



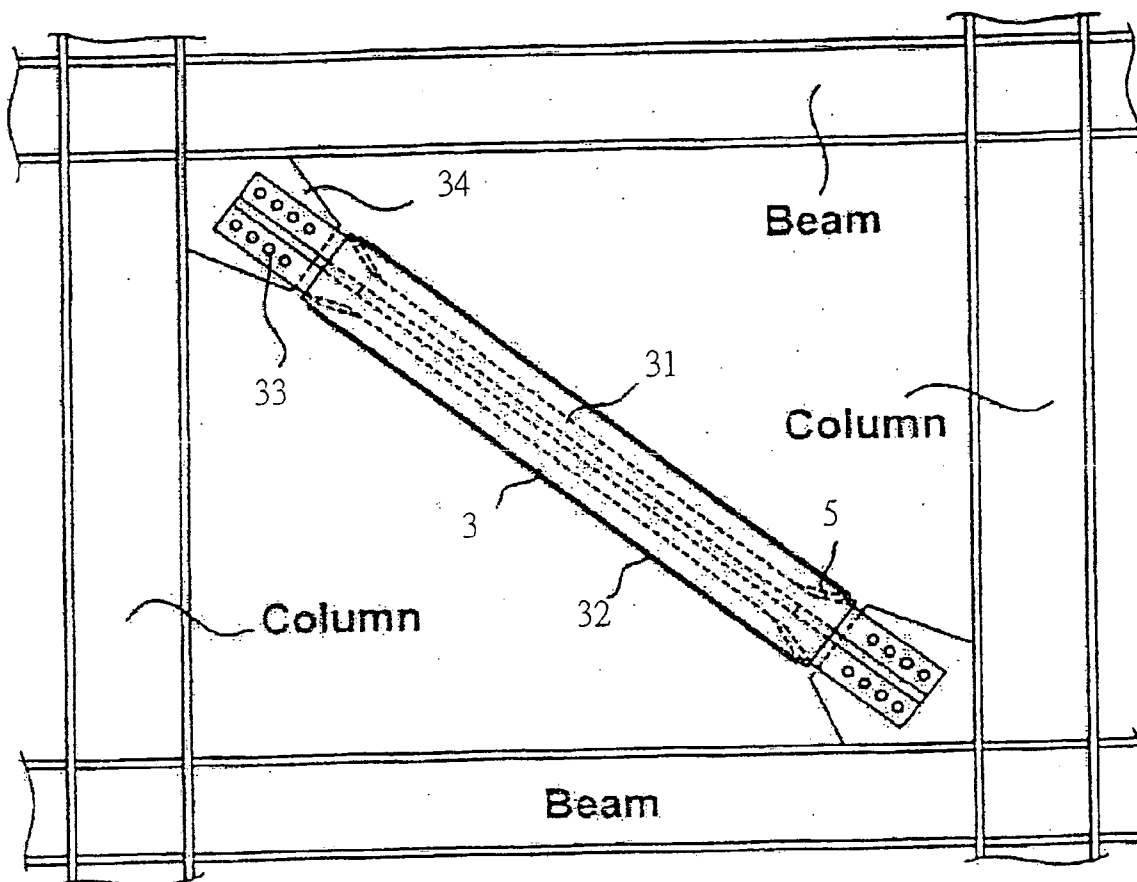
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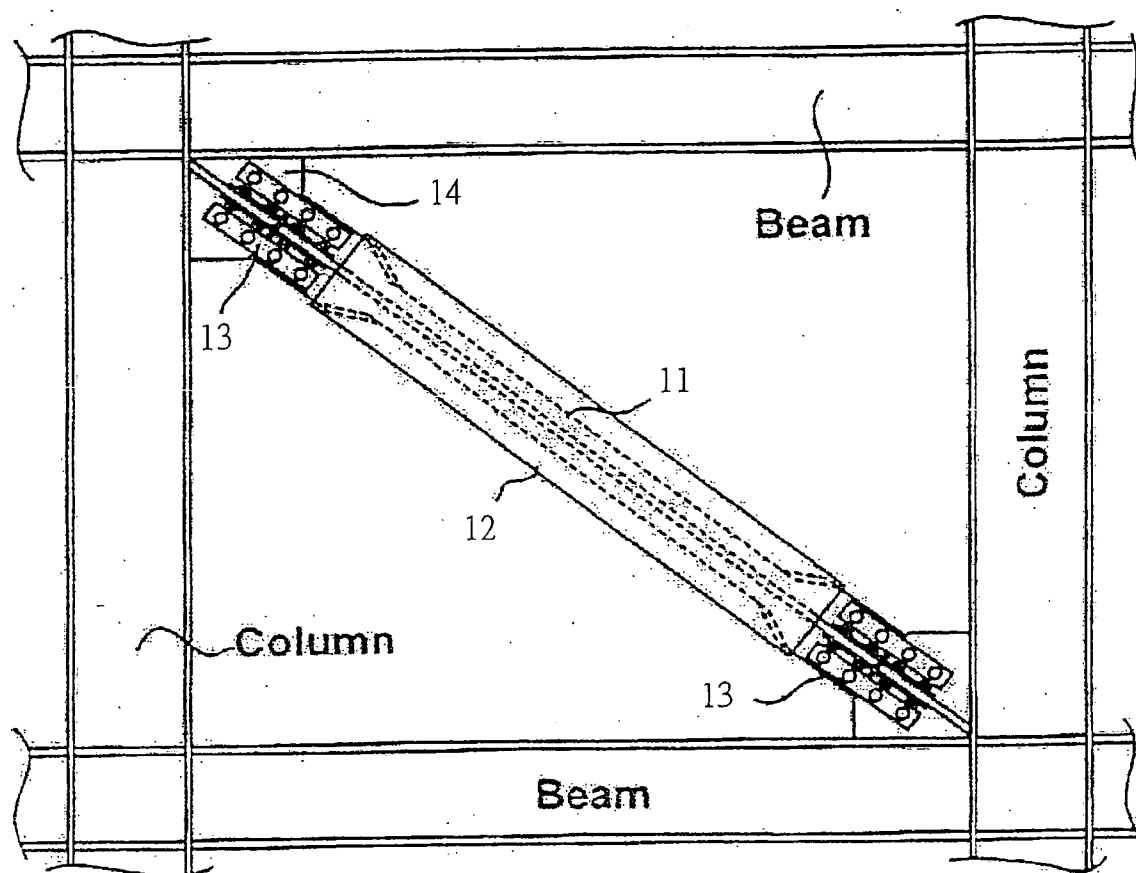
(19) **United States**(12) **Patent Application Publication****Jen et al.**(10) **Pub. No.: US 2006/0101733 A1**(43) **Pub. Date: May 18, 2006**(54) **BUCKLING-RESTRAINED DIAGONAL
BRACE USING LAPPING AND IMPROVED
PLUGGING CONNECTION**(76) Inventors: **Chiao-Yu Jen**, Taipei (TW); **Te-Wei
Jen**, Taipei (TW)

