step. That is, the shapes of the web 11 and the flange 12 at the lower end of the steel frame member 10 on the trailing side are matched with the shapes of the web 11A and the flange 12A at the upper end of the steel frame member 10A on the leading side. Thereafter, the fixing steel plate 13 of the steel frame member 10 is disposed in a state of being capable of being inserted to an upper end sides of the web 11A and the flange 12A, and connected such that the fixing steel plate 13 is inserted between the flanges 12A. This causes the vertical joint structure 5 of steel frame members to be constructed in the composite structure. Moreover, the steel frame member 10 on the trailing side is regarded as the steel frame member 10A. A connection step of vertically connecting, in a further upper layer, a steel frame member having a lower end to which

the fixing steel plate 13 similar to the steel frame member 10 is joined is repeated as many times as necessary. Thereby, each of a plurality of steel frame members in the composite structure extends upward via the vertical joint structure 5.

[0029] FIG. 7 is a top view illustrating the composite structure according to the first embodiment. As illustrated in FIG. 7, the composite structure 100 includes an outer frame member 101, the concrete 102, and a plurality of vertically joined steel frame members 10 and 10A. When the composite structure 100 is constructed, the vertical joining of the steel frame members 10 and 10A and the casting of the concrete 102 can be repeatedly executed. That is, when the plurality of steel frame members 10 and 10A is assembled via the vertical joint structure 5, the vertically joined steel frame members 10 and 10A are embedded in the concrete 102 together with the fixing steel plate 13 by casting the concrete 102 around the steel frame members 10 and 10A as a casting step after all the steel frame members 10 and 10A in the same layer on a horizontal plane are assembled. Thereafter, the steel frame members 10 and 10A in a further upper layer are vertically joined, and the composite structure 100 extends upward. The composite structure 100 can be constructed by repeating the casting of these steel frame members 10 and 10A and the concrete 102. In this case, in the steel frame members 10 and 10A embedded in the composite structure 100, the concrete 102 is coupled on both surfaces of the fixing steel plate 13 through the hole 13a in the fixing steel plate 13. Moreover, since the flange 12A of the steel frame member 10A on the trailing side is disposed in accordance with the shape of the fixing steel plate 13 of the steel frame member 10 on the leading side, the vertical joint structure 5 can be strengthened.

[0030] Furthermore, the vertical joining of the steel frame members 10 and 10A and the casting of the concrete 102 may be

repeatedly executed as follows. That is, first, the steel frame members 10 and 10A in the same layer are assembled via a vertical joint structure. Next, after the steel frame members 10 and 10A are assembled in at least one upper layer, the casting step of embedding the steel frame members 10 and 10A in the concrete 102 together with the fixing steel plate 13 is performed.

[0031] In the composite structure 100 configured as described above, the fixing steel plate 13 joined to the end, here, the upper end of the steel frame member 10 can secure fixation with the concrete 102 around the steel frame member 10, so that stress can be transmitted between the vertically joined steel frame members 10 and 10A. Moreover, when the steel frame member 10 having the protrusion 12a as illustrated in FIG. 5 is used, fixation between the concrete 102 and the steel frame member 10 can be more preferably secured. That is, according to the steel frame member 10 configured as described above, an overlapping section can be formed between a section of fixation with the cast concrete 102 formed by the protrusion 12a of the flange 12 and a section of fixation with the concrete 102 formed by the fixing steel plate 13 of a perforated steel plate dowel. This allows stress to be transmitted between the steel frame member 10 on the leading side and the steel frame member 10A on the trailing side, which are vertically joined, in accordance with a principle of a lap joint. This means that stress can be transmitted in a section shorter than that in a case where the protrusion 12a is not provided on the surface of the steel frame member 10.

[0032] According to the above-described first embodiment of the present invention, in the composite structure 100 including the outer frame member 101, the concrete 102, and the steel frame members 10 and 10A, when the steel frame members 10 and 10A are vertically joined, one steel frame member 10 to whose end to be vertically joined the fixing

steel plate 13 is attached is used to dispose the other steel frame member 10A to be vertically joined along the fixing steel plate 13 to construct the vertical joint structure 5. This makes it possible to omit a process of coupling steel frame members, which has been performed in site work, such as welding and bolt joining. Thus, construction of vertically joining the steel frame members can be simplified, and a construction period can be shortened.

