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NEW YORK, NY 10004 (US)(21) Appl. No.: **10/546,108**(22) PCT Filed: **Feb. 27, 2004**(86) PCT No.: **PCT/JP04/02372**(57) **ABSTRACT**

A beam joining apparatus for joining a flange 2 of a beam 1 to a flange 6 mounted on a pillar 5 includes a splice plate 9 fastened to the flanges 6, 2 of the pillar 5 and the beam 1 and having a central plastic region 11, and an anti-buckling member 13 mounted independently of the splice plate 9, on the splice plate 9, for preventing the buckling of the plastic region 11.

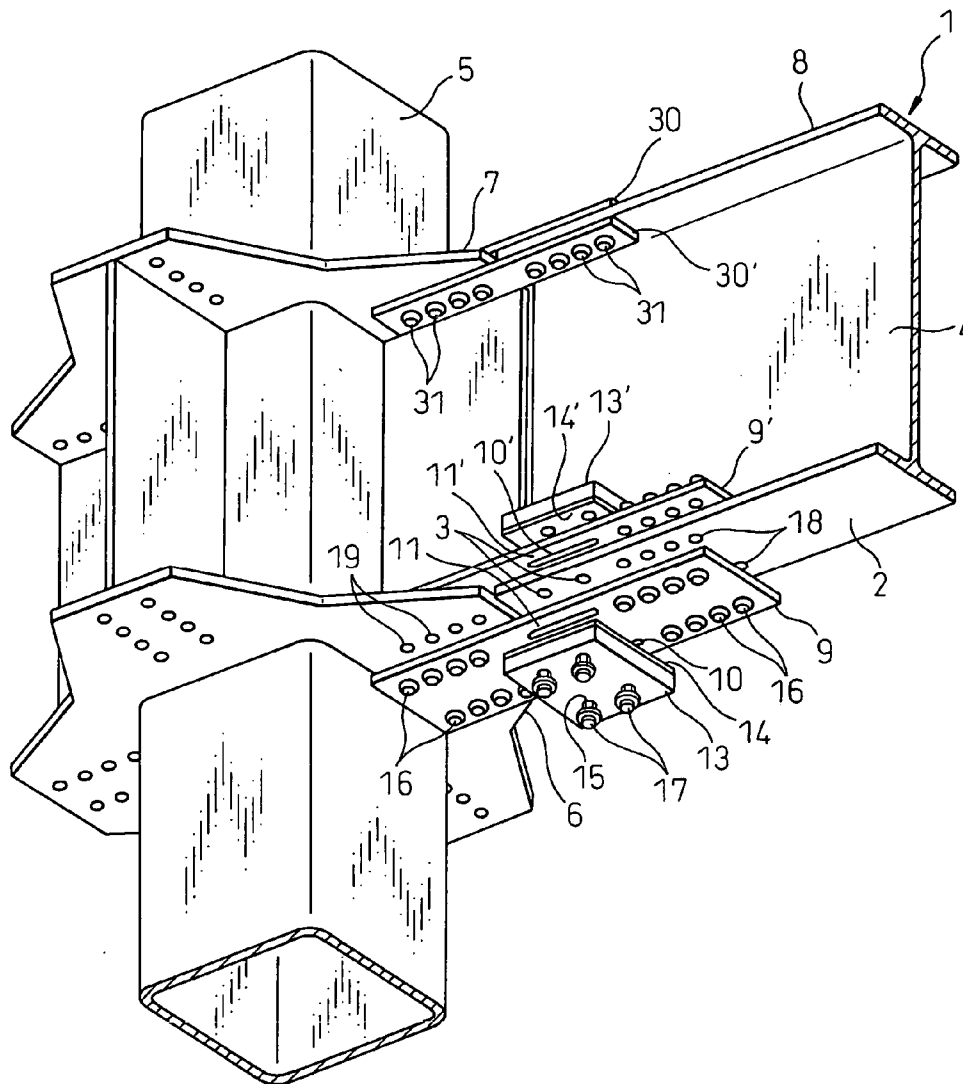


Fig. 1

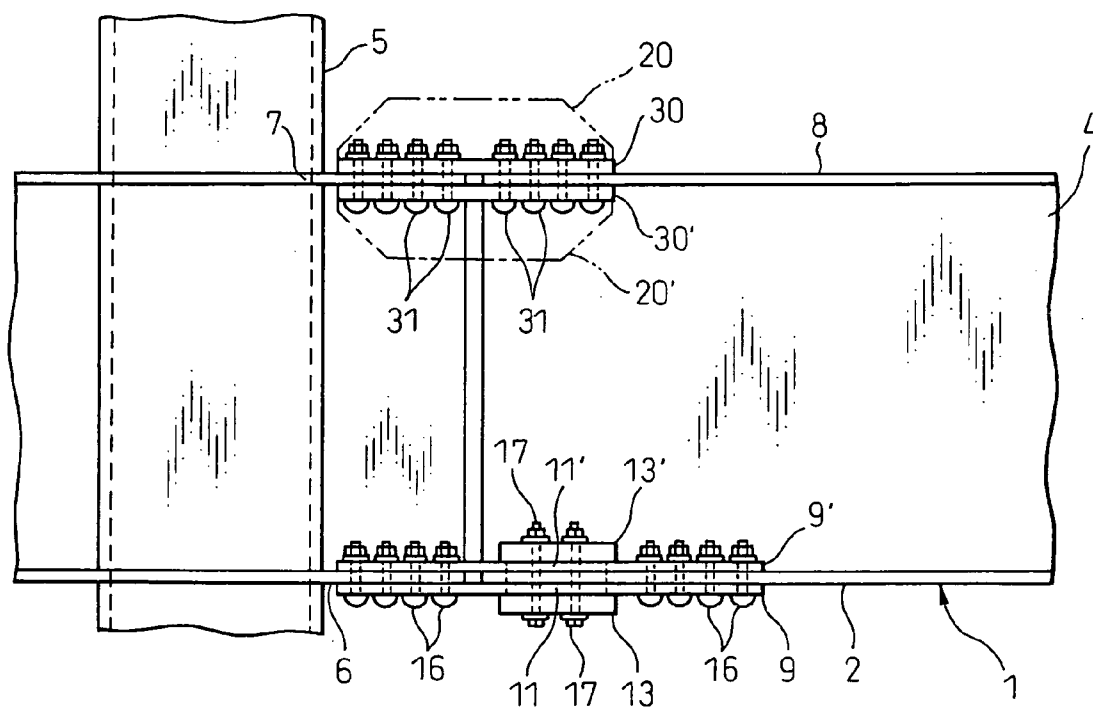


Fig. 2

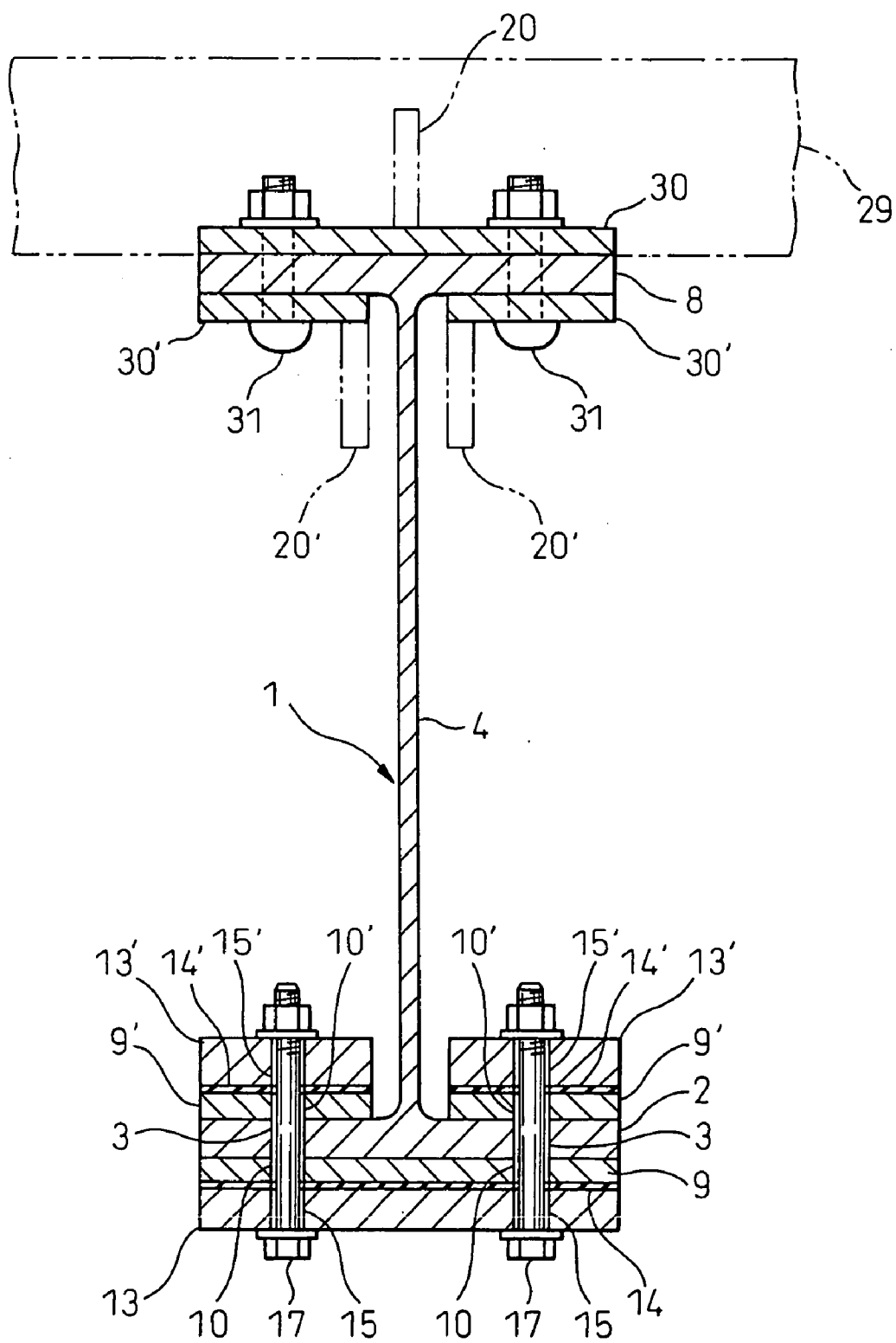


Fig.4A

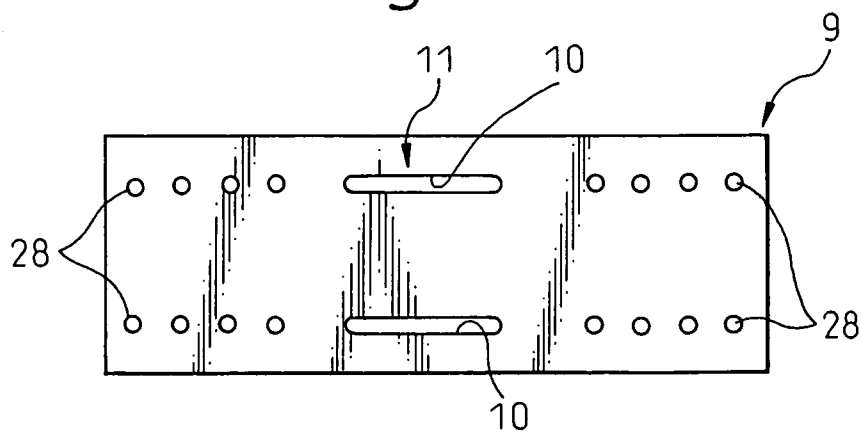


Fig.4B

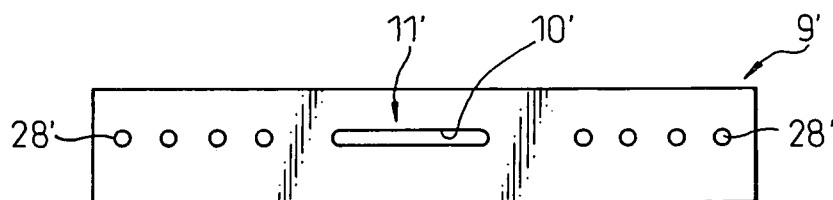


Fig.4C

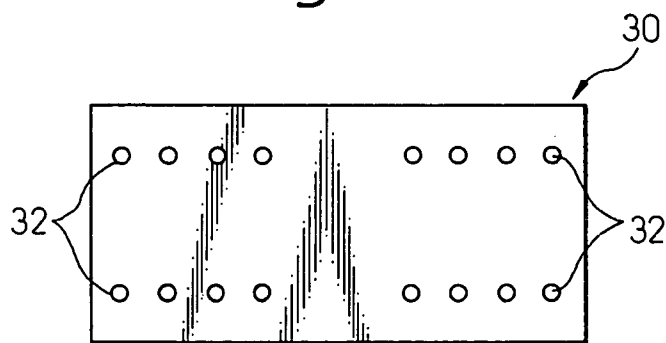


Fig.4D

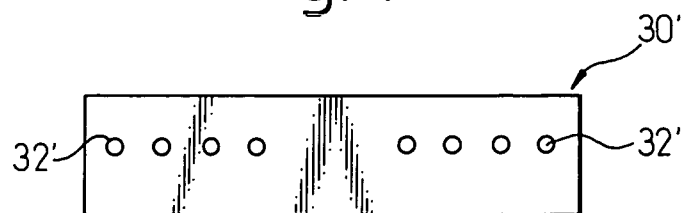


Fig.5A

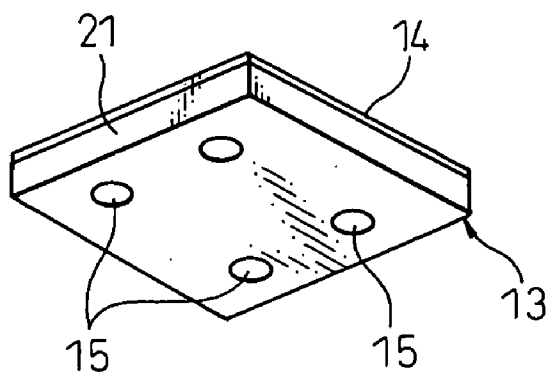


Fig. 5B

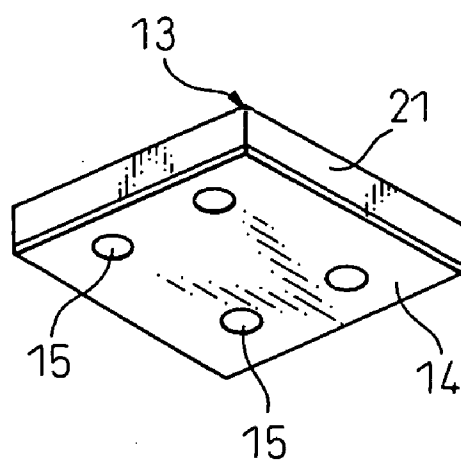


Fig.6

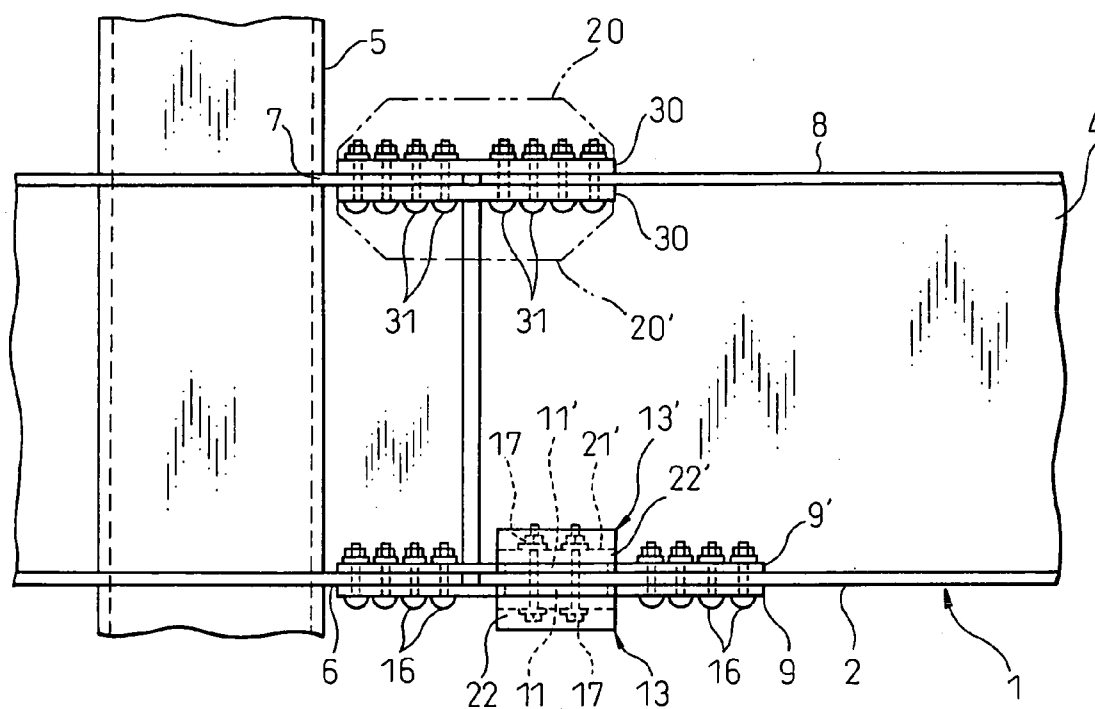


Fig.7

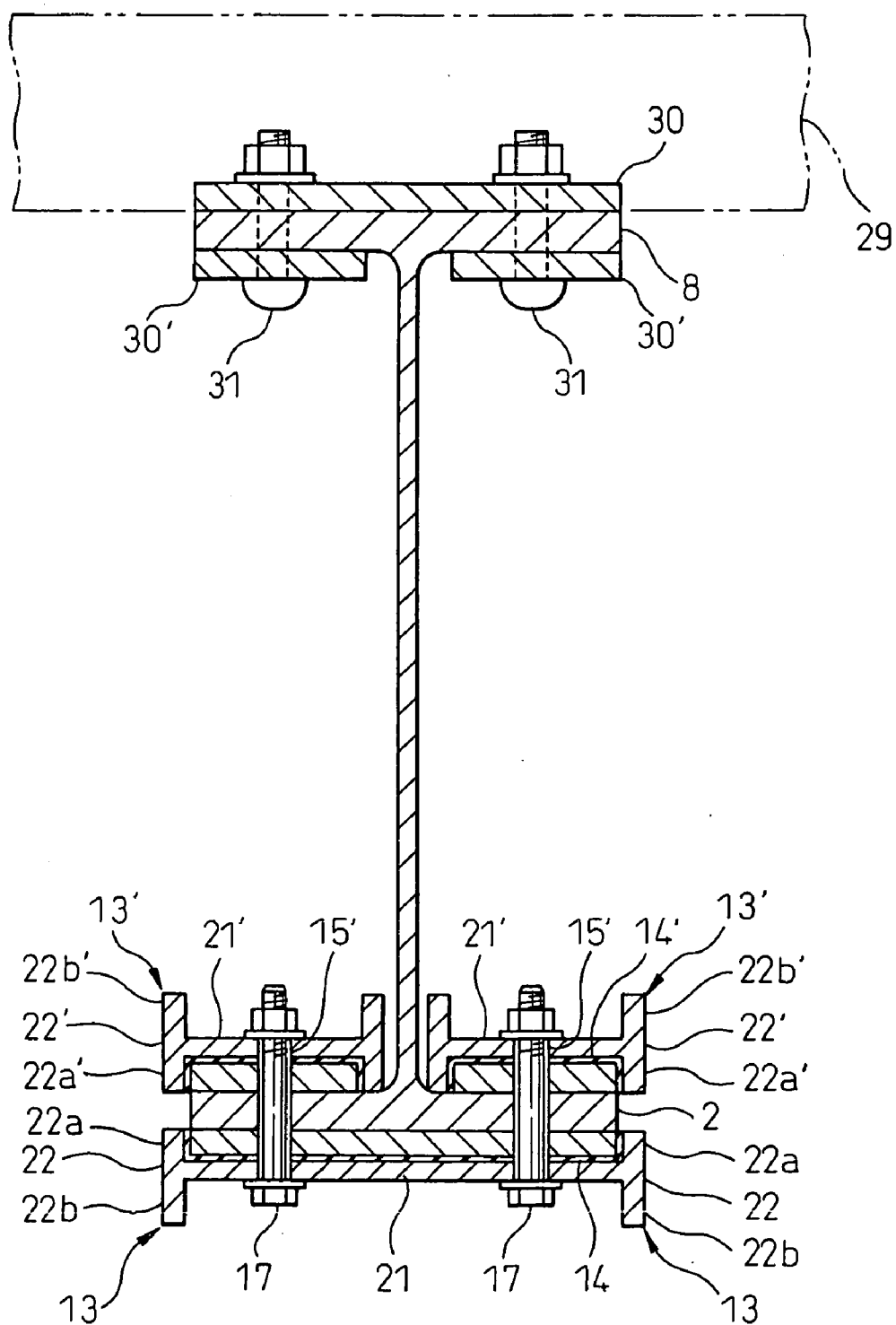


Fig. 9A

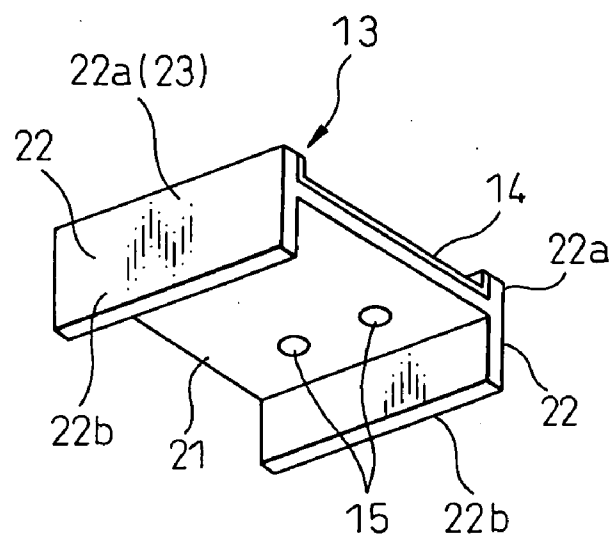


Fig. 9B

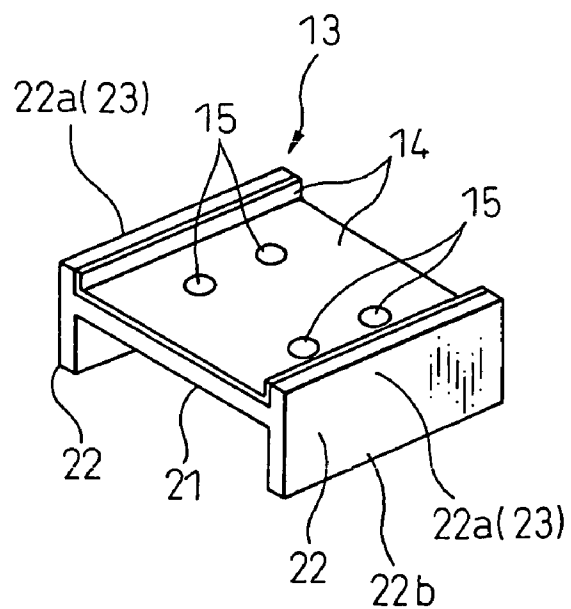