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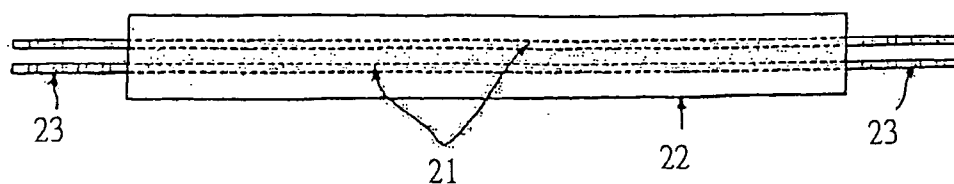
LEONG C LEI**PMB # 1008****1867 YGNACIO VALLEY ROAD****WALNUT CREEK, CA 94598 (US)**(21) Appl. No.: **10/986,874**(22) Filed: **Nov. 15, 2004****Publication Classification**(51) **Int. Cl.****E04H 9/02** (2006.01)(52) **U.S. Cl.** **52/167.1**(57) **ABSTRACT**

A buckling-restrained diagonal brace is provided. The buckling-restrained diagonal brace mainly contains a core element and a restraining element. The core element is an assembly of a specific number of steel members having a specific shape whose cross-sectional dimension is determined based on the load requirement. The core element has a larger cross-section at the ends than at its medial section. The core element is encased in the restraining element. The restraining element mainly contains a single or multiple steel tubes filled with concrete, mortar, or reinforcing members. The restraining element is to protect the core element so that it wouldn't be buckled and destructed under load. By using a lapping or an improved plugging type of connection to a structure frame, the buckling-restrained diagonal brace is able to yield steadily when loaded in both tension and compression and the buckling-restrained diagonal brace would have a full hysteretic curve. The buckling-restrained diagonal brace has a significantly enhanced ductility and energy dissipation capability, and is able to reduce vibration and to lower seismic impact.