[0033] (Second Embodiment)

Next, a steel frame member according to a second embodiment of the present invention will be described. Similarly to the steel frame member according to the first embodiment, the steel frame member according to the second embodiment is also used in a composite structure including concrete and a steel frame member disposed in the concrete. FIG. 8 illustrates an example of the steel frame member according to the second embodiment. FIG. 9 is a cross-sectional view taken along line IX-IX of the steel frame member in FIG. 8.

[0034] As illustrated in FIGS. 8 and 9, a steel frame member 20 according to the second embodiment is different from that of the first embodiment in that a fixing steel plate 23 is provided on the outer surface side of the steel frame member 20. Specifically, in the second embodiment, the fixing steel plate 23 is joined to a joint portion 24 on an outer surface side of a flange 22 at an end of the steel frame member 20, that is, an end of the flange 22 such that the longitudinal direction of the fixing steel plate 23 is substantially parallel to the longitudinal direction of the steel frame member 20. Although details will be described later, the fixing steel plate 23 is provided at an end of the steel frame member 20 and at a portion of connection with the steel frame member 10. For example, four fixing steel plates 23 serving as second fixing steel plates are joined on the

outer surface side of the flange 22. In the example in FIGS. 8 and 9, the fixing steel plates 23 are provided substantially in parallel to a surface of a web 21, and are preferably provided at symmetric positions with respect to a plane along the surface of the web 21. The fixing steel plates 23 may be symmetric with respect to the line of the web 21 or symmetric with respect to the point of the center of the web 21 in a surface perpendicular to the longitudinal direction of the steel frame member 20 in FIG. 8. Note that the positions and the number of the fixing steel plates 23 are not necessarily limited to these positions and number. In particular, one or a plurality of fixing steel plates 23 is required to be provided. A plurality of fixing steel plates 23, particularly an even number of fixing steel plates 23 are more preferably provided since the fixing steel plates 23 can be arranged at more preferred positions as described above. This point is similar to the steel frame member 10 in the first embodiment.

[0035] The configurations of the web 21, the flange 22, the fixing steel plate 23, a hole 23a, and a joint portion 24 are similar to those of the web 11, the flange 12, the fixing steel plate 13, the hole 13a, and the joint portion 14 according to the first embodiment, respectively, and thus the descriptions thereof will be omitted.

[0036] (Vertical Joint Structure of Steel Frame Members)

Next, a vertical joint structure serving as a joint structure of the steel frame member according to the second embodiment and the steel frame member according to the first embodiment configured as described above will be described. FIG. 10 is a front view illustrating a vertical joint structure of two steel frame members according to the second embodiment. FIG. 11 is a cross-sectional view taken along line XI-XI of the vertical joint structure of the steel frame members in FIG. 10. In the vertical joint structure according to the second embodiment, a fixing steel plate for vertically

joining steel frame members is attached to a trailing end in a steel frame member on the leading side, and attached to a leading end in a steel frame member on the trailing side.

[0037] That is, as illustrated in FIGS. 10 and 11, for example, the steel frame member 10 according to the first embodiment is defined as the leading side, and the steel frame member 20 according to the second embodiment is defined as the trailing side. The fixing steel plate 13 is joined to an upper end of the steel frame member 10, that is, a side vertically joined to the steel frame member 20 while the fixing steel plate 23 is joined to a lower end of the steel frame member 20, that is, a side vertically joined to the steel frame member 10.

