

DESCRIPTION

BRACE MEMBER AND METHOD OF ASSEMBLING THE SAME

Technical Field

[0001]

The present invention relates to a brace member that includes an axial force member which absorbs seismic energy when earthquakes occur and a stiffening tube which stiffens the axial force member and relates to a method of assembling the brace member.

Background Art

[0002]

Brace members have been installed in building constructions as antiseismic or vibration suppressing antiseismic dampers that absorb seismic energy so as to reduce damage to main structural members of the building constructions such as posts and beams. In general, buckling restrained braces each include an axial force member, a stiffening tube, and a coupling portion for coupling with a main frame. The buckling restrained brace is compressed in the axial direction due to vibration of a building construction caused by an earthquake. The compression of the buckling restrained brace in the axial direction is exerted on the axial force member of the buckling restrained brace. The buckling restrained brace includes the

stiffening tube that stiffens against bending and buckling of the axial force member so as to cause the axial force member to plastically strain in the axial direction of the brace member without buckling due to the compression in the axial direction. The stiffening tube, which is provided as a buckling restraining member for the axial force member, surrounds the axial force member without being subjected to the axial force input to the brace member. The buckling restrained brace having the above-described structure prevents or delays the occurrences of global buckling of the axial force member even when the compressive axial force acts thereon, thereby causing stable deformation in the axial direction and increasing the ability of absorbing seismic energy.

[0003]

As the related art, a brace member is disclosed. In this brace member, welding for disposing an axial force member and a stiffening member in a specified form is eliminated. Thus, the brace member can be easily fabricated, and an increase in weight of the brace member can be prevented (see, for example, Patent Literature 1).

Citation List

Patent Literature

[0004]

PTL 1: Japanese Unexamined Patent Application

Publication No. 2013-112949 (pages 4 to 5, Fig. 1)

Summary of Invention

Technical Problem

[0005]

In a brace member disclosed in Patent Literature 1, clevises are threadedly connected to both ends of an axial force member formed of bar steel that extends through a stiffening tube. One end portion of the stiffening tube is threadedly secured to one end portion of the axial force member with a securing ring that is threadedly engaged with both the stiffening tube and the axial force member interposed therebetween. A sleeve formed of a steel tube is threadedly secured to the other end portion of the axial force member. About a half of the sleeve in the longitudinal direction is inserted into the stiffening tube and about a half of the sleeve that is the remainder is exposed from the stiffening tube. Here, a gap having a specified size is formed between an outer circumference of the sleeve and an inner circumference of the stiffening tube. Accordingly, in this brace member, the axial force member can be disposed at a specified position relative to the stiffening tube without welding.

[0006]

However, it is required that the thickness of the sleeve be smaller than a half of the difference between an

inner diameter of the stiffening tube and an outer diameter of the axial force member. Furthermore, in order to reduce bending of the axial force member and obtain sufficient stiffening performance, it is preferable that an inner surface of the stiffening tube be close to an outer surface of the axial force member. Accordingly, an allowable thickness of the sleeve is naturally limited. Because of this limit, yielding due to bending may occur in a range of the sleeve exposed from the stiffening tube when bending strength of the sleeve is small. The axial force member is not surrounded by the stiffening tube in a range between an end surface of the stiffening tube on a side where the sleeve is secured and one of the clevises secured to an end portion of the axial force member on a side where the sleeve is provided. This range in which the axial force member is not surrounded is a shrinkage margin for the brace member for allowing extension or compression in the axial direction without transmitting the axial force to the stiffening tube. Furthermore, the axial force member is surrounded by the sleeve in the range between the end surface of the stiffening tube to the clevis. However, when the sleeve yields, the entire structure may become unstable because both ends of the brace are pin-supported by the clevises. This may lead to global buckling of the brace. It is required that global buckling of the brace be prevented by

preventing bending of the axial force member in the shrinkage margin range for the brace, appropriately ensuring the flexural rigidity and yield resistance of the stiffening tube, and appropriately controlling the shrinkage margin for the brace during fabrication so as to prevent the axial force to excessively act on the stiffening tube. Therefore, there has been a demand for a brace member that has a mechanism appropriately constrains the axial force member, that prevents a portion beyond an end portion of the stiffening tube, where the axial force member is not surrounded by the stiffening tube, from being rotationally strained and plasticized, and that has improved bending strength (large enduring force) instead of the sleeve.

[0007]

The present invention responds to the above-described demand. An object of the present invention is to provide a brace member and a method of assembling the brace member. In this brace member, rotational strain of an axial force member can be appropriately constrained at an end portion of a buckling restraining member (stiffening tube) and a shrinkage margin for extension and compression in the axial direction can be appropriately obtained without transmission of an axial force to the buckling restraining member (stiffening tube).

Solution to Problem

[0008]

(1) A brace member according to the present invention includes an axial force member, a stiffening tube, a securing-side cap, a sliding-side cap, and a socket tube. The axial force member has a bar shape. The axial force member is inserted through the stiffening tube. The securing-side cap is coupled to a securing-side end portion of the stiffening tube which is an end portion on one side in a longitudinal direction and coupled to an end portion of the axial force member. This end portion of the axial force member is located on the one side in the longitudinal direction. The sliding-side cap is coupled to an end portion of the axial force member. This end portion of the axial force member is located on another side in the longitudinal direction. The socket tube is removably coupled to a sliding-side end portion of the stiffening tube which is an end portion on the other side in the longitudinal direction or removably coupled to the sliding-side cap. The securing-side cap and the sliding-side cap include respective coupling elements to be used as joints for installation in a building construction. The socket tube surrounds an outer circumferential portion of the sliding-side end portion and an outer circumferential portion of the sliding-side cap.

[0009]

(2) In the brace member described above in (1), the socket tube is threadedly coupled to the stiffening tube or the sliding-side cap.

(3) In the brace member described above in (1) and (2), the axial force member has male screws at ends on both the sides, and the securing-side cap and the sliding-side cap have respective holes into which the axial force member is inserted. Each of the holes has a cylindrical portion and a female screw with which the axial force member is threadedly engaged on a far side of the cylindrical portion when seen in a direction in which the axial force member is inserted into the hole. The axial force member is coupled to the securing-side cap and the sliding-side cap by threaded engagement of the male screws with the female screws.

(4) In the brace member described above in (1) to (3), the sliding-side cap is coupled to the axial force member such that a gap is provided between an end surface of the sliding-side end portion of the stiffening tube and a surface of the sliding-side cap facing the end surface.

(5) In the brace member described above in (1) to (4), the coupling elements project in opposite directions to a side where the axial force member and the stiffening tube are coupled, and the coupling elements are respectively connected to the securing-side cap and the sliding-side cap.

(6) In the brace member described above in (1) to (5),

an inner diameter of the socket tube is fixed in the longitudinal direction in a range in which the socket tube surrounds the stiffening tube, and an outer diameter of the socket tube in this range reduces toward a center of the stiffening tube in the longitudinal direction.

[0010]

(7) In a method of assembling a brace member according to the present invention, the brace member includes an axial force member, a stiffening tube, a securing-side cap, a sliding-side cap, and a socket tube. The axial force member has a bar shape. The axial force member is inserted through the stiffening tube. The securing-side cap is coupled to a securing-side end portion of the stiffening tube which is an end portion on one side in a longitudinal direction and coupled to an end portion of the axial force member. This end portion of the axial force member is located on the one side in the longitudinal direction. The sliding-side cap is coupled to an end portion of the axial force member. This end portion of the axial force member is located on another side in the longitudinal direction. The socket tube is removably coupled to a sliding-side end portion of the stiffening tube which is an end portion on the other side in the longitudinal direction or removably coupled to the sliding-side cap. The securing-side cap and the sliding-side cap include respective coupling elements to be used as

joints for installation in a building construction. The socket tube surrounds an outer circumferential portion of the sliding-side end portion and an outer circumferential portion of the sliding-side cap. Here, the method of assembling the brace member includes the steps of coupling the securing-side cap, securing the stiffening tube, fitting the socket tube, securing the sliding-side cap, and coupling the socket tube. In the step of coupling the securing-side cap, the securing-side cap and the axial force member are coupled to each other. In the step of securing the stiffening tube, the securing-side cap and the stiffening tube are coupled to each other. In the step of fitting the socket tube, the socket tube is fitted onto the outer circumferential portion of the sliding-side end portion of the stiffening tube. In the step of securing the sliding-side cap, the sliding-side cap and the axial force member are coupled to each other. In the step of coupling the socket tube, the socket tube is coupled to the stiffening tube or the sliding-side cap. The step of coupling the socket tube is performed after the step of coupling the securing-side cap, the step of securing the stiffening tube, the step of fitting the socket tube, and the step of securing the sliding-side cap have been performed.