Fig.10A

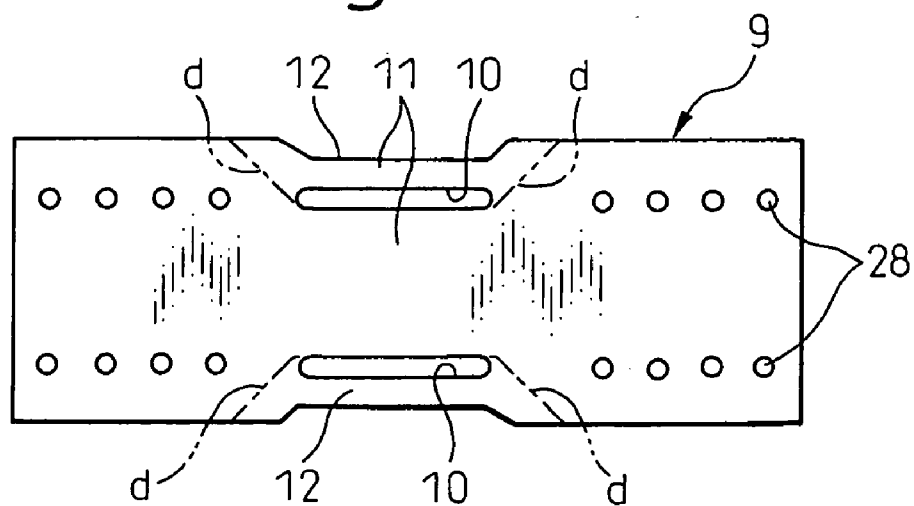


Fig.10B

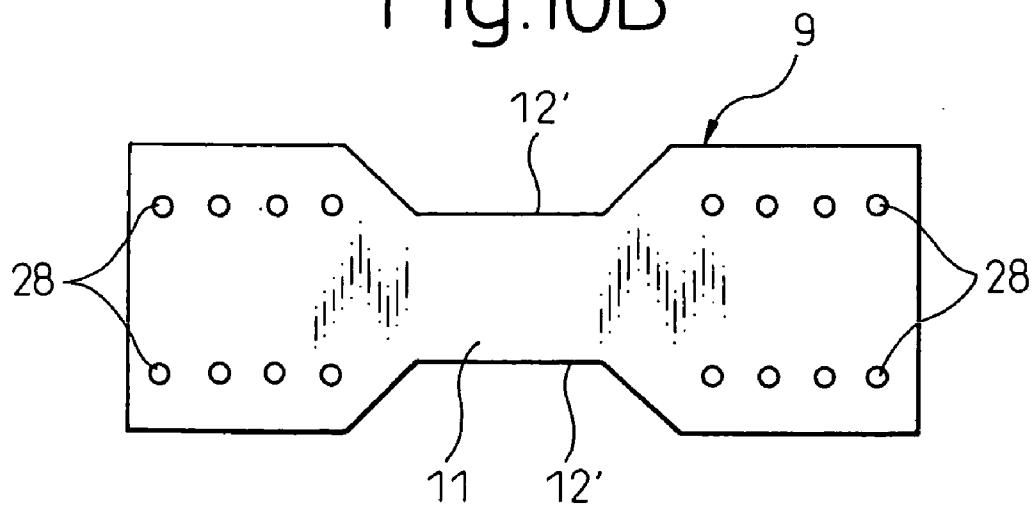


Fig.10C

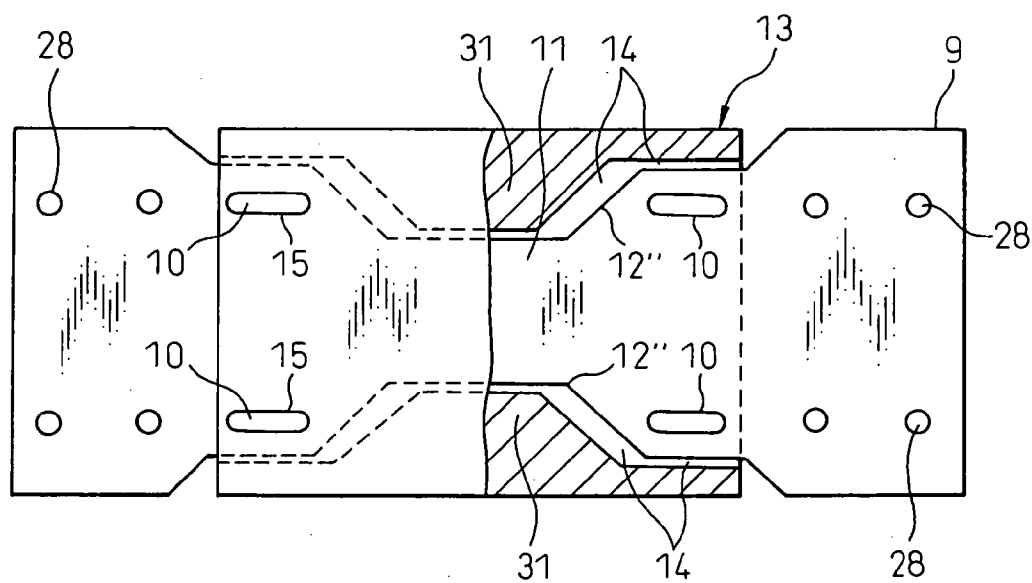


Fig.10D

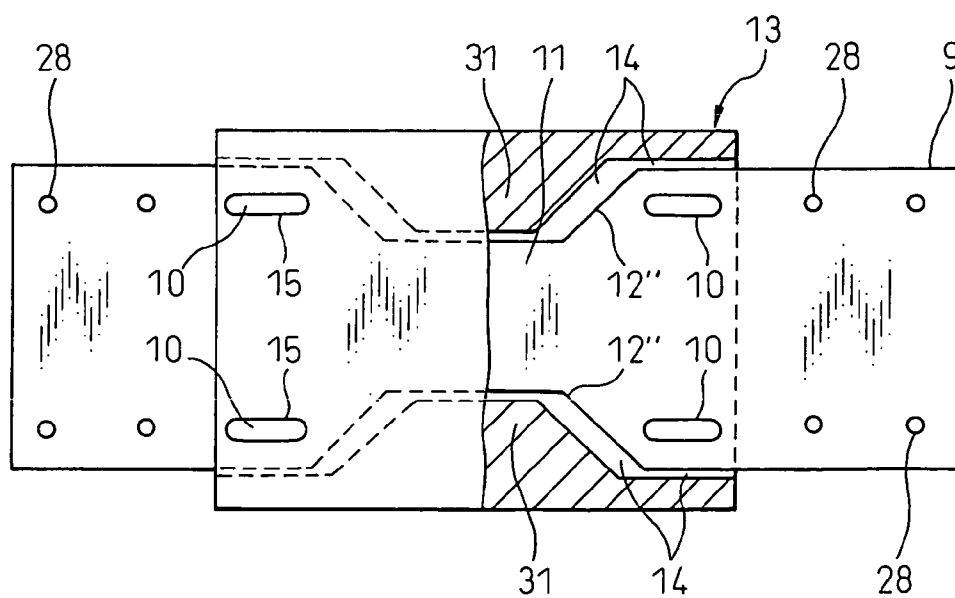


Fig.11

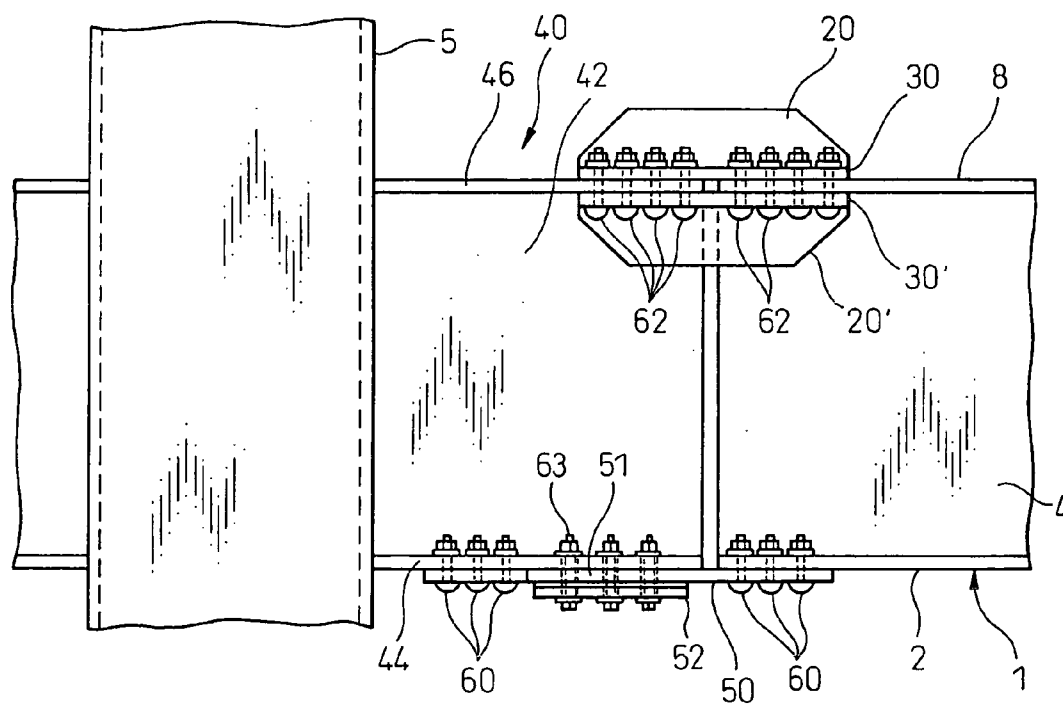


Fig.12

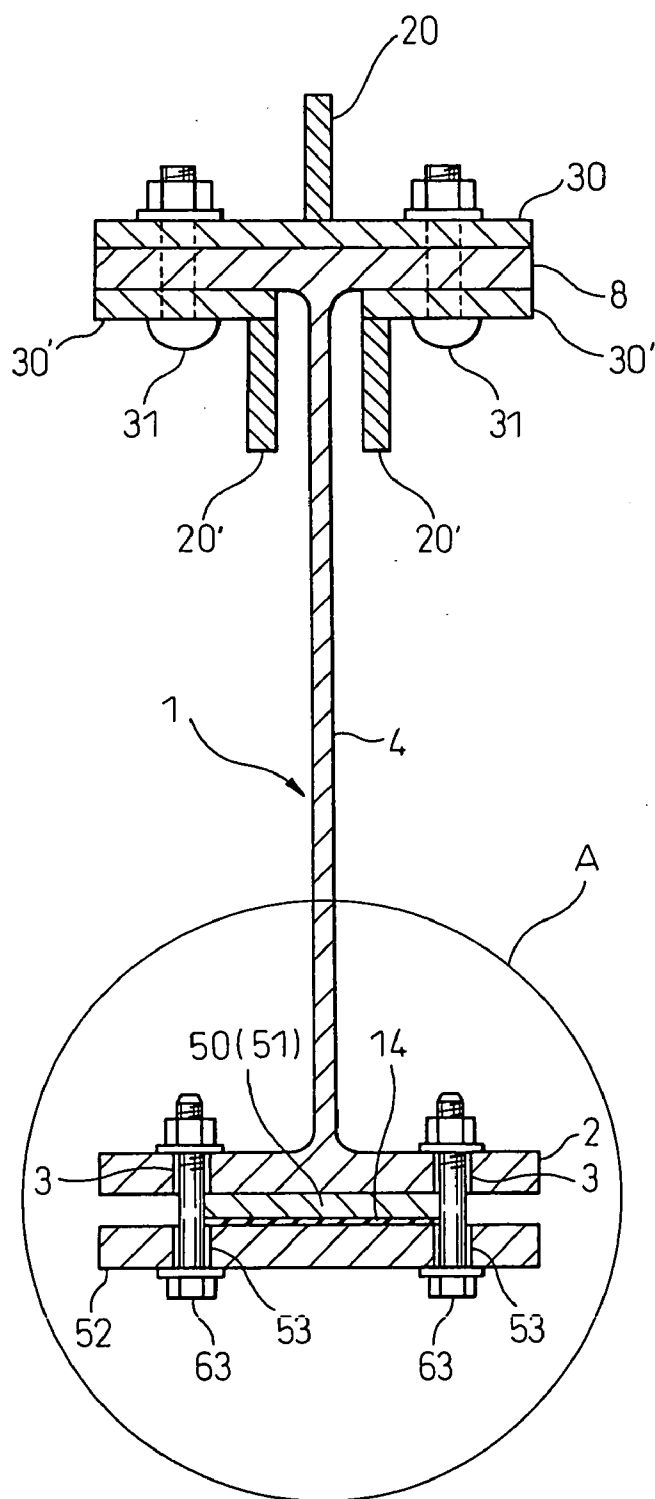


Fig.13

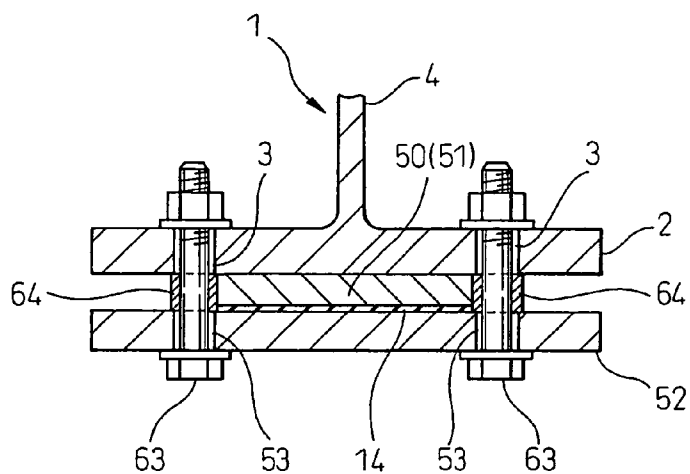


Fig.15

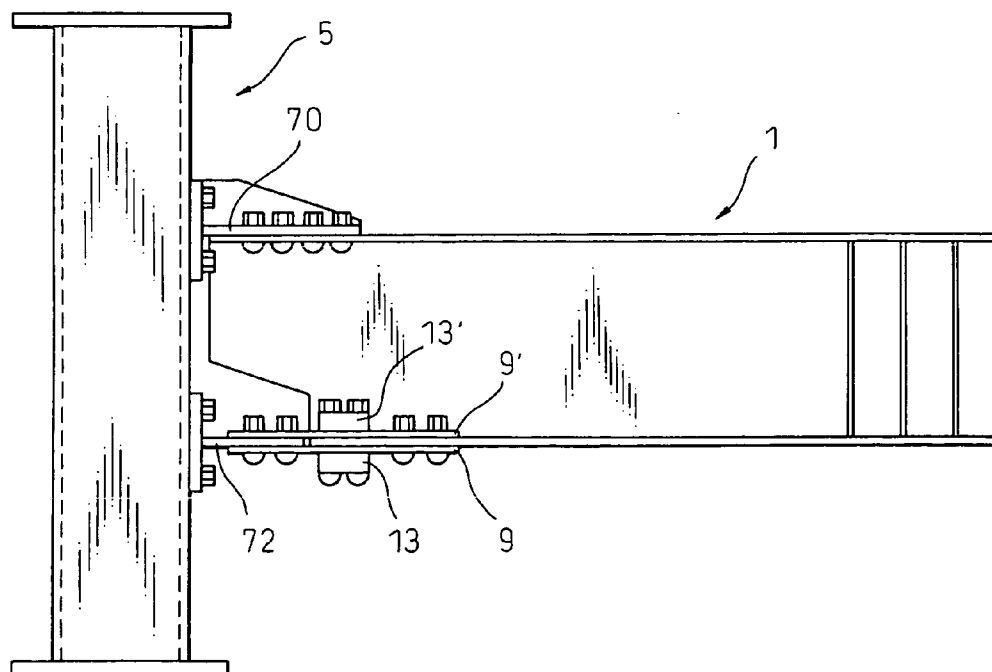


Fig.14A

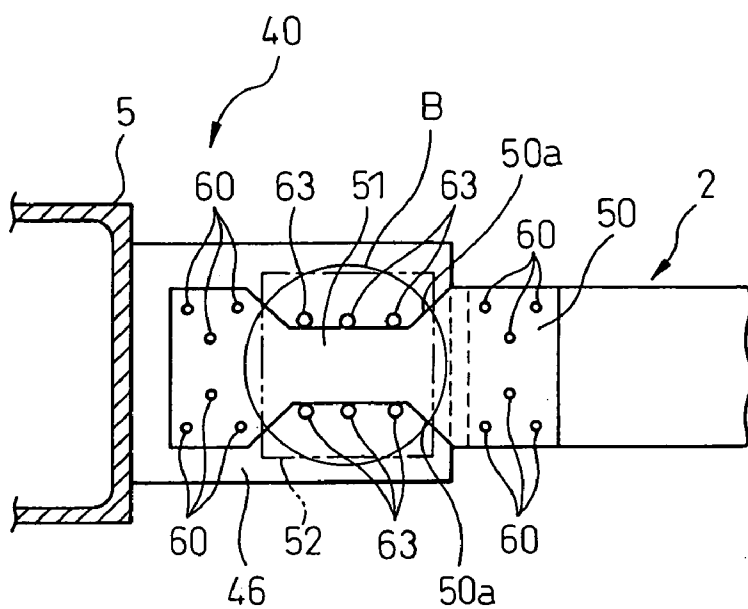


Fig.14B

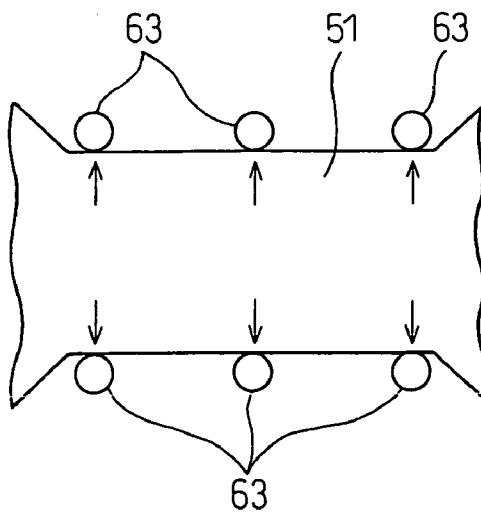


Fig.16

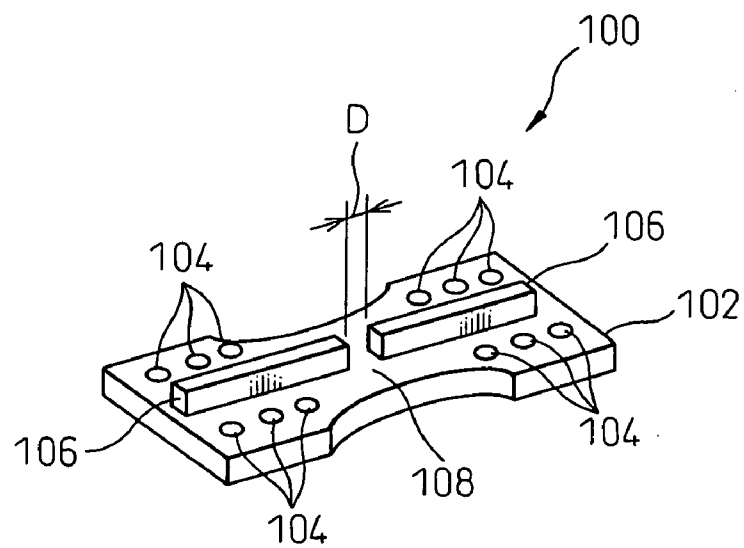
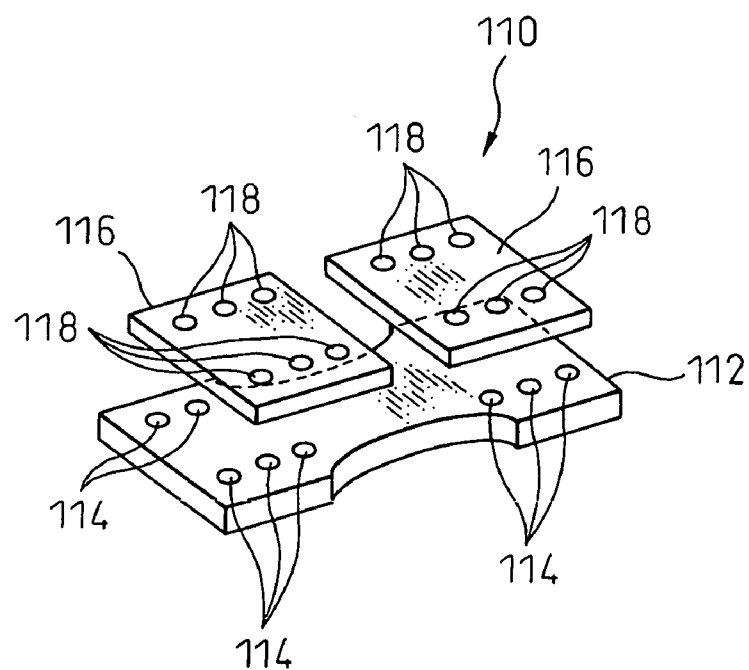


Fig.17



BEAM JOINT DEVICE

TECHNICAL FIELD

[0001] This invention relates to a beam joining apparatus for joining a beam to a pillar of an iron-frame building.

BACKGROUND ART

[0002] Japanese Unexamined Patent Publication No. 2000-144901 discloses a beam joining apparatus comprising a splice plate **100** shown in **FIG. 16** for joining a pillar flange and a beam flange of an iron-frame building to each other. In **FIG. 16**, the splice plate **100** includes a plate member **102** having a narrowed central portion. A pair of reinforcing ribs **106** arranged in spaced relation, to each other, in the