[0038] The connection step of vertically connecting these steel frame members 10 and 20 corresponds to a third connection step. That is, the steel frame member 20 on the trailing side is disposed above the steel frame member 10 such that the web 21 and the flange 22 of the steel frame member 20 are matched with the shape of the fixing steel plate 13 at the upper end of the steel frame member 10 on the leading side. That is, the steel frame member 20 is disposed at a position where the fixing steel plate 13 of the steel frame member 10 can be inserted between the flanges 22 of the steel frame member 20. Moreover, the steel frame member 20 is disposed above the steel frame member 10 such that an inner side end of the fixing steel plate 23 of the steel frame member 20 is located outside the flange 12 of the steel frame member 10. That is, the steel frame member 20 is disposed so as to match with the shapes of the web 21 and a flange 22A such that the web 11 and two flanges 12 of the steel frame member 10 are inserted between the fixing steel plates 23 of the steel frame member 20. Thereafter, the web 21 and the flange 22 are disposed along the fixing steel plates 13 and 23, and the lower end of the steel frame member 20 is connected to the

upper end of the steel frame member 10 to perform vertical joining. This causes a vertical joint structure 6 to be constructed in a connection portion of the steel frame members in the composite structure.

[0039] Moreover, the fixing steel plate 13 having an upper end similar to that of the steel frame member 10 is joined at the upper end of the steel frame member 20 on the trailing side. The steel frame member 20 is regarded as the above-described steel frame member 10. A steel frame member having a lower end similar to that of the steel frame member 20 is vertically joined repeatedly in a further upper layer as many times as necessary. Thereby, the steel frame member in the composite structure extends upward via the vertical joint structure. Similarly, the fixing steel plate 23 similar to the lower end of the steel frame member 20 is also joined to the upper end of the steel frame member 20 on the trailing side. The steel frame member 20 is defined as the leading side. The steel frame member 10 is defined as the trailing side. Vertical joining can thus be performed in a manner similar to that described above. In this case, the vertical joint structure 6 is turned upside down as compared with that in FIG. 10. Furthermore, the fixing steel plate 23 is defined as the first fixing steel plate. The fixing steel plate 13 is defined as a second fixing steel plate. In this manner, the steel frame members 10 and 20 are vertically joined sequentially such that the fixing steel plates 13 and 23 do not interfere with each other, whereby the steel frame member in the composite structure extends upward via the vertical joint structure. Note that the fixing steel plates 13 and 23 at the ends of the steel frame members 10 and 20 can be joined at various positions as long as the fixing steel plates 13 and 23 do not interfere with each other in vertical joining at the positions.

[0040] In the second embodiment described above, effects

similar to those of the first embodiment can be obtained. In the vertical joint structure 6, which is a joint structure, the fixing steel plates 13 and 23 joined to the ends of the two upper and lower steel frame members 10 and 20 are joined so as to having a shape in which the fixing steel plates 13 and 23 mesh with each other, and fixed to the surrounding concrete 102, which can form an overlapping section. Stress can thus be transmitted in a section shorter than that in the first embodiment by the way of a lap joint. Therefore, the stress can be efficiently transmitted.

[0041] (Third Embodiment)

Next, a steel frame member according to a third embodiment of the present invention will be described. The steel frame member according to the third embodiment is also used in a composite structure including concrete and a steel frame member disposed in the concrete. FIG. 12 illustrates an example of a steel frame member according to the third embodiment. FIG. 13 is a cross-sectional view taken along line XIII-XIII of the steel frame member in FIG. 12.

[0042] As illustrated in FIGS. 12 and 13, in the third embodiment, the steel frame member 10 on the leading side is similar to that of the first embodiment. A steel frame member 10B on the trailing side is different from the steel frame member 10 in that a fixing steel plate 13B is provided on the inner surface side of the steel frame member 10. That is, the fixing steel plate 13B in the steel frame member 10B is provided on the inner surface side of a flange 12B and on a side farther from a web 11B than the fixing steel plate 13 in the steel frame member 10. In the example in FIG. 13, the fixing steel plate 13B is joined at a joint portion 14B at an outer end of the flange 12B. Note that the fixing steel plate 13B has a configuration similar to that of the fixing steel plate 13, and a hole 13Ba also has structure similar to that of the hole 13a. The upper end of the steel frame member 10

and the lower end of the steel frame member 10B are vertically joined via the fixing steel plates 13 and 13B to constitute a vertical joint structure 7 serving as a connection portion. The fixing steel plates 13 and 13B may be provided on outer surface sides of the flanges 12 and 12B, respectively.