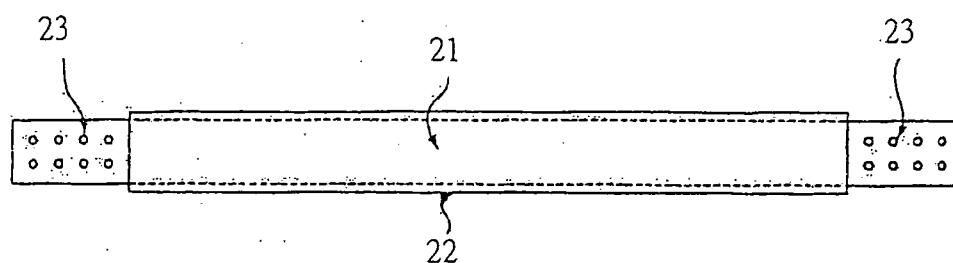




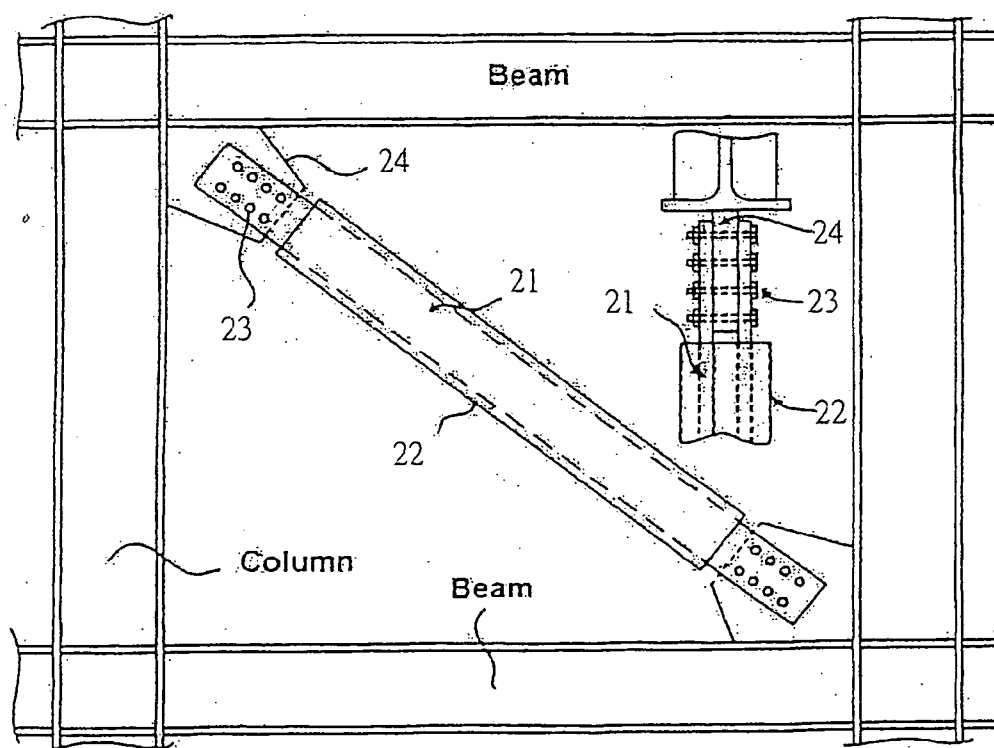
PRIOR ART
FIG. 1



PRIOR ART
FIG. 2A



PRIOR ART
FIG. 2B



PRIOR ART
FIG. 3

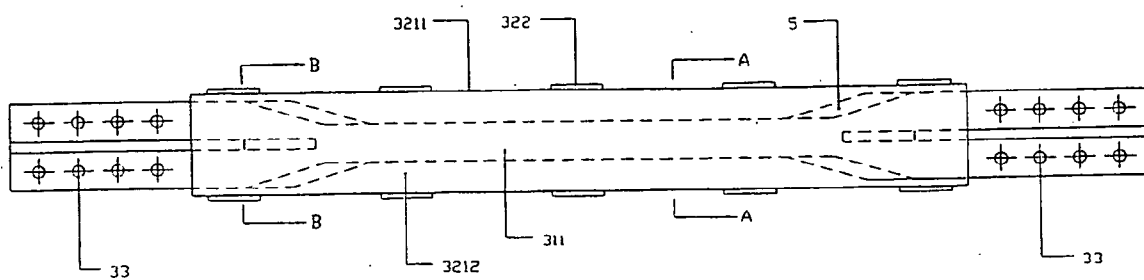


FIG. 5A

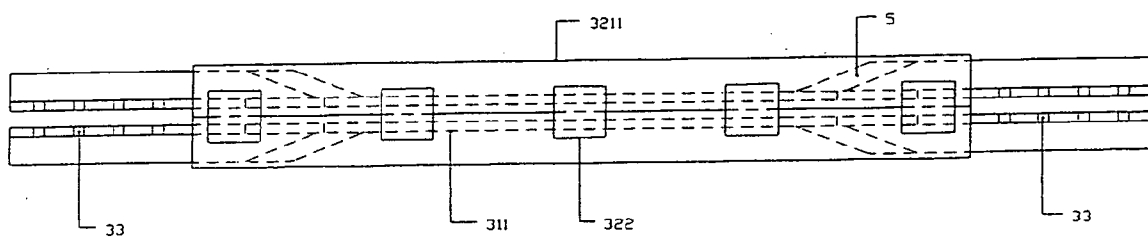


FIG. 5B