(8) In the method of assembling the brace member described above in (7), the step of securing the sliding-

side cap is performed after the step of coupling the securing-side cap and the step of securing the stiffening tube have been performed, and the step of securing the sliding-side cap includes a step of adjusting a gap in which the gap provided between an end surface of the sliding-side end portion of the stiffening tube and a surface of the sliding-side cap facing the end surface is adjusted.

Advantageous Effects of Invention

[0011]

(i) In the brace member according to the present invention, the end portion (securing-side end portion) of the stiffening tube on the one side in the longitudinal direction is coupled to the securing-side cap, and the outer circumference of the end portion (sliding-side end portion) of the stiffening tube on the other side in the longitudinal direction is surrounded by the socket tube. The outer diameter and the thickness of the socket tube, which surrounds the outer circumference of the stiffening tube, are not limited and can be increased. Accordingly, the bending strength and the stiffness of the socket tube can be improved. Strain is constrained by the socket tube having high stiffness in a region between the sliding-side end portion of the stiffening tube and the sliding-side cap, and accordingly, buckling and bending of the axial force member are suppressed in the region between the sliding-side end

portion of the stiffening tube and the sliding-side cap. Accordingly, the brace member that has high bending strength and is unlikely to buckle can be obtained.

[0012]

(ii) The socket tube is removably coupled to the stiffening tube or the sliding-side cap. This can facilitate the assembling in fabrication of the brace member. Furthermore, the dimension between the sliding-side end portion of the stiffening tube and the sliding-side cap is visible. This facilitates control of this dimension during fabrication, and further, facilitates control of the strain performance of the brace member. Accordingly, the brace member that is highly reliable can be obtained. In a state in which the brace member is attached to the building construction, after vibration of the building due to, for example, an earthquake has been input to the brace member, the axial force member can be visually checked through a space between the sliding-side end portion of the stiffening tube and the sliding-side cap by removing the socket tube. This allows a state of damage to the axial force member to be directly visible.

(iii) The axial force member is inserted into the holes provided in the securing-side cap and the sliding-side cap and threadedly engaged with the female screws disposed on the far sides of the cylindrical portions of the holes for

coupling. With this structure, even when bending strain occurs in the male screws provided in the axial force member, the bending strain around the male screws of the axial force member can be constrained by the cylindrical portions. Accordingly, the enduring force of the axial force member can be improved.

(iv) The sliding-side cap is coupled while the gap is set between the end surface of the sliding-side end portion of the stiffening tube and the surface (end surface) of the sliding-side cap that faces this end surface of the sliding-side end portion. Thus, even when a force from the building construction is applied to the brace member, no force (axial force) is applied to the stiffening tube in the axial direction. In such structure, it is not required to increase the strength of the stiffening tube. Accordingly, the cost of the stiffening tube can be reduced.

(v) The coupling elements project in the opposite directions to the side where the axial force member and the stiffening tube are coupled, and the coupling elements are respectively connected to the securing-side cap and the sliding-side cap. The coupling elements are prepared separately from the securing-side cap and the sliding-side cap and coupled afterward to the securing-side cap and the sliding-side cap. Thus, the coupling elements of the same structure can be used, and accordingly, the cost of coupling

elements can be reduced. Also, the coupling elements can be replaced in accordance with the building construction.

(vi) The inner diameter of the socket tube is fixed in the longitudinal direction in the range in which the socket tube surrounds the stiffening tube, and the outer profile of the socket tube in this range has a taper shape so as to be reduced toward the center of the stiffening tube in the longitudinal direction (axial direction). When the outer diameter of the socket tube has a taper shape, weight reduction can be facilitated and the design properties can be improved while the strength of the brace member in positions in the longitudinal direction can be ensured.

[0013]

(vii) The step of coupling the socket tube is performed after the step of coupling the securing-side cap, the step of securing the stiffening tube, the step of fitting the socket tube, and the step of securing the sliding-side cap have been performed. Accordingly, the assembly of the brace member can be performed while the above-described dimension between the sliding-side end portion of the stiffening tube and the sliding-side cap is viewed.

(viii) The step of securing the sliding-side cap includes the step of adjusting the gap in which the distance between the end surface of the sliding-side end portion of the stiffening tube and the surface of the sliding-side cap

that faces the end surface of the sliding-side end portion is adjusted. Therefore, the dimension between the sliding-side end portion of the stiffening tube and the sliding-side cap can be adjusted to a desired length. Thus, the dimension can be controlled with higher accuracy.

Brief Description of Drawings

[0014]

[Fig. 1] Fig. 1 is a side view of a brace member according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 illustrates a section taken along a central axis of the brace member illustrated in Fig. 1.

[Fig. 3] Fig. 3 is an enlarged view of a section of the brace member illustrated in Fig. 1 on the securing-side cap side.

[Fig. 4] Fig. 4 is an enlarged view of a section of the brace member illustrated in Fig. 1 on the sliding-side cap side.

[Fig. 5] Fig. 5 illustrates the structure of a related-art brace member as a comparative example.

[Fig. 6] Fig. 6 is a sectional side view that illustrates test samples for loading test in which the performance of the brace member according to the first embodiment of the present invention is checked and that defines the length of the portions.

[Fig. 7] Fig. 7 includes load-strain diagrams

illustrating results of the loading test in which the performance of the brace member according to the first embodiment of the present invention is checked, and out of the load-strain diagrams, (a) illustrates the result with the test sample No.1 and (b) illustrates the result with the test sample No. 2.

[Fig. 8] Fig. 8 is a load-strain diagram illustrating a result of loading test in which the performance of the related-art brace member as the comparative member is checked.

[Fig. 9] Fig. 9 is a view of a section passing through the central axis of a brace member according to a second embodiment of the present invention, illustrating the structure around the socket tube.

Description of Embodiments

[0015]

Embodiments of the present invention will be described below with reference to the drawings. It should be understood that the present invention is not limited to the embodiments described below. Drawings are schematic illustration, and relative sizes, the thicknesses, or so forth of members are not limited to the dimensions illustrated in the drawings. The relationships between the sizes of elements in the following drawings may be different from the relationships between the sizes of the actual

elements. Reference signs denoting the elements in the drawings without nonnumeric suffixes (such as "a" and "b") collectively represent the reference signs with the nonnumeric suffixes.

[0016]

[First Embodiment]

Fig. 1 is a side view of a brace member according to a first embodiment of the present invention. Fig. 2 illustrates a section taken along a central axis of the brace member illustrated in Fig. 1. Furthermore, in Figs. 1 and 2, the brace member is illustrated with part thereof in the longitudinal direction omitted. In the Figs. 1 and 2, the left side is referred to as one side in the longitudinal direction and the right side is referred to as the other side in the longitudinal direction.

[0017]

A brace member 100 includes a bar-shaped axial force member 10 and a cylindrical stiffening tube 20 that covers an outer circumference of the axial force member 10. A central axis 101 is a central axis of the brace member 100 and coincident with a central axis of the axial force member 10. The center of the stiffening tube 20 is also disposed at the same position as the position of the central axis 101. That is, the axial force member 10 is inserted through the cylindrical stiffening tube 20 in the longitudinal direction

at the center of the inside of the cylindrical stiffening tube 20. The outer circumference of the axial force member 10 is surrounded by the stiffening tube 20 so as to constrain strain of the axial force member 10. An end portion 11a on the one side of the axial force member 10 in the longitudinal direction is coupled to a securing-side cap 30. A securing-side end portion 21a being an end portion of the stiffening tube 20 on the one side in the longitudinal direction is also coupled to the securing-side cap 30.