[0043] In the third embodiment, fixability with the surrounding concrete 102 is secured in the vertical joint structure 7 in which the fixing steel plates 13 and 13B joined to ends of the two upper and lower steel frame members 10 and 10B are mutually configured like a nested basket. Stress can thus be transmitted in a section shorter than that in the first embodiment. Therefore, the stress can be efficiently transmitted.

[0044] (Fourth Embodiment)

Next, a steel frame member according to a fourth embodiment of the present invention will be described. The steel frame member according to the fourth embodiment is also used in a composite structure including concrete and a steel frame member disposed in the concrete. FIG. 14 illustrates an example of a steel frame member according to the fourth embodiment. As illustrated in FIG. 14, in a steel frame member 30 according to the fourth embodiment, a fixing steel plate 33 includes, for example, a perforated steel plate dowel whose longitudinal direction is substantially parallel to the longitudinal direction of the steel frame member 30 and whose surface is substantially parallel to a surface of a web 31, and is joined at a joint portion 34 on the inner surface of a flange 32. In the fixing steel plate 33, the diameter of a hole 33a formed along the longitudinal direction of the steel frame member 30 increases toward the direction away from the end of the steel frame member 30. In other words, in the fixing steel plate 33, a hole 33a becomes smaller toward the end of the steel frame member 30. In the example in FIG. 14, the diameter increases in the order of holes 331, 332, 333,

334, and 335. The other portions have configuration similar to that of the first embodiment.

[0045] According to the fourth embodiment, effects similar to those of the first embodiment can be obtained. The diameter of the hole 33a decreases toward the joint portion 34 where the stress level of the steel frame member 30 is strengthened, so that stress resistance of the fixing steel plate 33 can be improved. Furthermore, the length of a steel plate to be secured between the holes 331 to 335 can be reduced by reducing the size of the hole 33a. Thus, the distances between the holes 331 to 335 can be shortened, and the length of a member of the fixing steel plate 33 can be shortened. Note that the fixing steel plate 33 according to the fourth embodiment can also be adopted as the fixing steel plates 13 and 13B (see FIG. 12) according to the third embodiment.

[0046] (Fifth Embodiment)

Next, a fifth embodiment will be described. The steel frame member according to the fifth embodiment is also used in a composite structure including concrete and a steel frame member disposed in the concrete. FIG. 15 is a front view illustrating a steel frame member and a vertical joint structure according to the fifth embodiment. As illustrated in FIG. 15, in the steel frame member according to the fifth embodiment, each of the fixing steel plates 13 and 23 in the steel frame member 10 (see FIG. 1) according to the first embodiment and the steel frame member 20 (see FIG. 8) according to the second embodiment is configured similarly to the fixing steel plate 33 in the fourth embodiment.

[0047] As illustrated in FIG. 15, in a steel frame member 40 according to the fifth embodiment, a fixing steel plate 43 includes, for example, a perforated steel plate dowel whose longitudinal direction is substantially parallel to the longitudinal direction of the steel frame member 40. The fixing steel plate 43 is joined at a joint portion 44 on the

inner surface of a flange 42 provided on each of both sides of a web 41 of the steel frame member 40.

[0048] In the fixing steel plate 43, the diameter of a hole 43a formed along the longitudinal direction of the steel frame member 40 increases toward the direction away from the end of the steel frame member 40. In other words, in the fixing steel plate 43, the hole 43a becomes smaller toward the end of the steel frame member 40. In the example in FIG. 15, the diameter increases in the order of holes 431, 432, 433, 434, and 435.

[0049] Furthermore, the upper end of the steel frame member 30 and the lower end of the steel frame member 40 are vertically joined via the fixing steel plates 33 and 43 to constitute a vertical joint structure 8 serving as a connection portion. Note that the steel frame member 30 and the steel frame member 40 may be upside down. That is, the steel frame member 40 may be defined as the leading side, and the steel frame member 30 may be defined as the trailing side. The other portions have configuration similar to that of the first and second embodiments.

[0050] According to the fifth embodiment, effects similar to those of the first and second embodiments can be obtained. The diameter of the hole 43a decreases toward the joint portion 44 where the stress level of the steel frame member 40 is strengthened, so that effects similar to those of the fourth embodiment can be obtained.