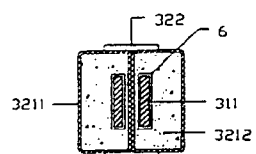


FIG. 5C

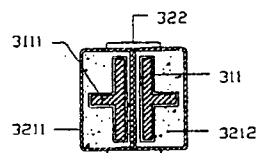


FIG. 5D

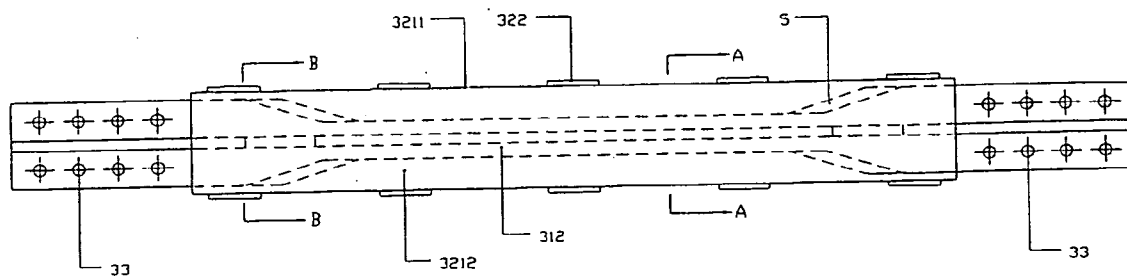


FIG. 6A

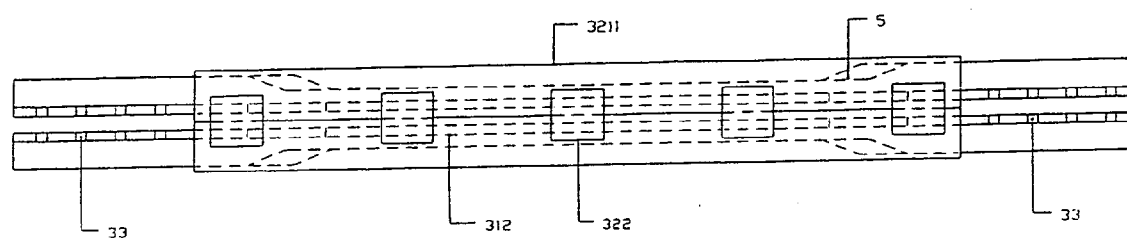


FIG. 6B

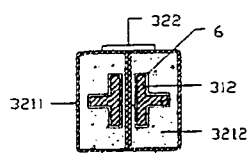


FIG. 6C

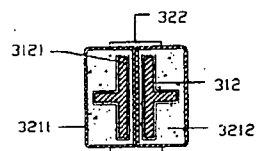