axial direction of the beam are fixedly attached to the plate member **102**. In the plate member **102**, the portion between the reinforcing ribs **106** forms a plastic region **108**. Also, the plate member **102** is formed with bolt holes **104** for fastening the plate member **102** by bolts (not shown) to the pillar flange (not shown) and the beam flange (not shown).

[0003] In the splice plate **100**, an increased size D of the interval between the reinforcing ribs **106** would cause the plastic region **108** to buckle under a large force which would be exerted on the plate member **102** at the time of an earthquake or the like and, therefore, the interval between the reinforcing ribs **24** cannot be widened. In the case where the interval D between the reinforcing ribs **24** is increased, on the other hand, a tension and a compression which may act on the plate member **102** in axial direction of the beam at the time of an earthquake would increase the distortion of the plastic region **11** of the plate member **102** (distortion δ of plastic region=extension of plate member **102** divided by interval D between reinforcing ribs **106**) and may break the plate member **102** at the plastic region **108** (Problem 1).

[0004] Further, when welding the reinforcing ribs **106** to the plate member **102**, the plate member **102** is thermally affected along the weld line formed at the time of the welding, so that the mechanical characteristics, such as the yield point, the tensile strength and tenacity thereof, are reduced (Problem 2). As a result, the repetitive load of earthquakes is liable to break the plate member **102** early due to the fatigue along the weld line. Also, stress is concentrated along the weld line of the plate **102**, and the breakage is liable to occur from the weld line (Problem 3).

[0005] On the other hand, Japanese Unexamined Patent Publication No. 2000-144901 discloses a beam joining apparatus **110** having anti-buckling members **116** as shown in **FIG. 17**. The beam joining apparatus **110** is mounted on the pillar flange (not shown) and the beam flange (not shown) by inserting bolts (not shown) through the bolt holes **114**, **118** formed in the splice plate **112** and the anti-buckling members **116**. As compared with the beam joining apparatus **100** shown in **FIG. 16**, therefore, the anti-buckling members **116** must be mounted on the pillar flange and the beam flange (not shown), thereby increasing the number of parts and the number of steps for assembling the beam joining apparatus (Problem 4).

[0006] Also, in constructing this structure, the splice plate **112** is mounted on the pillar flange and the beam flange at the same time as the anti-buckling members **116**, but the

anti-buckling members **116** cannot be mounted after the splice plate **112**, thereby reducing the construction freedom. Further, as the anti-buckling members **116** are mounted directly on the splice plate **112**, the gap between the anti-buckling members **116** and the plastic region of the splice plate **112** is changed by the change in the building structure, and thus this gap cannot be maintained constant, thereby making it impossible to prevent buckling in steady manner (Problem 5).

DISCLOSURE OF THE INVENTION

[0007] The object of this invention is to provide a beam joining apparatus solving at least the problems of the prior art, as described above, by mounting an anti-buckling member independent of the splice plate on the plastic region of the splice plate without mounting the reinforcing ribs on the splice plate unlike in the prior art.