[0018]

An end portion 11b on the other side of the axial force member 10 in the longitudinal direction is coupled to a sliding-side cap 60. A sliding-side end portion 21b being an end portion of the stiffening tube 20 on the other side in the longitudinal direction is spaced from the sliding-side cap 60 by a distance A. That is, a gap is provided between an end surface of the sliding-side end portion 21b of the stiffening tube 20 and a surface of the sliding-side cap 60 that faces this end surface of the sliding-side end portion 21b. An outer circumference of the sliding-side end portion 21b of the stiffening tube 20 is surrounded by a socket tube 50 the inside of which has a cylindrical shape. An end portion of the socket tube 50 on the sliding-side cap 60 side is removably coupled to the sliding-side cap 60.

[0019]

Clevises 40 are coupled to the securing-side cap 30 and the sliding-side cap 60. Each of the clevises 40 projects toward the opposite side to the side coupled to the axial force member 10. The clevises 40 correspond to "coupling elements" of the present invention. One of the clevises 40 coupled to the securing-side cap 30 is referred to as a clevis 40a, and the other clevis 40 coupled to the sliding-side cap 60 is referred to as a clevis 40b. The clevis 40a is referred as a "first coupling element" of the present invention, and the clevis 40b is referred to as a "second coupling element" of the present invention. The clevises 40 serve as joints for installing the brace member 100 in a building construction (not illustrated).

[0020]

Fig. 3 is an enlarged view of a section of the brace member illustrated in Fig. 1 on the securing-side cap 30 side. Fig. 4 is an enlarged view of a section of the brace member illustrated in Fig. 1 on the sliding-side cap 60 side. The details of the components are described below with reference to Figs. 3 and 4.

[0021]

(The Axial Force Member)

The axial force member 10 is an elongated bar steel having a circular section. According to the first embodiment, the axial force member 10 that is a steel bar

member having a circular section is presented. The axial force member 10 may be a steel tube or may be formed by coupling flat plates to have a cross shape in section. The shape of the section of the axial force member 10 taken along a plane perpendicular to the central axis 101 of the brace member 100 is not limited. A male screw 12a is formed in the end portion 11a on the one side of the axial force member 10 in the longitudinal direction. Furthermore, a male screw 12b is formed in the other end portion 11b of the axial force member 10 in the longitudinal direction. In the case where the axial force member 10 is formed of a material that can be plastically strained, energy input to the brace member 100 is absorbed by the axial force member 10 when the axial force member 10 is plastically strained. Thus, a higher effect of an antiseismic and vibration suppressing damper can be obtained. In order to prevent unusual noise from being generated when an outer circumferential surface of the axial force member 10 and an inner circumferential surface of the stiffening tube 20 slide against each other and in order to prevent an excessive increase in the axial force due to friction between the axial force member 10 and the stiffening tube 20, for example, a lining member formed of synthetic resin may be provided on the outer circumferential surface of the axial force member 10.

[0022]

(The Stiffening Tube)

The stiffening tube 20 is a steel tube having a circular shape in section and allows the axial force member 10 to be inserted therethrough. The shape of the stiffening tube 20 is not limited to a cylindrical shape. It is sufficient that, when the axial force member 10 is bent due to the axial force, the stiffening tube 20 be able to constrain bending of the axial force member 10 so as to prevent the axial force from buckling. For example, the stiffening tube 20 may be a tube having a square shape in section.

[0023]

The dimension of the stiffening tube 20 in the longitudinal direction is set such that, when the end portion 11a of the axial force member 10 on the one side and the securing-side end portion 21a of the stiffening tube 20 are secured to the securing-side cap 30, the end portion 11b of the axial force member 10 on the other side projects from the sliding-side end portion 21b of the stiffening tube 20. According to the first embodiment, the length of the stiffening tube 20 is smaller than that of the axial force member 10. Furthermore, a male screw 22a is formed on the outer circumferential side of the securing-side end portion 21a of the stiffening tube 20. The male screw 22a is threadedly engaged with a stiffening-tube-threaded-

engagement female screw portion 34 formed in the securing-side cap 30. The stiffening tube 20 and the axial force member 10 are secured in the securing-side cap 30 such that the stiffening tube 20 and the axial force member 10 are not moved relative to each other in the longitudinal direction. [0024]

As illustrated in Fig. 4, the distance A is set between the end surface of the sliding-side end portion 21b of the stiffening tube 20 and an end surface of the sliding-side cap 60 coupled to the end portion 11b of the axial force member 10. According to the first embodiment, the brace member 100 can be designed on the assumption that the axial force (a force acting in the central axis 101 direction of the brace member 100) is not input to the stiffening tube 20 due to setting of the distance A. When designing on the assumption that the axial force is not input to the stiffening tube 20, the thickness of the stiffening tube 20 can be reduced and the outer diameter of the stiffening tube 20 can be further reduced compared to the case where the axial force acts on the stiffening tube 20. Thus, the stiffening tube 20 does not need to be increased in size, and accordingly, the cost and weight of the brace member 100 can be reduced. Thus, in order to ensure strain performance of the brace, it is important to appropriately control the distance A so that the axial force is not transmitted to the

stiffening tube 20. The distance A is appropriately determined in accordance with the size and material of the brace member 100 and the building construction for which the brace member 100 is used.

[0025]

(The Securing-side Cap)

The securing-side cap 30 has a columnar shape having a hole 31 at the center. The hole 31 is formed from one end portion of the columnar shape. A female screw 33 is formed on a far side of the hole 31. The male screw 12a of the axial force member 10 is inserted into the hole 31 and threadedly engaged with the female screw 33 formed on the far side of the hole 31. Thus, the axial force member 10 is coupled to the securing-side cap 30. The hole 31 may penetrate through the securing-side cap 30 or may be closed at an end. With the hole 31 that allows the axial force member 10 to be inserted from one side and a support portion 32 that is provided on a near side relative to the female screw 33 and that is brought into contact with the axial force member 10 when the axial force member 10 is strained, the strain occurring in the male screw 12a when the axial force member 10 is subjected to the axial force can be suppressed.

[0026]

Although the male screw 12a of the axial force member

10 is threadedly engaged with the securing-side cap 30 being a component to be mated according to the first embodiment, there may be a non-threadedly-engaged male screw portion 13a that is not threadedly engaged with a female thread at the mouth of the female screw 33 in a completed state of the brace member 100. This male screw portion 13a is specifically an incomplete thread of the male screw 12a or a portion of the male screw 12a not in threaded engagement. The latter may happen when the male screw 12a is longer than the female screw 33 due to dimensional errors of the axial force member 10 and the securing-side cap 30.

[0027]

The axial force member 10 may be strained in a bending direction when the axial force member 10 is strained due to an axial force caused by vibration of the building construction. The non-threadedly-engaged male screw portion 13a is threaded, and accordingly, has a reduced sectional area compared to other columnar portions of the axial force member 10. Thus, the strength and stiffness of the non-threadedly-engaged male screw portion 13a is small. Furthermore, stress tends to concentrate on the non-threadedly-engaged male screw portion 13a because of the shape of the groove of the screw. Accordingly, there is a high probability that, when the axial force member 10 is strained, the strain starts from the non-threadedly-engaged

male screw portion 13a, which becomes a start point of breakage of the axial force member 10. In the case where the axial force member 10 is strained, the strain around the non-threadedly-engaged male screw portion 13a is suppressed by causing the axial force member 10 to be brought into contact with the support portion 32, and thus, an enduring force of the axial force member 10 can be improved.

[0028]

Although a gap is needed between the inner diameter of the support portion 32 and the outer diameter of the axial force member 10, the size of this gap is desirably as reduced as possible. Furthermore, as the dimension of the support portion 32 in the central axis 101 direction is larger, the strain of the axial force member 10 around the non-threadedly-engaged male screw portion 13a can be suppressed more.