FIG. 6D

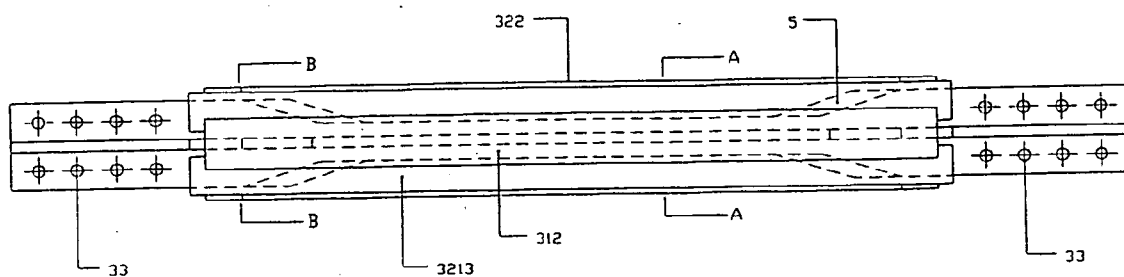


FIG. 7A

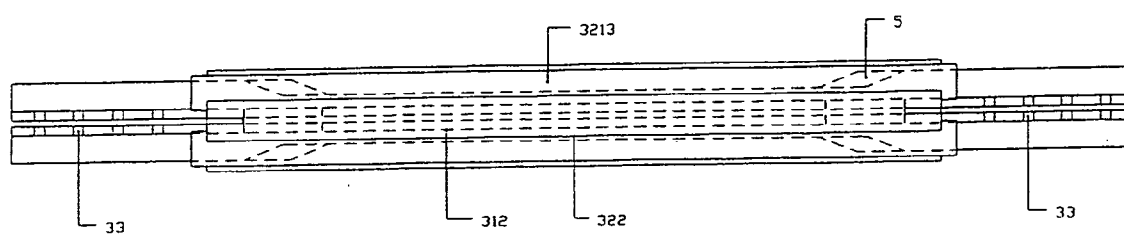


FIG. 7B

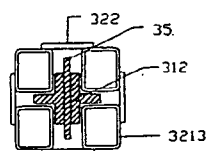


FIG. 7C

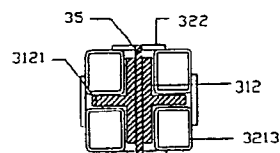


FIG. 7D

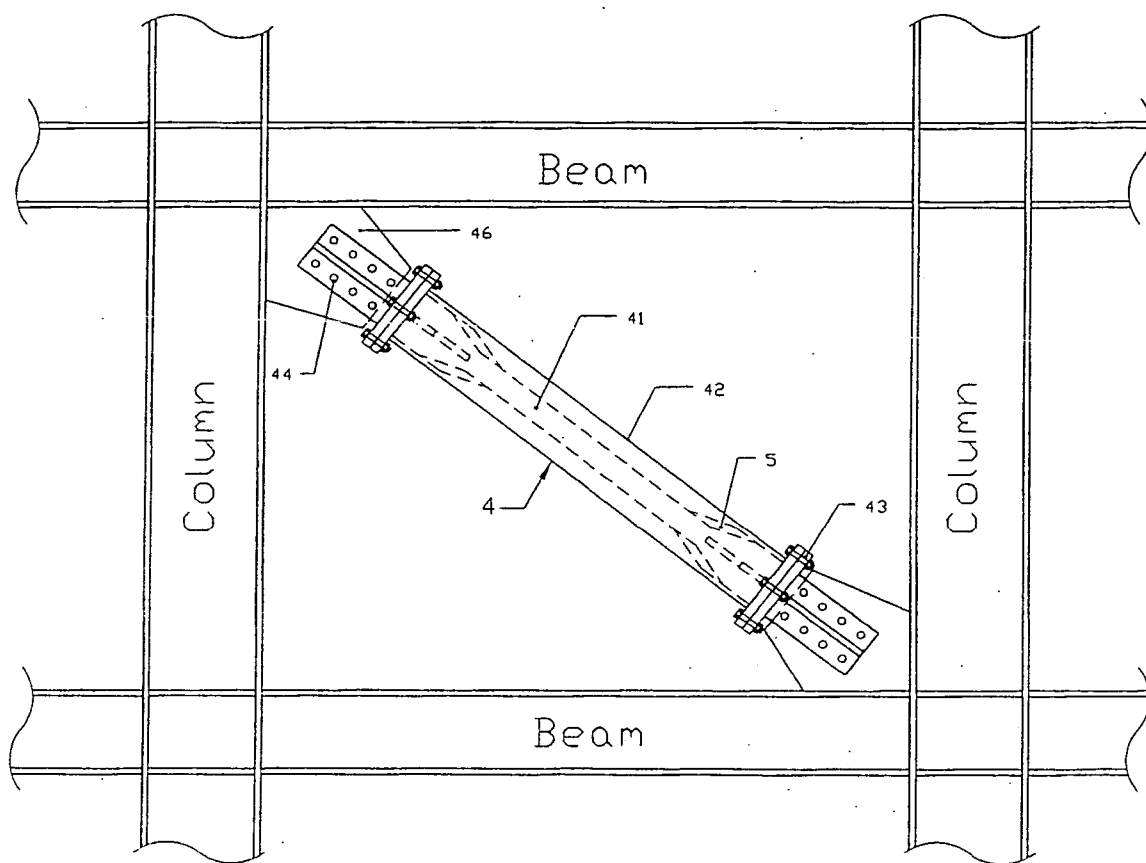


FIG. 8