[0008] According to this invention, there is provided a beam joining apparatus for joining a flange of the beam to a flange mounted on a pillar, comprising a splice plate fastened to the pillar and beam flanges and having a plastic central portion, an anti-buckling member mounted on the splice plate independently of the splice plate for preventing the buckling of the plastic region, and an anti-sticking means arranged between the splice plate and the anti-buckling member to prevent the anti-buckling member and the splice plate from sticking to each other.

[0009] This invention can produce the following effects:

[0010] (1) The buckling of the splice plate due to the deformation under tension and compression is prevented and, even after the splice plate is plasticized, a stable hysteresis characteristic is obtained.

[0011] (2) The length of the plastic region of the splice plate can be freely set. In the case where the plastic region desirably yields early under the earthquake load, therefore, the length of the plastic region is shortened, and vice versa. In this way, the yield timing can be adjusted by the length of the plastic region, and the design freedom is remarkably improved.

[0012] (3) The maximum distortion to which the plastic region is subjected to at the time of an earthquake can be controlled by the length of the plastic region, and therefore the performance of the plastic region against the metal fatigue can also be controlled.

[0013] (4) The plastic region of the splice plate is free of the weld zone, and therefore the effect of welding on the material is eliminated. Thus, the yield load of the splice plate is not changed nor is the tenacity thereof reduced. Also, the deterioration due to the fatigue caused by the stress concentration or the material change along the weld line is prevented.

[0014] (5) The anti-buckling member includes a means for preventing the transverse deformation of the splice plate to prevent the splice plate from being buckled and deformed in transverse direction. Thus, the buckling along the thickness of the plastic region of the splice plate is prevented while at the same time preventing the excessive deformation along the width thereof.

[0015] (6) According to this invention, the anti-buckling member can be arranged in such a manner as to always

secure a predetermined clearance for the plastic region of the splice plate, and therefore the buckling can always be prevented in stable fashion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] **FIG. 1** is a side view showing a beam joining apparatus according to a first embodiment of the invention.

[0017] **FIG. 2** is a longitudinal front view of a beam joining apparatus cut along the plastic region of the splice plate according to the first embodiment.

[0018] **FIG. 3** is an exploded perspective view of the beam joining apparatus according to the first embodiment of the invention.

[0019] **FIG. 4A** is a plan view of a first splice plate.

[0020] **FIG. 4B** is a plan view of a second splice plate.

[0021] **FIG. 4C** is a plan view of a third splice plate.

[0022] **FIG. 4D** is a plan view of a fourth splice plate.

[0023] **FIG. 5A** is a perspective view of a first anti-buckling member as taken from thereunder.

[0024] **FIG. 5B** is a perspective view of a first anti-buckling member as taken from thereabove.

[0025] **FIG. 6** is a side view showing a beam joining apparatus according to a second embodiment of the invention.

[0026] **FIG. 7** is a longitudinal front view cut along the plastic region of the splice plate according to the second embodiment of the invention.

[0027] **FIG. 8** is an exploded perspective view of the beam joining apparatus according to the second embodiment of the invention.

[0028] **FIG. 9A** is a perspective view of another example of the first anti-buckling member as taken from thereunder.

[0029] **FIG. 9B** is a perspective view of another example of the first anti-buckling member as taken from thereabove.

[0030] **FIG. 10A** is a plan view of another example of the first splice plate.

[0031] **FIG. 10B** is a plan view of still another example of the first splice plate.

[0032] **FIG. 10C** is a plan view of yet another example of the first splice plate.

[0033] **FIG. 10D** is a plan view of a further example of the first splice plate.

[0034] **FIG. 11** is a side view of the beam joining apparatus according to a third embodiment of the invention.

[0035] **FIG. 12** is a longitudinal front view of the beam joining apparatus cut along the plastic region of the splice plate according to the third embodiment of the invention.

[0036] **FIG. 13** is an enlarged sectional view of the part indicated by A in **FIG. 12**.

[0037] **FIG. 14A** is a bottom view of the beam joining apparatus according to the third embodiment as taken from thereunder.

[0038] **FIG. 14B** is an enlarged plan view of the part indicated by B in **FIG. 14A**.

[0039] **FIG. 15** is a side view showing an example of application of the beam joining apparatus according to the invention to the pillar flange of split-T type.

[0040] **FIG. 16** is a perspective view showing an example of the splice plate according to the prior art.

[0041] **FIG. 17** is a perspective view showing another example of the splice plate according to the prior art.

BEST MODE FOR CARRYING OUT THE INVENTION

[0042] Preferred embodiments of the invention are described below.

[0043] First, with reference to **FIGS. 1** to **5B**, a beam joining apparatus according to a first embodiment of the invention is explained.

[0044] In **FIGS. 1** to **3**, a beam **1** is coupled to a pillar **5** erected vertically from the foundation (not shown) of a building. The beam **1** includes a web **4** arranged vertically, a lower flange **2** formed integrally along the lower edge of the web **4**, and an upper flange **8** formed integrally along the upper edge of the web **4**. The pillar **5** has mounted thereon upper and lower flanges **7**, **6** arranged in substantially the same spaced relation with each other along the pillar **5** as the upper and lower flanges **8**, **2** of the beam **1**. In **FIG. 2**, the two-dot chain with reference numeral **29** indicates a floor slab.

[0045] The portion of the beam **1** adjacent to the end of the lower flange **2** is formed with a pair of bolt holes **3** along the axial direction of the beam **1** symmetrically about the center of the web portion **4**. The bolt holes **3** are preferably formed at the same position along the axis of the beam **1**.

[0046] The lower flange **2** of the beam **1** is fastened to the lower flange **6** of the pillar **5** by first and second splice plates **9**, **9'** as beam joint members. The first and second splice plates **9**, **9'** are fastened to the lower flange **6** of the pillar **5** and the lower flange **2** of the beam **1** by bolts **16**. The lower flange **6** of the pillar **5** and the lower flange **2** of the beam **1** are formed with a plurality of bolt holes **19**, **18** through which the bolts **16** are inserted.

[0047] The upper flange **8** of the beam **1** is fastened to the upper flange **7** of the pillar **5** by third and fourth splice plates **30**, **30'** as beam joint members. The third and fourth splice plates **30**, **30'** are fastened to the upper flange **7** of the pillar **5** and the upper flange **8** of the beam **1** by bolts **31**. The upper flange **7** of the pillar **5** and the upper flange **8** of the beam **1** are formed with a plurality of bolt holes (not shown) through which the bolts **31** are inserted.

[0048] The first splice plate **9** is arranged on the lower surfaces of the lower flange **2** of the beam **1** and the lower flange **6** of the pillar **5**. The first splice plate **9**, as shown in **FIG. 4A**, is formed of a rectangular plate member, and a pair of slots **10** are formed at the longitudinal central portion of the first splice plate **9**. The slots **10** are arranged in parallel spaced relation with each other along the width of the first splice plate **9** in such a manner as to be superposed vertically on the bolt holes **3** of the lower flange **2** when the first splice plate **9** is mounted on the lower flange **2** of the beam **1**.

Further, the first splice plate **9** is formed with a plurality of bolt holes **28** corresponding to the bolt holes **18, 19** of the lower flange **2** of the beam **1** and the lower flange **6** of the pillar **5**.

[0049] According to this embodiment, the slots **10** thus formed reduce the cross sectional area of the first splice plate **9** at the longitudinal central area thereof including the slots **10**. As a result, the yield strength of this area is lower than that of the other areas, and therefore this particular area makes up the plastic region **11** of the first splice plate **9**.

[0050] The second splice plate **9'** is arranged on the upper surfaces of the lower flange **2** of the beam **1** and the lower flange **6** of the pillar **5**. Referring to **FIG. 4B**, the second splice plate **9'** is formed of a rectangular plate member, and a slot **10'** is formed at the longitudinal central portion of the second splice plate **9'**. Further, the second splice plate **9'** is formed with a plurality of bolt holes **28'** corresponding to the bolt holes **18, 19** of the lower flange **2** of the beam **1** and the lower flange **6** of the pillar **5**. The slot **10'** is arranged in such a manner as to be superposed vertically on the pair of the bolt holes **3** of the lower flange **2** when each of the second splice plates **9'** is mounted on the lower flange **2** of the beam **1**.

[0051] According to this embodiment, the slot **10'** reduces that sectional area of the longitudinal central area of the second splice plate **9'** including the slot **10'** which crosses the second splice plate **9'**. Thus, the yield strength of this particular area is lower than that of the other areas, and this particular area makes up the plastic region **11'** of the second splice plate **9'**.

[0052] The third splice plate **30** is arranged on the upper surface of the upper flange **8** of the beam **1** and the upper flange **7** of the pillar **5**. Referring to **FIG. 4C**, the third splice plate **30** is formed of a rectangular plate member, and formed with a plurality of bolt holes **32** corresponding to the bolt holes (not shown) of the upper flange **8** of the beam **1** and the upper flange **7** of the pillar **5**. According to this embodiment, the third splice plate **30** has no plastic region.

[0053] The fourth splice plate **30'** is arranged on the lower surface of the upper flange **8** of the beam **1** and the upper flange **7** of the pillar **5**. Referring to **FIG. 4D**, the fourth splice plate **30'** is formed of a rectangular plate member, and formed with a plurality of bolt holes **32'** corresponding to the bolt holes (not shown) of the upper flange **8** of the beam **1** and the upper flange **7** of the pillar **5**. The fourth splice plate **30'** has no plastic region either.

[0054] As described above, the upper flange **8** of the beam **1** and the upper flange **7** of the pillar **5** are coupled to each other through the third and fourth splice plates **30, 30'** having no plastic region, and thus have such a structure that the third and fourth splice plates **30, 30'** resist the vertical shearing force. The third and fourth splice plates **30, 30'**, as shown by two-dot chains in **FIG. 1**, may have reinforcing ribs **20, 20'**.