[0029]

Furthermore, a cylindrical recess having a specified depth from the end surface of the securing-side cap is provided on the mouth side of the hole 31. The stiffening-tube-threaded-engagement female screw portion 34 is provided in an inner circumferential portion of this cylindrical shape. The stiffening-tube-threaded-engagement female screw portion 34 is coaxial with the hole 31. The stiffening tube 20 is threadedly engaged with the stiffening-tube-threaded-

engagement female screw portion 34, thereby being coupled to the axial force member 10 such that the stiffening-tube-threaded-engagement female screw portion 34 and the axial force member 10 do not move relative to each other in a direction parallel to the central axis 101 of the brace member 100.

[0030]

A cylindrical recess is provided in an end surface of the securing-side cap 30 opposite to the end surface on the side where the stiffening-tube-threaded-engagement female screw portion 34 is provided. The cylindrical recess has a specified depth from this opposite end surface. A clevis-threaded-engagement female screw portion 37 is provided in an inner circumferential portion of this cylindrical shape. A male screw provided on the clevis 40a is coupled to the clevis-threaded-engagement female screw portion 37.

[0031]

A taper portion 35 and a chamfer portion 36 are formed in ridges between the end surfaces and an outer circumference of the securing-side cap 30. The outer diameters of the taper portion 35 and the chamfer portion 36 reduce toward the respective end surfaces. This can facilitate the reduction in weight of the securing-side cap 30 and improve design properties of the securing-side cap 30 while ensuring the strength of the securing-side cap 30 at

the above-described positions in the longitudinal direction. The dimensions of the taper portion 35 and the chamfer portion 36 can be appropriately changed. The taper portion 35 may be changed to a chamfer portion and the chamfer portion 36 may be changed to a taper portion in accordance with desired strength or desired design property.

[0032]

(The Sliding-side Cap)

The sliding-side cap 60 has a columnar shape having a hole 61 at the center. The hole 61 is formed from one end portion of the columnar shape. A female screw 63 is formed on a far side of the hole 61. The axial force member 10 is inserted into the hole 61 and threadedly engaged with the female screw 63 formed on a far side of the hole 61. Thus, the axial force member 10 is coupled to the sliding-side cap 60. The hole 61 may penetrate through the sliding-side cap 60 or may be closed at an end. As is the case with the hole 31 of the securing-side cap 30, the hole 61 of the sliding-side cap 60 also allows the axial force member 10 to be inserted from one side. Regarding the hole 61, with a support portion 62 that is provided on a near side relative to the female screw 63 in the insertion direction of the axial force member 10 and that is brought into contact with the axial force member 10 when the axial force member 10 is strained, the strain occurring in the male screw 12b when

the axial force member 10 is subjected to the axial force can be suppressed. When the axial force member 10 is strained, there is a high probability that the strain starts from a non-threadedly-engaged male screw portion 13b, which becomes a start point of breakage of the axial force member 10. However, when the strain around the non-threadedly-engaged male screw portion 13b is suppressed by causing the axial force member 10 to be brought into contact with the support portion 62, the enduring force of the axial force member 10 can be improved.

[0033]

As is the case with the hole 31 of the securing-side cap 30, although a gap is needed between the inner diameter of the support portion 62 and the outer diameter of the axial force member 10, the size of this gap is preferably as reduced as possible. Furthermore, the dimension of the support portion 62 in the central axis 101 direction is desirably increased as much as possible so as to allow the strain of the axial force member 10 around the non-threadedly-engaged male screw portion 13b to be suppressed more.

[0034]

A step is formed at the outer circumference of the end surface of the sliding-side cap 60 on the side where the axial force member 10 is inserted, thereby a central portion

of the sliding-side cap 60 has such a shape that a column having a smaller diameter than that of the outer circumference of the sliding-side cap 60 projects on the end surface side. A socket-tube-threaded-engagement male screw portion 64 with which the socket tube 50 is threadedly engaged is provided in an outer circumference of the column. [0035]

A cylindrical recess is provided in an end surface of the sliding-side cap 60 opposite to the end surface on the side where the socket-tube-threaded-engagement male screw portion 64 is provided. The cylindrical recess has a specified depth from this opposite end surface. A clevis-threaded-engagement female screw portion 67 is provided in an inner circumferential portion of this cylindrical shape. A male screw provided on the clevis 40b is coupled to the clevis-threaded-engagement female screw portion 67. [0036]

A chamfer portion 66 is formed in a ridge between the end surface on the side where the clevis 40b is coupled and the outer circumference of the sliding-side cap 60. This can facilitate the reduction in weight of the sliding-side cap 60 and improve design properties of the sliding-side cap 60 while ensuring the safety and durability of the sliding-side cap 60. The dimensions of the chamfer portion 66 can be appropriately changed, and the shape of the chamfer

portion 66 can be changed to a taper shape in accordance with the strength or design properties.

[0037]

(The Clevises)

The clevises 40 function as joints for installation in the building construction (not illustrated). The clevises 40 each have a discoid portion 41, a plate-shaped portion 42 provided on one end surface of the discoid portion 41, an attachment hole 44 penetrating through the plate-shaped portion 42, and a male screw 43 formed on an outer circumference of the discoid portion 41. The center line of the attachment hole 44 and the center line of the male screw 43 intersect each other at a right angle. However, it is noted that the intersection does not mean geometrically correct intersection, and industrial errors are tolerable. The clevises 40 are threadedly coupled to the securing-side cap 30 and the sliding-side cap 60, respectively. The cost of the entire brace member 100 can be suppressed when the clevis 40a and the clevis 40b have the same shape. Instead, the shapes of the clevis 40a and clevis 40b may be different from each other in accordance with a building construction for which the brace member 100 is used.

[0038]

Although the securing-side and the sliding-side caps 30 and 60 and the clevises 40 are separately fabricated and

integrated with one another by threaded coupling according to the first embodiment, the present invention is not limited to this. The securing-side and the sliding-side caps 30 and 60 may be integrated with the clevises 40 by mechanical coupling such as shrink fit or metallurgical connection such as welding. Alternatively, securing-side and the sliding-side caps 30 and 60 may be initially integrally fabricated with the clevises 40 by, for example, casting.

[0039]

(The Socket Tube)

The socket tube 50 has a through hole 51, a taper portion 52, and a cylindrical portion 55. The through hole 51 extends in the longitudinal direction inside the socket tube 50. The taper portion 52 and the cylindrical portion 55 are provided on the outer circumferential side. A sliding-side-cap-threaded-engagement female screw 54 is formed inside the cylindrical portion 55 of the socket tube 50. The socket-tube-threaded-engagement male screw portion 64 of the sliding-side cap 60 is threadedly engaged with the sliding-side-cap-threaded-engagement female screw 54, thereby the socket tube 50 and the sliding-side cap 60 are coupled to each other. The through hole 51 surrounds the sliding-side end portion 21b of the stiffening tube 20. A gap is set between an inner side surface of the through hole

51 and an outer circumferential surface of the stiffening tube 20. A gap B between the inner side surface of the through hole 51 and the outer circumferential surface of the stiffening tube 20 and a length C by which the through hole 51 surrounds the sliding-side end portion 21b of the stiffening tube 20 in the longitudinal direction are appropriately determined in accordance with, for example, accuracy of the assembly of the brace member 100, accuracy of parts of the stiffening tube 20, the securing-side cap 30, the axial force member 10, the sliding-side cap 60, the socket tube 50, and so forth, and the allowance for bending of the axial force member 10.

[0040]

When the brace member 100 is subjected to an axial force due to vibration of the building construction, the axial force member 10 is bent. The bending of a portion of the axial force member 10 surrounded by the stiffening tube 20 is constrained by the stiffening tube 20. However, the distance A is set between the sliding-side end portion 21b of the stiffening tube 20 and the sliding-side cap 60, and the bending of the axial force member 10 is not constrained in this section. Accordingly, the gap B and the length C may be set so as to keep the strain of the axial force member 10 within a range of the allowable strain of the axial force member 10 in the section in which the bending of

the axial force member 10 is not constrained (section of the distance A).