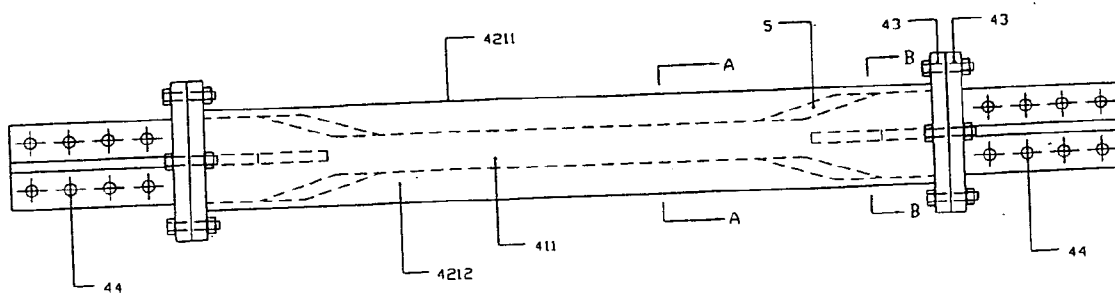


FIG. 9A

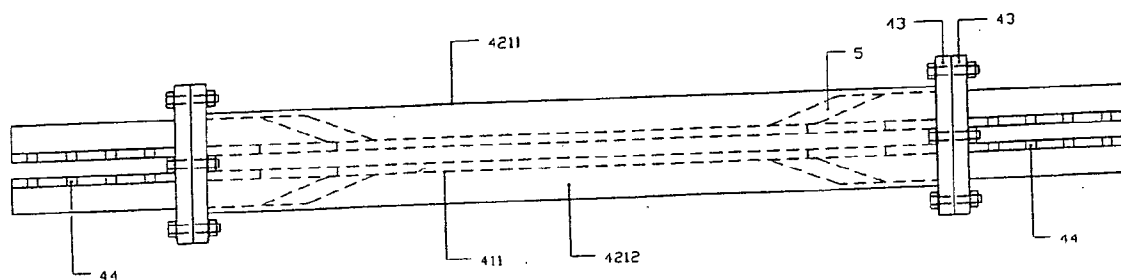


FIG. 9B

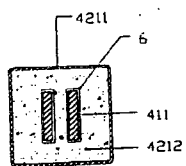


FIG. 9C

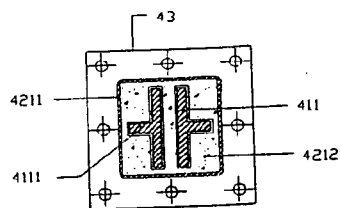


FIG. 9D

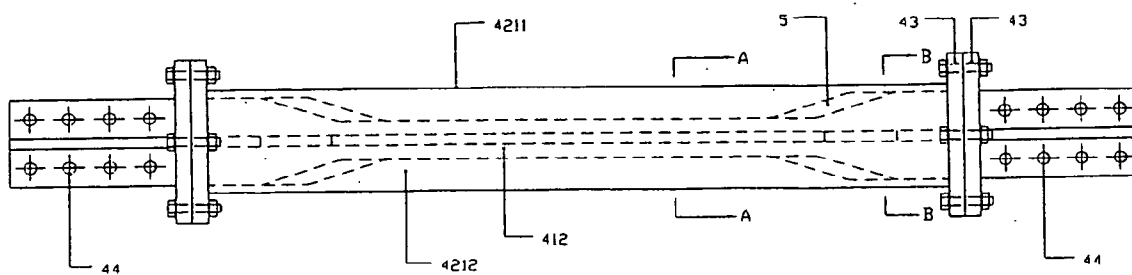


FIG. 10A