[0055] Incidentally, the first and second splice plates **9, 9'** and the third and fourth splice plates **30, 30'**, though preferably formed of a steel material low in yield point, may be made of other well-known materials, as required.

[0056] The beam joining apparatus according to this embodiment further comprises first and second anti-buckling members **13, 13'** formed of a rectangular thick steel

plate to prevent the buckling of the plastic regions **11, 11'** of the first and second splice plates **9, 9'**. The first anti-buckling member **13** is arranged on the lower surface of the first splice plate **9** in such a manner as to be superposed on the plastic region **11**, and a first anti-sticking layer **14** formed of a sheet or film of synthetic rubber or the like is inserted as an anti-sticking means between the lower surface of the first splice plate **9** and the plastic region **11**. The anti-sticking means prevents the first splice plate **9** from sticking to the first anti-buckling member **13** in the case where the plastic region **11**, having been plastically deformed, is expanded along the thickness and pressed against the first anti-buckling member **13**. The term "stick" is defined to indicate the state in which the splice plate and the anti-buckling member cannot move relatively to each other due to the friction force between them.

[0057] In similar fashion, the second anti-buckling member **13'** is arranged on the upper surface of the second splice plate **9'** in such a position as to be superposed on the plastic region **11'**, and second anti-sticking layers **14'** formed of a sheet or film of synthetic rubber or the like are inserted as an anti-sticking means between the second splice plate **9'** and the plastic region **11'**.

[0058] The first anti-buckling member **13**, if made of the same material as the first splice plate **9**, is formed of a thicker steel plate than the first splice plate **9** as shown in **FIGS. 5A, 5B** to secure a higher bending rigidity than the first splice plate **9**. The first anti-buckling member **13** is formed of a rectangular plate member **21** having four bolt holes **15** arranged in such a manner as to be superposed on the slots **10, 10'** of the first and second splice plates **9, 9'**. The first anti-sticking layer **14** is desirably attached in advance to one side surface of the plate member **21** for convenience in construction.

[0059] The second anti-buckling member **13'** is formed of a rectangular plate member and has bolt holes (not shown) or slots corresponding to a pair of the slots **10** of the first splice plate **9** and the slots **10'** of the second splice plate **9'**. The second anti-sticking layer **14'** is also preferably attached to one side surface of the plate member **21** in advance for the convenience of construction.

[0060] The first splice plate **9** is arranged on the lower surface of the lower flange **2** of the beam **1** and the lower flange **6** of the pillar **5**. The two second splice plates **9'** are arranged on the upper surface of the lower flange **2** and the upper surface of the lower flange **6** of the pillar **5** on both sides of the web **4** of the beam **1**. The third splice plate **30** is arranged on the upper surface of the upper flange **8** of the beam **1** and the upper surface of the upper flange **7** of the pillar **5**. The two fourth splice plates **30'** are arranged on the lower surface of the upper flange **8** and the lower surface of the upper flange **6** of the pillar **5** on both sides of the web **4** of the beam **1**.

[0061] The first to fourth splice plates **9, 9', 30, 30'** arranged in this way are fastened to the lower flange **2** of the beam **1**, the lower flange **6** of the pillar **5**, the upper flange **8** of the beam **1** and the upper flange **7** of the pillar **5** by inserting the bolts **16** such as high-tensile bolts into the bolt holes and screwing the nuts on the bolts **16**, so that the beam **1** is coupled to the pillar **5**. In the process, the bolt holes **3** of the lower flange **2** of the beam **1** and the slots **10, 10'** of the first and second splice plates **9, 9'** are arranged in the same vertical position.

[0062] Then, the first anti-buckling member 13 is arranged on the plastic region 11 of the lower surface of the first splice plate 9. Similarly, the second anti-buckling member 13' is arranged on the plastic region 11' of the upper surface of the second splice plate 9'. Next, the first and second anti-buckling members 13, 13' are mounted on the plastic regions 11, 11' of the first and second splice plates 9, 9' by inserting the bolts 17 into the bolt holes 15 of the first anti-buckling member 13, the slots 10 of the first splice plate 9, the bolt holes 3 of the lower flange 2 of the beam 1, the slots 10' of the second splice plate 9' and the bolt holes 15' of the second anti-buckling member 13' and screwing nuts on the bolts 17.

[0063] According to this embodiment, the first and second anti-sticking layers 14, 14' prevent the first and second anti-buckling members 13, 13' from coming into direct contact with the first and second splice plates 9, 9', respectively. As a result, when the plastic regions 11, 11' of the first and second splice plates 9, 9' are plastically deformed, transmission of the axial force to the first and second anti-buckling members 13, 13' is prevented. Further, the first and second anti-sticking layers 14, 14' absorb the expansion of the plastic regions 11, 11' of the first and second splice plates 9, 9' under the compressive load. Therefore, the rigidity of the first and second anti-buckling members 13, 13' is not transmitted to the plastic regions 11, 11'. As a result, the load and the secondary rigidity of the plastic regions 11, 11' after plasticization are prevented from rising sharply. In the design stage, therefore, only the rigidity and load of the plastic regions 11, 11' have to be taken into consideration. When the plastic regions 11, 11' are compressed and expanded, an increase in the rigidity and load of the plastic regions 11, 11' which otherwise might occur due to the contact with the first and second anti-buckling members 13, 13' is suppressed.

[0064] In place of the first and second anti-sticking layers 14, 14', a space (clearance) may be formed between the first and second anti-buckling members 13, 13' and the first and second splice plates 9, 9'. In this case, ribs (not shown) or contacts (not shown) may be formed on the first and second anti-buckling members 13, 13' as an anti-sticking means to form a space (clearance) between the first and second anti-buckling members 13, 13' and the first and second splice plates 9, 9'.

[0065] In the beam joining apparatus having this configuration, even after the lower flange 2 of the beam 1 is coupled to the lower flange 6 of the pillar 5 through the splice plate 9, the first and second anti-buckling members 13, 13' can be mounted. Also, the first and second anti-buckling members 13, 13' are independent of the first and second splice plates 9, 9' and the lower flange 6 of the pillar 5, and movable in axial direction relatively to the first and second splice plates 9, 9' by the bolt holes 3 of the lower flange 2 of the beam 1 and the slots 10, 10' formed in the first and second splice plates 9, 9'.

Second Embodiment

[0066] With reference to FIGS. 6 to 9B, a second embodiment of the invention is explained. Incidentally, this embodiment is different from the first embodiment only in the shape of the first and second anti-buckling members and the remaining portions thereof are similarly configured to the corresponding portions of the first embodiment. Therefore, the similar component elements are not explained.

[0067] According to this embodiment, the first anti-buckling member 13 includes, as shown in FIGS. 9A, 9B, a rectangular plate member 21 and flanges 22 formed integrally with the edges of the plate member 21. The plate member 21 is formed with four bolt holes 15 arranged at positions corresponding to the bolt holes 3 of the lower flange 2 of the beam 1. Also in this embodiment, the first anti-sticking layer 14 is desirably attached to one side surface of the plate member 21 in advance for convenience in construction.

[0068] The plate member 21 prevents the buckling deformation along the thickness of the first splice plate 9, and the flanges 22 prevent the buckling deformation primarily along the width of the first splice plate 9. More specifically, the inside portions 22a of the flanges 22 are arranged in somewhat larger spaced relation than the width of the plastic region 11 of the first splice plate 9, thereby providing a splice plate transverse deformation prevention means for improving the bending rigidity of the plate member 21 while at the same time preventing the buckling deformation along the width of the first splice plate 9. The outside portions 22b of the flanges 22 improve the bending rigidity of the plate member 21. In this way, the portions 22a, 22b of the flanges 22 have different functions and therefore are not required to be arranged in the same vertical plane. As shown in FIGS. 9A, 9B, however, the arrangement of the portions 22a, 22b in the same vertical plane simplifies the shape and can reduce the production cost of the first anti-buckling member 13.

[0069] In embodying the invention, the portions 22a of the flanges 22 making up the splice plate transverse deformation prevention means can be arranged partly discretely along the length of the anti-buckling member 13, as required, in accordance with the shape of the splice plate 9.

[0070] The second anti-buckling member 13' arranged on the upper surface of the lower flange 2 of the beam 1 is different from the first anti-buckling member 13 shown in FIGS. 9A, 8B in that the former is smaller in width than the latter and has two bolt holes. The other configuration is similar to that of the example explained in FIGS. 9A, 8B, and therefore not shown in detail.

[0071] FIGS. 10A to 10D show other examples of the first splice plate 9.

[0072] In the case of FIG. 10A, a pair of notches 12 cut inward from the longitudinal edges of the first splice plate 9 are formed outside the slots 10.

[0073] In the case of FIG. 10B, as shown by double-dotted lines in FIG. 10A, the first splice plate 9 has notches 12' formed so deeply as to cover the otherwise existing slots 10. In this example, the independent slots 10 as shown in FIGS. 4A, 10A are not formed.

[0074] Further, in the case of FIG. 10C, a pair of trapezoidal notches 12" are cut inward from the longitudinal edges of the first splice plate 9, and a plastic region 11 is formed between the notches 12". A wide portion having slots 10 for mounting the anti-buckling member 13 is formed on each axial side of the plastic region 11. In this case, the first anti-buckling member 13 preferably has a transversely inward trapezoidal protrusion 31. In the first splice plate 9 shown in FIG. 10C, the first anti-buckling member 13 can assume any one of the forms (1) in which it is arranged only

on the lower flange 2 of the beam 1, (2) in which it is arranged only on the lower flange 6 of the pillar 5, and (3) in which it is arranged over the lower flange 2 of the beam 1 and the lower flange 6 of the pillar 5.