[0041]

The outer diameter of the taper portion 52 reduces toward a tip end 57. Since external visible surfaces from the sliding-side cap 60 to the stiffening tube 20 are smoothly connected to one another while the stiffening tube 20 is reinforced, the design properties is improved while the strength is ensured. Alternatively, the taper portion 52 may have a usual cylindrical shape.

[0042]

(A Method of Assembling the Brace Member 100)

A method of assembling the brace member 100, which has the above-described structure, is as follows. First, the female screw 33 of the securing-side cap 30 and the male screw 12a of the axial force member 10 are threadedly coupled to each other. This step corresponds to a "step of coupling the securing-side cap" of the present invention. Then, the stiffening-tube-threaded-engagement female screw portion 34 of the securing-side cap 30 and the male screw 22a of the stiffening tube 20 are threadedly coupled to each other. This step corresponds to a "step of securing the stiffening tube" of the present invention. After that, the sliding-side end portion 21b of the stiffening tube 20 is inserted into the through hole 51 of the socket tube 50.

This step corresponds to a "step of fitting the socket tube" of the present invention. The order of the three steps described above can be appropriately determined for convenience of fabrication.

[0043]

After the above-described steps have been completed, the axial force member 10 is inserted into the hole 61 of the sliding-side cap 60, and the female screw 63 and the male screw 12b of the axial force member 10 are coupled to each other. This step corresponds to a "step of securing the sliding-side cap" of the present invention. After this step has been completed, the distance A, which is set between the end surface of the sliding-side end portion 21b of the stiffening tube 20 and the end surface of the sliding-side cap 60 coupled to the end portion 11b of the axial force member 10, is determined. This step may further include a step of checking the dimension (distance A) and, if necessary, a step of adjusting the distance A between the end surface of the sliding-side end portion 21b of the stiffening tube 20 and the surface of the sliding-side cap 60 that faces this end surface of the sliding-side end portion 21b. This step corresponds to a "step of adjusting a gap" of the present invention. By performing the step of securing the sliding-side cap and the step of adjusting the gap, the strain performance of the brace member 100 can be

controlled as designed.

[0044]

After that, the sliding-side-cap-threaded-engagement female screw 54 of the socket tube 50 and the socket-tube-threaded-engagement male screw portion 64 of the sliding-side cap 60 are threadedly coupled to each other. This step corresponds to a "step of coupling the socket tube" of the present invention. A step of attaching the clevis 40a to the securing-side cap 30 and a step of attaching the clevis 40b to the sliding-side cap 60 may be performed before the above-described steps of assembling the brace member 100 in advance or after the above-described steps of assembling the brace member 100 have been completed. Furthermore, the steps of assembling the clevises 40 are not necessary when the clevises 40 are integrally formed with the securing-side cap 30 and the sliding-side cap 60, respectively in advance.

[0045]

(Comparative Example)

Fig. 5 illustrates the structure of a related-art brace member 900 as a comparative example. In the related-art brace member 900, a distance A2 is set between an integrated clevis 960 and a stiffening tube 920. As is the case with the brace member 100 according to the first embodiment, when the brace member 900 is subjected to an axial force, a portion of an axial force member 910 corresponding to the

distance A2 is bent and strained. In the related-art brace member 900, a sleeve 970 is disposed between the stiffening tube 920 and the axial force member 910 so as to surround a portion of an outer circumference of the axial force member 910 between the integrated clevis 960 and the stiffening tube 920. This structure improves bending strength of the portion of the axial force member 910 that is likely to be bent and strained. However, with the related art, the thickness of the sleeve 970 is limited due to the structure. Thus, a sufficient bending strength of the axial force member 910 is not necessarily obtained.

[0046]

(Operations and Effects of the Brace Member 100 according to the First Embodiment)

In the brace member 100 according to the first embodiment, the securing-side end portion 21a which is the end portion of the stiffening tube 20 on the one side in the longitudinal direction is coupled to the securing-side cap 30, and a specified range starting from the sliding-side end portion 21b which is the end portion of the stiffening tube 20 on the other side in the longitudinal direction is surrounded by the through hole 51 of the socket tube 50. The thickness of the socket tube 50, which surrounds the outer circumference of the stiffening tube 20, is not limited. Thus, the outer diameter and the thickness of the

socket tube 50 can be increased compared to those of the sleeve 970 of the related-art brace member 900. According to the present invention, strain of the axial force member 10 is constrained by the socket tube 50 having high stiffness in a region between the sliding-side end portion 21b of the stiffening tube 20 and the sliding-side cap 60, and accordingly, buckling and bending of the axial force member 10 are suppressed in the region between the sliding-side end portion 21b of the stiffening tube 20 and the sliding-side cap 60. Accordingly, the brace member 100 having high bending strength can be obtained.

[0047]

The socket tube 50 and the sliding-side cap 60 are removably coupled to each other. This can facilitate the assembling during fabrication of the brace member 100. Furthermore, the dimension between the sliding-side end portion 21b of the stiffening tube 20 and the sliding-side cap 60 is visible. This facilitates control of this dimension during fabrication, and further, facilitates control of the strain performance of the brace member 100. In a state in which the brace member 100 is attached to the building construction, after vibration of the building due to, for example, an earthquake has been input to the brace member 100, the axial force member 10 can be visually checked through a space between the sliding-side end portion

21b of the stiffening tube 20 and the sliding-side cap 60 by removing the socket tube 50. This allows a state of damage to the axial force member 10 to be directly visible.

[0048]

Both the ends of the axial force member 10 are threadedly coupled to the securing-side cap 30 and the sliding-side cap 60, respectively. By setting the screws of these in opposite directions (for example, the male screw 12a and the female screw 33 have right-handed threads and the male screw 12b and the female screw 63 have left-handed threads), the distance between the attachment hole 44a and the attachment hole 44b at both ends of the brace member 100 can be adjusted. This facilitates installation of the brace member 100 in the building construction.

[0049]

The axial force member 10 is inserted into the hole 31 and the hole 61 provided in the securing-side cap 30 and the sliding-side cap 60 and threadedly engaged with the female screw 33 and the female screw 63 disposed on the far side of the hole 31 and the hole 61 for coupling. With this structure, even when bending strain occurs around male screws 11 provided in the axial force member 10, the bending strain around the male screws 11 of the axial force member 10 can be constrained by the support portion 32 and the support portion 62. Accordingly, the enduring force of the

axial force member 10 can be improved.

[0050]

The sliding-side cap 60 is coupled while the distance A is set between the end surface of the sliding-side end portion 21b of the stiffening tube 20 and the surface of the sliding-side cap 60 that faces this end surface of the sliding-side end portion 21b. Thus, even when a force is applied from the building construction to the brace member 100, a force (axial force) is not applied to the stiffening tube 20 in the axial direction. With this structure, it is not required to increase the strength of the stiffening tube 20. Accordingly, the cost of the stiffening tube 20 can be reduced.

[0051]

The clevises 40 (corresponding to the "coupling elements" of the present invention) project in opposite directions to the side where the axial force member 10 and the stiffening tube 20 are coupled, and the clevises 40 are respectively coupled to the securing-side cap 30 and the sliding-side cap 60. The clevises 40 are prepared separately from the securing-side cap 30 and the sliding-side cap 60 and coupled afterward to the securing-side cap 30 and the sliding-side cap 60. Thus, the clevises 40 of the same structure can be used, and accordingly, the cost of clevises 40 can be reduced. Furthermore, the coupling

elements can be replaced in accordance with the building construction.

[0052]

The outer diameter of the socket tube 50 reduces toward an end surface 50a (tip end) on the one side in the longitudinal direction (toward the center of the stiffening tube 20 in the longitudinal direction). Accordingly, weight reduction can be facilitated and the design properties can be improved while the strength of the brace member 100 in positions in the longitudinal direction can be ensured.