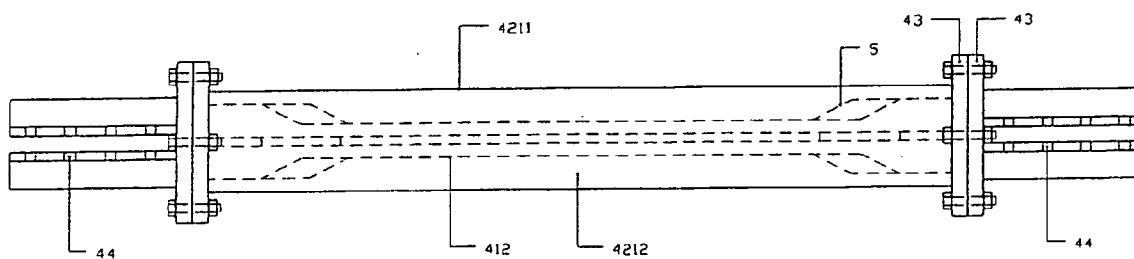


FIG. 10B

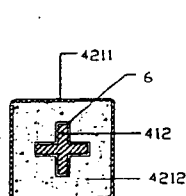


FIG. 10C

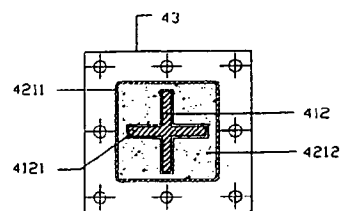


FIG. 10D

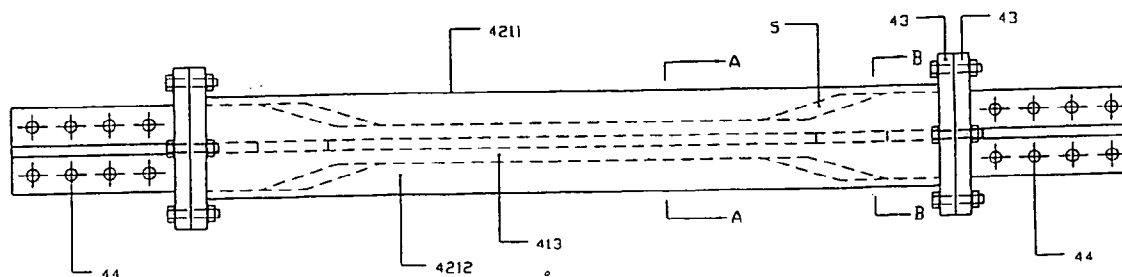


FIG. 11A

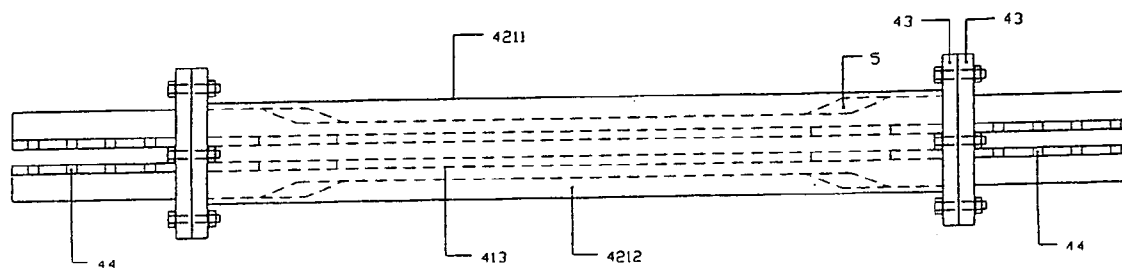


FIG. 11B

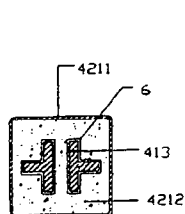