[0051] (First Variation)

Next, a first variation of the above-described embodiments will be described. A steel frame member according to the first variation is also used in a composite structure including concrete and a steel frame member disposed in the concrete. FIG. 16 is a front view illustrating an example of the steel frame member according to the first variation. FIG. 17 is a cross-sectional view taken along line XVII-XVII of the steel frame member in FIG. 16.

[0052] As illustrated in FIGS. 16 and 17, in the first variation, a basic steel frame member includes T-shaped steel. That is, in a steel frame member 50 according to the first variation, a flange 52 is provided on one side of a surface perpendicular to the longitudinal direction of a web 51.

[0053] A fixing steel plate 53 has configuration similar to that of the fixing steel plate 13 in the first embodiment. That is, the fixing steel plate 53 is joined to a joint portion 54 on the inner surface side of the flange 52 such that the longitudinal direction of the fixing steel plate 53 is substantially parallel to the longitudinal direction of the steel frame member 50 and a surface of the fixing steel plate 53 is substantially parallel to a surface of the web 51. That is, a fixing steel plate 53 is provided on an inner surface side of the steel frame member 50. A hole 53a of the fixing steel plate 53 is formed as illustrated in FIGS. 3 and 4. The other portions have configuration similar to that of the first embodiment. Also in the first variation, effects similar to those of the above-described embodiments can be obtained.

[0054] (Second Variation)

Next, a second variation of the above-described embodiments will be described. A steel frame member according to the second variation is also used in a composite structure including concrete and a steel frame member disposed in the concrete. FIG. 18 is a cross-sectional view corresponding to FIG. 2 of a steel frame member according to a second variation of the above-described embodiments.

[0055] As illustrated in FIG. 18, a steel frame member 60 according to the second variation includes a web 61, flanges 62, and a fixing steel plate 63. The flanges 62 are provided on both sides along a direction perpendicular to the longitudinal direction of the web 61. In the second variation, the fixing steel plate 63 is provided on a surface of the web 61, which is the inner surface side of the steel frame member

60. That is, the fixing steel plate 63 is joined at joint portions 64 on both side surfaces of the web 61 at an end of the web 61 of the steel frame member 10. Note that the fixing steel plate 63 may be located on one surface of the web 61. The position where the fixing steel plate 63 is provided is not necessarily limited. Also in the second variation, effects similar to those of the above-described embodiments can be obtained.

[0056] Although the embodiments of the present invention have been specifically described above, the present invention is not limited to the above-described embodiments, and various variations based on the technical idea of the present invention and embodiments obtained by combining the embodiments can be adopted. For example, the configurations of the fixing steel plates and the configurations and shapes of a basic steel frame member described in the above-described embodiments are merely examples, and a device configuration different from the above may be used as necessary. Furthermore, the steel frame members 10, 10A, 20, 30, 40, 50, and 60 may be used as any of steel frame members on the leading side and the trailing side as long as the fixing steel plates 13, 13B, 23, 33, 43, 53, and 63 do not interfere with each other.

[0057] Although, in the above-described embodiment, a perforated steel plate is adopted as a fixing steel plate, various steel plates and members can be adopted as the fixing steel plates as long as the steel plates and members can secure a function of fixation with concrete, including a steel plate having a headed stud and a ribbed steel plate.

[0058] Furthermore, although, in the above-described embodiments, the H-shaped steel is adopted as the basic steel frame member, a square steel pipe, a circular steel pipe, so-called T-shaped steel having a T-shaped cross-sectional shape, a shape in which the H-shaped steel and the T-shaped steel are

combined, and the like can be adopted as the basic steel frame member. Note that the H-shaped steel and the T-shaped steel has an open cross section in a cross section orthogonal to the longitudinal direction of a steel frame member to be used while the square steel pipe and the circular steel pipe has a closed cross section. Thus, the inside of a steel pipe is preferably filled with concrete. In this case, construction such as performing casting in addition to the concrete of the composite structure 100 can be appropriately added.