[0053]

In assembling of the brace member 100, the step of coupling the socket tube is performed after the step of coupling the securing-side cap, the step of securing the stiffening tube, the step of fitting the socket tube, and the step of securing the sliding-side cap have been performed. Accordingly, the assembly of the brace member 100 can be performed while the above-described dimension between the sliding-side end portion 21b of the stiffening tube 20 and the sliding-side cap 60 is viewed. Furthermore, the step of securing the sliding-side cap includes the step of adjusting the gap in which the gap between the end surface of the sliding-side end portion 21b of the stiffening tube 20 and the surface of the sliding-side cap 60 that faces the end surface of the sliding-side end

portion 21b is adjusted. This allows control of the dimension of the distance A to be performed with higher accuracy, and accordingly, allows the strain performance of the brace member 100 to be controlled as designed.

[0054]

Although each of coupling portions of the brace member 100 is threadedly coupled according to the first embodiment, coupling may be performed not only by means of threads but also by other means. However, it is required that the coupling portion between the socket tube 50 and the sliding-side cap 60 be coupled by a coupling method that allows the socket tube 50 and the sliding-side cap 60 to be removable from each other even after the brace member 100 has been completed. For example, the socket tube 50 may be secured by using a securing screw inserted from a side surface thereof.

[0055]

[Table 1]

Sign	Axial force member			Stiffening tube		Socket tube		Clevis	Gap	Entire length	
	D_s mm	σ_y N/mm ²	N_y kN	D_B mm	t_B mm	l_K mm	t_K mm	l_C mm	e_K mm	e_s mm	l mm
No. 1	48.50	622	1149	120.0	28	250	12	326.5	4.0	15.5	2500
No. 2			1149	114.3	25					15.8	

[0056]

(Test Samples)

Fig. 6 is a sectional side view that illustrates test

samples for loading test in which the performance of the brace member 100 according to the first embodiment of the present invention is checked and that defines the length or dimensions of the indicated portions. Some of the reference signs are omitted from the illustration. Table 1 lists the dimensions and the like of the test samples (No. 1 and No. 2).

[0057]

In Fig. 6, for the test sample No.1 and the test sample No. 2, the outer diameter of the axial force member 10 is referred to as " D_s ". The yield point of the axial force member 10 is referred to as " σ_y ", and the product of the sectional area and the yield point σ_y of the axial force member 10 is referred to as " N_y ". The outer diameter of the stiffening tube 20 is referred to as " D_B ", and the thickness of the stiffening tube 20 is referred to as " t_B ". Out of the length of part of the clevis 40 and the socket tube 50, the distance between the end surface 20b of the stiffening tube 20 on the other side in the longitudinal direction and the center of the attachment hole 44b of the clevis 40b is referred to as " l_c ", and the distance between the end surface 20b of the stiffening tube 20 on the other side in the longitudinal direction and the end surface 50a of the socket tube 50 on the one side in the longitudinal direction is referred to as " l_k ". The distance between the center of

the attachment hole 44a of the clevis 40a and an end surface 30b of the securing-side cap 30 on the other side is referred to as " l_J ", the distance between the end surface 30b of the securing-side cap 30 on the other side and the end surface 50a of the socket tube 50 on the one side is referred to as " l_B ", and the distance between the end surface 50a of the socket tube 50 on the one side and the attachment hole 44b of the clevis 40b is referred to as " l_J ".
[0058]

Furthermore, the distance between the center of the attachment hole 44a of the clevis 40a and the center of the attachment hole 44b of the clevis 40b is referred to as " l ". Furthermore, the difference between the outer diameter of the axial force member 10 and the inner diameter of the stiffening tube 20 is referred to as " e_s ", and the difference between the outer diameter of the stiffening tube 20 and the inner diameter of the socket tube 50 is referred to as " e_k ". In Fig. 6, a gap " $e_s/2$ " between the outer circumferential surface of the axial force member 10 and the inner circumferential surface of the stiffening tube 20 and a gap " $e_s/2$ " between the outer circumferential surface of the stiffening tube 20 and an inner circumferential surface of the socket tube 50 are illustrated. The thickness of the socket tube 50 at the end surface 50a (tip end) on the one side in the longitudinal direction is referred to as " t_k ".

[0059]

[Table 2]

Sign	Axial force member			Stiffening tube		Entire length	
	D_s mm	σ_y N/mm ²	N_y kN	D_B mm	t_B mm	e_s mm	l mm
No. 3	46.00	635	1055	114.3	25	18.3	2500

[0060]

(Comparative Member)

A test sample for the loading test in which the performance of the related-art brace member as a comparative member is checked is described below. The test sample is the related-art brace member 900 illustrated in Fig. 5 that is a sectional side view defining the lengths of the portions. Table 2 lists the dimensions and so forth of the test sample (No. 3).

[0061]

In Fig. 5, for the brace member 900 as the comparative member (No. 3), the outer diameter of the axial force member 910 is referred to as " D_s ", the outer diameter of the stiffening tube 920 is referred to as " D_B ", and the thickness of the stiffening tube 920 is referred to as " t_B ". The yield point of the axial force member 910 is referred to as " σ_y ", and the product of the sectional area and the yield point σ_y of the axial force member 10 is referred to as " N_y ". The integrated clevises 940 and 960 (where female screws 941 and 961 are formed) are disposed at end portions 911a and

911b (where male screws 912a and 912b are formed) of the axial force member 910. The distance between the center of a coupling hole 944 of the integrated clevis 940 on the one side and the center of a coupling hole 966 of the integrated clevis 960 on the other side is referred to as "l". The end portion 911a (where the male screw 912a is formed) of the axial force member 910 on the one side and an end portion 921a (where a female screw 922a is formed) of the stiffening tube 920 on the one side are coupled to each other by using a cap 930 (where a female screw 931 and a male screw 932 are formed). The cylindrical sleeve 970 is disposed at a position close to the end portion 911b of the axial force member 910 on the other side. The sleeve 970 is inserted in the stiffening tube 920 by a distance "L" from the end portion 920b of the stiffening tube 920 on the other side. The difference between the outer diameter of the sleeve 970 and an inner surface 922b at an end portion 921b of the stiffening tube 920 on the other side is referred to as " $e_s/2$ ".

[0062]

(Second Moment of Area)

From the above description, the inner diameter of the socket tube 50 of the test sample No. 2 is calculated from the outer diameter D_B of the stiffening tube 20 and a difference e_k , which is the difference between the outer

diameter D_B of the stiffening tube 20 and the inner diameter of the socket tube 50. When calculated in accordance with the values in Table 1, the inner diameter of the socket tube 50 of the test sample No. 2 is " $114.3 + 4.0 = 118.3$ (mm)". An outer diameter of the socket tube 50 at a portion of the socket tube 50 having a smallest outer diameter is calculated from the inner diameter of the socket tube 50 and the thickness t_K at the end surface 50a of the socket tube 50. When calculated in accordance with the values in Table 1, such an outer diameter is " $118.3 + 2 \times 12 = 142.3$ (mm)". Accordingly, the second moment of area of the socket tube 50, at a smallest portion is at least " 1.0×10^7 (mm⁴)" or larger. [0063]

Meanwhile, the inner diameter and a largest outer diameter of the sleeve 970 of a test sample No. 3 being the comparative member are, in accordance with the values in Table 2, 46.0 (mm) and $114.3 - 2 \times 25 = 64.3$ (mm), respectively. The second moment of area of the sleeve 970 is 0.062×10^7 (mm⁴) or smaller at the maximum. [0064]

The second moment of area of the socket tube 50 according to the first embodiment is a high (large) value that is about 17 times the second moment of area of the related-art sleeve 970 being the comparative member. That is, the brace member 100 according to the first embodiment

suppresses strain of the axial force member 10 by the socket tube 50 having higher stiffness than that of the sleeve 970 provided in the brace member 900.

[0065]

(Loading test)

Fig. 7 includes load-strain diagrams illustrating results of the loading test in which the performance of the brace member 100 according to the first embodiment of the present invention is checked, and out of the load-strain diagrams, (a) illustrates the result with the test sample No.1 and (b) illustrates the result with the test sample No. 2. In the loading test, alternating stress, that is, compression and tension are alternately repeatedly applied to the brace member 100.