[0075] Also, in the example shown in FIG. 10D representing a modification of FIG. 10C, a wide portion having slots 10 for mounting the anti-buckling member 13 is formed on each axial side of the plastic region 11, and each wide portion is extended with the same width to a mounting portion having the bolt holes 28. In this case, the diameter of each bolt hole 28 is smaller than the diameter of the slot 10 to prevent the breakage at the mounting portion.

[0076] In embodying the invention, a second splice plate 9' may be arranged on one of the obverse and reverse surfaces (upper and lower surfaces) of the lower flange 6 of the pillar 5 and the lower flange 2 of the beam 1, and one anti-buckling member 13 may be arranged outside the second splice plate 9'.

[0077] According to this invention, the anti-buckling member 13 is mounted on the plastic region 11 of the splice plate 9, and therefore can be short.

[0078] In the embodiments described above, the first and second splice plates 9, 9' having the plastic regions 11, 11' are used to couple the lower flange 6 of the pillar 5 and the lower flange 2 of the beam 1 to each other. As an alternative, the first and second splice plates 9, 9' having the plastic regions 11, 11' may be used to couple both of the upper and lower flanges 8, 2 of the beam 1 to the upper and lower flanges 7, 6 of the pillar 5.

[0079] Next, a third embodiment of the invention is explained with reference to FIGS. 11 to 14B.

[0080] According to this embodiment, the pillar 5 has mounted thereon a H-shaped bracket 40 including a web 42 in vertical position, a lower flange 44 formed integrally along the lower edge of the web 42, and an upper flange 46 formed integrally along the upper edge of the web 42, and the beam 1 is coupled to the H-shaped bracket 40. More specifically, the lower flange 2 of the beam 1 is coupled to the lower flange 44 of the H-shaped bracket 40 through the first splice plate 50, and the upper flange 8 of the beam 1 is coupled to the upper flange 46 of the H-shaped bracket 40 through the third and fourth splice plates 30, 30' having the reinforcing ribs 20, 20', respectively, explained in the first embodiment. According to this embodiment, the second splice plate described above is not used.

[0081] The first splice plate 50 has substantially a configuration similar to the first splice plate 9 shown in FIG. 10B. A pair of trapezoidal notches 50a are cut inward from the longitudinal edges of the first splice plate 50. A plastic region 51 is formed between the notches 50a. An anti-buckling member 52 is arranged superposed on the plastic region 51 of the first splice plate 50, and an anti-sticking layer 14 of a sheet member or a film member of synthetic rubber or the like is inserted as an anti-sticking means between the anti-buckling member 52 and the plastic region 51.

[0082] The first splice plate 50 is arranged on the lower surfaces of the lower flange 2 of the beam 1 and the lower flange 44 of the H-shaped bracket 40 of the pillar 5. The third splice plate 30 is arranged on the upper surface of the

upper flange 8 of the beam 1 and the upper surface of the upper flange 46 of the H-shaped bracket 40. Two fourth splice plates 30' are arranged on the lower surface of the upper flange 8 of the beam 1 and the lower surface of the upper flange 46 of the H-shaped bracket 40 on both sides of the web 4 of the beam 1 and the web 42 of the H-shaped bracket 40.

[0083] The first, third and fourth splice plates 50, 30, 30' arranged in this way are fastened to the lower flange 2 of the beam 1, the lower flange 44 of the H-shaped bracket 40, the upper flange 8 of the beam 1 and the upper flange 46 of the H-shaped bracket 40 by inserting the bolts 60, 62 such as high-tensile bolts into the respective bolt holes and screwing nuts on the bolts 60, 62. In this way, the beam 1 is coupled to the pillar 5.

[0084] Then, the anti-buckling member 52 is arranged on the plastic region 51 on the lower surface of the first splice plate 50. Next, the anti-buckling member 52 is mounted on the plastic region 51 of the first splice plate 50 by inserting the bolts 63 through the bolt holes 53 of the anti-buckling member 52 and the bolt holes 3 of the lower flange 2 of the beam 1 and screwing nuts on them. In the process, according to this embodiment, the bolts 63 are arranged in the immediate vicinity of, but slightly spaced from and substantially adapted to contact, the side surface of the plastic region 51, having been plastically deformed (FIG. 12). As a result, the transverse deformation of the plastic region 51 is prevented or limited. The bolts 63 may contact the side surface of the plastic region 51 which is not plastically deformed. In short, when the plastic region 51 is plastically deformed, the bolts 63 contact the side surface of the plastic region 51 thereby to limit the transverse deformation thereof.

[0085] Also, as shown in FIG. 13., an annular member 64 may be arranged around each bolt 63 to prevent the side surface of the plastic region 51 from contacting the side surface of the bolts 63 directly. Also, by increasing the length of the annular members 64, longitudinal to the bolts 63, to some degree as compared with the thickness of the plastic region 51, a space is formed between the surface of the splice plate 50 and the opposed surface of the anti-buckling member 52. When the plastic region 51 is plastically deformed, this space operates as an anti-sticking means to prevent the plastic region 51 from being pressed against and sticking to the anti-buckling member 52.

[0086] According to this embodiment, as already described above, the upper flange 46 of the pillar 5 and the upper flange 8 of the beam 1 are coupled by the third and fourth splice plates 30, 30' having the reinforcing ribs 20, 20'. As a result, the reinforcing ribs 20, 20' bear the shearing force acting on the third and fourth splice plates 30, 30'. As in conventional practice, therefore, the web 42 of the H-shaped bracket 40 and the web 4 of the beam 1 are not required to be coupled to each other by a splice plate (not shown).

[0087] Incidentally, the upper and lower flanges 7, 6 according to the first and second embodiments described above may be used as the upper and lower flanges 46, 44 of the H-shaped bracket of the third embodiment. In similar fashion, the upper and lower flanges 46, 44 of the H-shaped bracket according to the third embodiment may be used as the upper and lower flanges 7, 6, respectively, of the first and second embodiments. Further, the upper and lower flanges

of the pillar may be formed of split-T members **70, 72** of the cut T-steel as shown in **FIG. 15**.

[0088] Furthermore, the anti-sticking means, in addition to the anti-sticking layer **14** formed of a sheet member or a film member or the air layer formed between the splice plate and the anti-buckling member, may be a lubricant or a film coated on one of the surfaces of the opposed splice plates or the anti-buckling member.

1. A beam joining apparatus for joining a beam flange to a flange mounted on a pillar, comprising:

a splice plate fastened to the flanges of the pillar and the beam and having a plastic region at the central portion thereof; and

an anti-buckling member mounted on the splice plate and formed independently of the splice plate to prevent the buckling of the plastic region.

2. A beam joining apparatus as set forth in claim 1, further comprising an anti-sticking means arranged between the splice plate and the anti-buckling member to prevent the anti-buckling member and the splice plate from sticking to each other.

3. A beam joining apparatus as set forth in claim 1, wherein the longitudinal central portion of the splice plate has a smaller sectional area crossing the splice plate, and this particular portion has a lower yield strength than the remaining portions and forms the plastic region of the splice plate.

4. A beam joining apparatus as set forth in claim 3, wherein the longitudinal central portion of the splice plate is formed with at least one hole.

5. A beam joining apparatus as set forth in claim 3, wherein the splice plate has notches formed on the sides of the longitudinal central portion.

6. A beam joining apparatus as set forth in claim 3, wherein the splice plate has notches formed on the sides of the longitudinal central portion and at least one hole arranged adjacent to the notches.

7. A beam joining apparatus as set forth in claim 2, wherein the anti-sticking means includes an anti-sticking layer arranged between the splice plate and the anti-buckling member.

8. A beam joining apparatus as set forth in claim 7, wherein the anti-sticking layer includes a sheet member or a film member.

9. A beam joining apparatus as set forth in claim 2, wherein the anti-sticking member includes a means to form an air layer between the splice plate and the anti-buckling member.

10. A beam joining apparatus as set forth in claim 2, wherein the anti-sticking means includes a lubricant coated on one of the opposed surfaces of the splice plate and the anti-buckling member.

11. A beam joining apparatus as set forth in claim 2, wherein the anti-sticking means includes a film coated on one of the opposed surfaces of the splice plate and the anti-buckling member.

12. A beam joining apparatus as set forth in claim 1, wherein the splice plate is mounted on at least one of the upper and lower surfaces of the flanges of the pillar and the beam.

13. A beam joining apparatus as set forth in claim 1,

wherein the beam includes a web arranged in vertical direction, an upper flange formed integrally along the upper edge portion of the web, and a lower flange formed integrally along the lower edge portion of the web,

wherein the pillar has upper and lower flanges arranged spaced along the pillar by the distance equal to the distance between the upper and lower flanges of the beam, and

wherein the splice plate is used to couple the lower flange of the beam to the lower flange of the pillar, and

the beam joining apparatus further comprising another splice plate for coupling the upper flange of the beam to the upper flange of the pillar, which another splice plate has reinforcing ribs arranged in vertical plane and resistant to the shearing force.

14. A beam joining apparatus as set forth in claim 1, wherein bolts for mounting the anti-buckling member on the plastic region are arranged in such a manner as to contact the side surface of the plastic region deformed thereby to limit the deformation of the plastic region.

15. A beam joining apparatus as set forth in claim 1, wherein an annular member is arranged between the splice plate and the anti-buckling member, and bolts for mounting the anti-buckling member on the plastic region are inserted through the annular member, so that when the plastic region is deformed, the side surface of the plastic region is adapted to come into contact with the outer surface of the annular member thereby to limit the deformation of the plastic region.

16. A beam joining apparatus as set forth in claim 1, wherein the anti-buckling member includes a splice plate transverse deformation prevention means for preventing the transverse buckling deformation of the splice plate.

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