[0059] Here, in many cases, it is difficult to confirm the internal states of the square steel pipe and the circular steel pipe having a closed cross section with respect to the cross section orthogonal to the longitudinal direction of the steel frame member at the time when concrete is cast in the steel pipe. In this case, a gap not filled with concrete is generated, and a load transfer function of the fixing steel plate 13 may fail to be sufficiently fulfilled. Therefore, in a case of steel having a shape with a closed cross section with respect to the cross section orthogonal to the longitudinal direction of the steel frame member such as the square steel pipe and the circular steel pipe, measures such as enhancing fluidity of concrete are preferably taken. In this regard, in a case of steel having a shape with an open cross section with respect to the cross section orthogonal to the longitudinal direction of the steel frame member such as the H-shaped steel and T-shaped steel, such measures are unnecessary. Management items in a process are preferably reduced.

Industrial Applicability

[0060] As described above, the steel frame member, the joint structure, the composite structure, and the method of constructing the composite structure according to the present invention are preferably applied to the construction of vertically joining steel frame members.

Reference Signs List

[0061] 5, 6, 7, 8 VERTICAL JOINT STRUCTURE
10, 10A, 10B, 20, 30, 40, 50, 60 STEEL FRAME MEMBER
11, 11A, 11B, 21, 31, 41, 51, 61 WEB
12, 12A, 12B, 22, 22A, 32, 42, 52, 62 FLANGE
12a PROTRUSION
13, 13B, 23, 33, 43, 53, 63 FIXING STEEL PLATE
13a, 13Ba, 23a, 33a, 43a, 53a, 331, 332, 333, 334, 335,
431, 432, 433, 434, 435 HOLE
13aa SIDE PORTION
14, 14B, 24, 34, 44, 54, 64 JOINT PORTION
100 COMPOSITE STRUCTURE
101 OUTER FRAME MEMBER
102 CONCRETE

CLAIMS

1. A steel frame member for a composite structure including concrete and a steel frame member disposed in the concrete, the steel frame member comprising:
 - a fixing steel plate to be embedded by the concrete,
 - wherein the fixing steel plate is provided on at least one end of the steel frame member.
2. The steel frame member according to claim 1, wherein the fixing steel plate is provided on an inner surface side or an outer surface side of the steel frame member.
3. The steel frame member according to claim 1 or 2, wherein a protrusion is formed on at least a part of a surface of the steel frame member.
4. A joint structure for a composite structure including concrete and a steel frame member disposed in the concrete, the joint structure connecting a first steel frame member and a second steel frame member in an axial direction of the composite structure, the joint structure comprising:
 - a first fixing steel plate provided at an end of the first steel frame member,
 - wherein at least one of an outer surface and an inner surface of the second steel frame member is disposed along the first fixing steel plate.
5. The joint structure according to claim 4, comprising a second fixing steel plate provided at an end of the second steel frame member in a connection portion between the second steel frame member and the first steel frame member.
6. A composite structure comprising:
 - concrete; and

a steel frame member disposed in the concrete,
wherein a first steel frame member and a second steel frame member are connected by the joint structure according to claim 4 or 5.

7. A method of constructing a composite structure including concrete and a plurality of steel frame members disposed in the concrete, the method comprising:

a connection step of connecting a second steel frame member on a trailing side to a first steel frame member on a leading side along an axial direction; and

a casting step of casting the concrete around the steel frame members after the steel frame members to be connected are connected in the connection step,

wherein the connection step includes any one of:

a first connection step of disposing a first steel frame member provided with a first fixing steel plate at an end of the first steel frame member such that the end at which the first fixing steel plate is provided is on a connection side and performing connection such that a second steel frame member is fitted to the first fixing steel plate;

a second connection step of disposing a second steel frame member provided with a second fixing steel plate at an end of the second steel frame member to one end of a first steel frame member such that the end at which the second fixing steel plate is provided is on a connection side and performing connection such that the second fixing steel plate of the second steel frame member is fitted to the first steel frame member; and

a third connection step of disposing a first steel frame member provided with a first fixing steel plate at an end of the first steel frame member such that the end at which the first fixing steel plate is provided is on a connection side, disposing a second steel frame member provided with a second

fixing steel plate at an end of the second steel frame member such that the end at which the second fixing steel plate is provided is on a connection side, and performing connection such that: the first fixing steel plate is fitted to the second steel frame member; and the second fixing steel plate is fitted to the first steel frame member.