[0066]

Referring to (a) of Fig. 7, first, the brace member 100 is compressed by 0.25%. That is, the distance l between the center of the attachment hole 44a of the clevis 40a and the center of the attachment hole 44b of the clevis 40b is reduced by 6.25 mm. Compression stress and compression strain at this time are illustrated in the first quadrant of (a) of Fig. 7. Next, the axial force member 10 is stretched by 0.25%. That is, the distance l is increased by 6.25 mm. Tensile stress and tensile strain at this time are illustrated in the third quadrant of (a) of Fig. 7.

[0067]

Furthermore, the brace member 100 is compressed by 0.5% (the distance 1 is reduced by 12.5 mm), and then, the brace member 100 is stretched by 0.5% (the distance 1 is increased by 12.5 mm). Furthermore, the brace member 100 is compressed by 1.0% (the distance 1 is reduced by 25mm), and then, the brace member 100 is stretched by 1.0% (the distance 1 is increased by 25mm). This stress of compression and stretching is regarded as a single cycle, and this cycle is repeated five times.

[0068]

Then, as the last cycles, the brace member 100 is compressed by 2.0% (the distance 1 is reduced by 50mm), and next, the brace member 100 is stretched by 2.0% (the distance 1 is increased by 50mm). This stress of compression and stretching is regarded as a single cycle, and this cycle is repeated until the brace member 100 buckles or breaks.

[0069]

In the loading test performed with the above-described cycles, the axial force member 10 of the test sample No.1 broke when the test sample No.1 was stretched in the fourth cycle of the last cycles after three of the last cycles had been performed.

[0070]

Referring to (b) of Fig. 7, as is the case with the test sample No.1, the axial force member 10 of the test sample No.2 broke when the test sample No.2 was stretched in the fourth cycle of the last cycles after three of the last cycles had been performed.

That is, neither the brace member 100 of the test sample No.1 nor the brace member 100 of the test sample No. 2 buckled. This indicates that the bending of the axial force member 10 is appropriately constrained by the stiffening tube 20 and the socket tube 50.

[0071]

Fig. 8 is a load-strain diagram illustrating a result of the loading test in which the performance of the related-art brace member as the comparative member is checked. The stress conditions are the same as those for the test samples No.1 and No. 2. Referring to Fig. 8, with the test sample No. 3, the brace member 900 buckled when the test sample No. 3 was compressed by 1.0% after stress of compression and stretching of 0.10% was applied one cycle, stress of compression and stretching of 0.25% was applied two cycles, and stress of compression and stretching of 0.5% was applied two cycles.

[0072]

Also from the loading test results with the above-described test samples No. 1 to 3, it has been confirmed

that, compared to the structure of the related-art brace member 900 in which the sleeve 970 is used, the structure of the brace member 100 according to the first embodiment, in which the socket tube 50 is used, has high (large) bending strength, and accordingly, is unlikely to buckle.

[0073]

[Second Embodiment]

A position to which the socket tube 50 is coupled is the sliding-side cap 60 according to the first embodiment. This position is changed to the stiffening tube 20 according to a second embodiment. For the second embodiment, changes from the first embodiment are mainly described.

[0074]

Fig. 9 is a view of a section passing through the central axis of a brace member 200 according to the second embodiment of the present invention, illustrating the structure around the socket tube. Elements that are the same as or corresponding to those of the first embodiment are denoted by the same reference signs, thereby part of description is omitted. Relative sizes, the thicknesses, or so forth of members are not limited to the dimensions illustrated in the drawings. The structure of the securing-side cap 30, illustration of which is omitted, is the same as that of the first embodiment.

[0075]

In the brace member 100 according to the first embodiment, the sliding-side end portion 21b of the stiffening tube 20 is spaced from the sliding-side cap 60 by the distance A, and the outer circumference of the sliding-side end portion 21b of the stiffening tube 20 is surrounded by the socket tube 50 the inside of which has a cylindrical shape. The end portion of the socket tube 50 on the sliding-side cap 60 side is removably coupled to the socket-tube-threaded-engagement male screw portion 64 at the outer circumference of the sliding-side cap 60 by threaded coupling.

[0076]

Meanwhile, in the brace member 200 according to the second embodiment illustrated in Fig. 9, a male screw 224 is provided in an outer circumference of a sliding-side end portion 221b of a stiffening tube 220 spaced from a sliding-side cap 260 by a distance A1. A female screw 254 provided in a through hole 251 of a socket tube 250 is threadedly engaged with this male screw 224 and surrounds an outer circumference of the stiffening tube 220. An end portion of the socket tube 250 on the sliding-side cap 260 side surrounds the outer circumference of the sliding-side cap 260. According to the second embodiment, the through hole 251 is larger than the sliding-side cap 260. The socket tube 250 can be attached from the sliding-side cap 260 side

after the sliding-side cap 260 and the axial force member 10 have been coupled to each other. Furthermore, the through hole 251 is larger than a clevis 240b. Thus, the socket tube 250 can be attached even after the clevis 240b has been coupled to the sliding-side cap 260.

[0077]

An outer circumferential surface of the sliding-side cap 260 is fitted into the through hole 251 of the socket tube 250 with a gap B1 therebetween. The through hole 251 surrounds the outer circumference of the sliding-side cap 260 by a length C1 in the longitudinal direction. The gap B1 and the length C1 are appropriately determined in accordance with, for example, accuracy of the assembly of the brace member 200, accuracy of parts of the stiffening tube 220, the securing-side cap 30, the axial force member 10, the sliding-side cap 260, the socket tube 250, and so force, and the allowance for bending of the axial force member 10.

[0078]

(Operations and Effects of the Brace Member 200 according to the Second Embodiment)

Although the coupling position of the socket tube 250 is changed in the brace member 200 according to the second embodiment, a specified range of the stiffening tube 220 from the sliding-side end portion 221b is surrounded by the

through hole 251 of the socket tube 250. The thickness of the socket tube 250, which surrounds the outer circumference of the stiffening tube 220, is not limited. Thus, as is the case with the brace member 100 according to the first embodiment, the outer diameter and the thickness of the socket tube 250 can be increased. Accordingly, as is the case with the brace member 100 according to the first embodiment, the brace member 200 having high bending strength can be obtained.

[0079]

The socket tube 250 and the stiffening tube 220 are removably coupled to each other. As is the case with the brace member 100 according to the first embodiment, this can facilitate the assembling during fabrication of the brace member 200. This also facilitates control of the dimension of the distance A1 during fabrication, and accordingly, facilitates control of the strain performance of the brace member 200. Also, as is the case with the brace member 100 according to the first embodiment, a state of damage to the axial force member 10 can be directly visible in a state in which the brace member 200 is attached to the building construction.

[0080]

As is the case with the brace member 100 according to the first embodiment, both the ends of the axial force

member 10 of the brace member 200 are threadedly coupled to the securing-side cap 30 and the sliding-side cap 260, respectively. By setting the screws of these in opposite directions, the distance between attachment holes at both ends of the brace member 200 can be adjusted. This facilitates installation of the brace member 200 in the building construction.

[0081]

Also, the structures of the axial force member 10 around portions where the axial force member 10 is threadedly engaged with the securing-side cap 30 and the sliding-side cap 260 are similar to those of the brace member 100 according to the first embodiment. Accordingly, even when bending strain occurs around a male screw 11 provided in the axial force member 10, the bending strain around the male screw 11 of the axial force member 10 can be constrained by a support portion 262. Accordingly, the enduring force of the axial force member 10 can be improved.

[0082]

The sliding-side cap 260 is coupled while the distance A1 is set between an end surface of the sliding-side end portion 221b of the stiffening tube 220 and a surface of the sliding-side cap 260 that faces this end surface of the sliding-side end portion 221b. Thus, as is the case with the brace member 100 according to the first embodiment, even

when a force is applied from the building construction to the brace member 200, a force (axial force) is not applied to the stiffening tube 220 in the axial direction. With this structure, it is not required to increase the strength of the stiffening tube 220. Accordingly, the cost of the stiffening tube 220 can be reduced.

[0083]

The clevises 40 are prepared separately from the securing-side cap 30 and the sliding-side cap 60 and coupled afterward to the securing-side cap 30 and the sliding-side cap 60. Thus, the clevises 40 of the same structure can be used, and accordingly, the cost of clevises 40 can be reduced. Also, the coupling elements (clevises 40) can be replaced in accordance with the building construction.

[0084]

The assembly of the brace member 200 can be performed as is the case with the brace member 100 according to the first embodiment. Thus, the dimension (distance A1) between the sliding-side end portion 221b and the sliding-side cap 260 of the stiffening tube 220 can be visually checked. This allows control of the dimension of the distance A1 to be performed with higher accuracy, and accordingly, allows the strain performance of the brace member 200 to be controlled as designed.

[0085]

Although coupling portions of the brace member 200 are for threaded coupling also according to the second embodiment, coupling may be performed not only by threaded coupling but also by other means. However, it is required that the coupling portion of the socket tube 250 with the stiffening tube 220 be coupled by a coupling method that allows attachment/removal even after the brace member 200 has been completed. For example, the socket tube 50 may be secured to the stiffening tube 220 by using a securing screw inserted from a side surface.

Industrial Applicability

[0086]

According to the present invention, brace members of high (large) bending strength can be obtained with a simple structure and used for axial force members having sectional shapes of a variety of forms. Accordingly, a variety of brace members that can address a variety of requirements of the building construction can be widely used.

Reference Signs List

[0087]

10 axial force member, 11a end portion (one side), 11b end portion (the other side), 12a male screw, 12b male screw, 13a male screw portion, 13b male screw portion, 20 stiffening tube, 20b end surface (the other side), 21a securing-side end portion, 21b sliding-side end portion,

22a male screw, 30 securing-side cap, 30b end surface, 31 hole, 32 support portion, 33 female screw, 34 stiffening-tube-threaded-engagement female screw portion, 35 taper portion, 36 chamfer portion, 37 clevis-threaded-engagement female screw portion, 40 clevis, 40a clevis (securing-side cap side), 40b clevis (sliding-side cap side), 41 discoid portion, 42 plate-shaped portion, 43 male screw, 44 attachment hole, 44a attachment hole, 44b attachment hole, 50 socket tube, 50a end surface, 51 through hole, 52 taper portion, 54 sliding-side-cap-threaded-engagement female screw, 55 cylindrical portion, 57 tip end, 60 sliding-side cap, 61 hole, 62 support portion, 63 female screw, 64 socket-tube-threaded-engagement male screw portion, 66 chamfer portion, 67 clevis-threaded-engagement female screw portion, 100 brace member, 101 central axis, 200 brace member, 220 stiffening tube, 221b sliding-side end portion, 224 male screw, 240b clevis, 250 socket tube, 251 through hole, 254 female screw, 260 sliding-side cap, 262 support portion, 263 female screw, 267 clevis-threaded-engagement female screw portion, 900 brace member (comparative member), 910 axial force member, 911a end portion, 911b end portion, 912a male screw, 912b male screw, 920 stiffening tube, 920b end surface, 921a end portion, 921b end portion, 922a female screw, 922b inner surface, 931 female screw, 932 male screw, 940 integrated

clevis, 941 female screw, 944 coupling hole, 960
integrated clevis, 961 female screw, 966 coupling hole, 970
sleeve, A distance, A1 distance, A2 distance, B gap, B1
gap, C length, D_s outer diameter, D_B outer diameter, e_k
difference (from inner diameters) e_s difference (from inner
diameters) N_y the product of the sectional area of the axial
force member 10 and the yield point σ_y , l distance, l_B
distance, $_{Fl_J}$ distance, t_B thickness, t_K thickness, σ_y
yield point

CLAIMS

[Claim 1]

A brace member comprising:

an axial force member having a bar shape;

a stiffening tube through which the axial force member is inserted;

a securing-side cap that is coupled to a securing-side end portion of the stiffening tube which is an end portion on one side in a longitudinal direction and that is coupled to an end portion of the axial force member, the end portion of the axial force member located on the one side in the longitudinal direction;

a sliding-side cap that is coupled to an end portion of the axial force member, the end portion of the axial force member located on another side in the longitudinal direction; and

a socket tube that is removably coupled to a sliding-side end portion of the stiffening tube which is an end portion on the other side in the longitudinal direction or removably coupled to the sliding-side cap;

wherein the securing-side cap and the sliding-side cap include

respective coupling elements to be used as joints for installation in a building construction, and

wherein the socket tube surrounds an outer

circumferential portion of the sliding-side end portion and an outer circumferential portion of the sliding-side cap.

[Claim 2]

The brace member according to Claim 1,

wherein the socket tube is threadedly coupled to the stiffening tube or the sliding-side cap.

[Claim 3]

The brace member according to Claim 1 or 2,

wherein the axial force member has male screws at ends on both the sides,

wherein the securing-side cap and the sliding-side cap have respective holes into which the axial force member is inserted,

wherein each of the holes has a cylindrical portion and a female screw with which the axial force member is threadedly engaged on a far side of the cylindrical portion when seen in a direction in which the axial force member is inserted into the hole, and

wherein the axial force member is coupled to the securing-side cap and the sliding-side cap by threaded engagement of the male screws with the female screws.

[Claim 4]

The brace member according to any one of Claims 1 to 3,

wherein the sliding-side cap is coupled to the axial force member such that a gap is provided between an end

surface of the sliding-side end portion of the stiffening tube and a surface of the sliding-side cap facing the end surface.

[Claim 5]

The brace member according to any one of Claims 1 to 4, wherein the coupling elements project in opposite directions to a side where the axial force member and the stiffening tube are coupled, and the coupling elements are respectively connected to the securing-side cap and the sliding-side cap.

[Claim 6]

The brace member according to any one of Claims 1 to 5, wherein an inner diameter of the socket tube is fixed in the longitudinal direction in a range in which the socket tube surrounds the stiffening tube, and

an outer diameter of the socket tube in this range reduces toward a center of the stiffening tube in the longitudinal direction.

[Claim 7]

A method of assembling a brace member,
the brace member including
an axial force member having a bar shape,
a stiffening tube through which the axial force member is inserted,

a securing-side cap that is coupled to a securing-side

end portion of the stiffening tube which is an end portion on one side in a longitudinal direction and that is coupled to an end portion of the axial force member, the end portion of the axial force member located on the one side in the longitudinal direction,

a sliding-side cap that is coupled to an end portion of the axial force member, the end portion of the axial force member located on another side in the longitudinal direction,

a socket tube that is removably coupled to a sliding-side end portion of the stiffening tube which is an end portion on the other side in the longitudinal direction or removably coupled to the sliding-side cap,

wherein the securing-side cap and the sliding-side cap include

respective coupling elements to be used as joints for installation in a building construction, and

wherein the socket tube surrounds an outer circumferential portion of the sliding-side end portion and an outer circumferential portion of the sliding-side cap;

the method of assembling the brace member including the steps of

coupling the securing-side cap in which the securing-side cap and the axial force member are coupled to each other,

securing the stiffening tube in which the securing-side

cap and the stiffening tube are coupled to each other,

fitting the socket tube in which the socket tube is fitted onto the outer circumferential portion of the sliding-side end portion of the stiffening tube,

securing the sliding-side cap in which the sliding-side cap and the axial force member are coupled to each other, and

coupling the socket tube in which the socket tube is coupled to the stiffening tube or the sliding-side cap,

wherein the step of coupling the socket tube is performed after the step of coupling the securing-side cap, the step of securing the stiffening tube, the step of fitting the socket tube, and the step of securing the sliding-side cap have been performed.

[Claim 8]

The method of assembling the brace member according to Claim 7,

wherein the step of securing the sliding-side cap is performed after the step of coupling the securing-side cap and the step of securing the stiffening tube have been performed, and the step of securing the sliding-side cap includes a step of adjusting a gap in which the gap provided between an end surface of the sliding-side end portion of the stiffening tube and a surface of the sliding-side cap facing the end surface is adjusted.