FIG. 11C

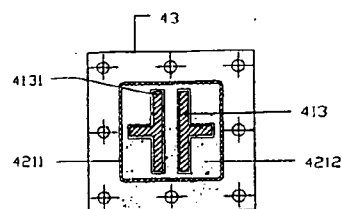


FIG. 11D

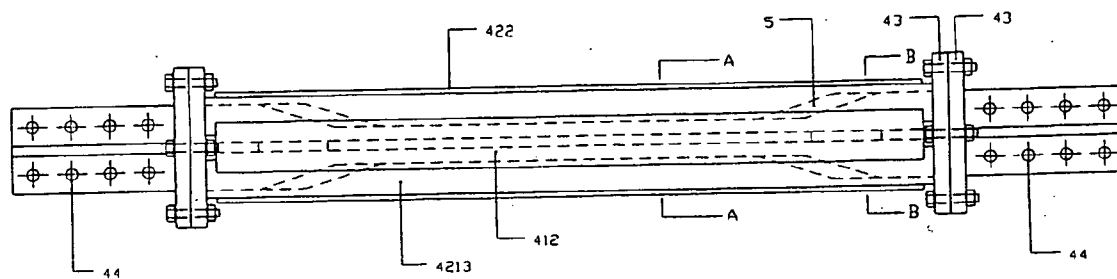


FIG. 12A

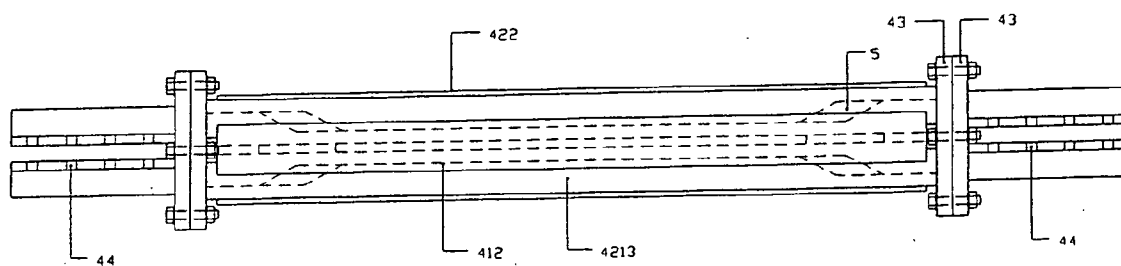


FIG. 12B

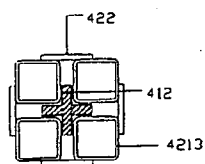


FIG. 12C

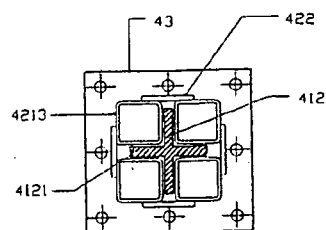


FIG. 12D

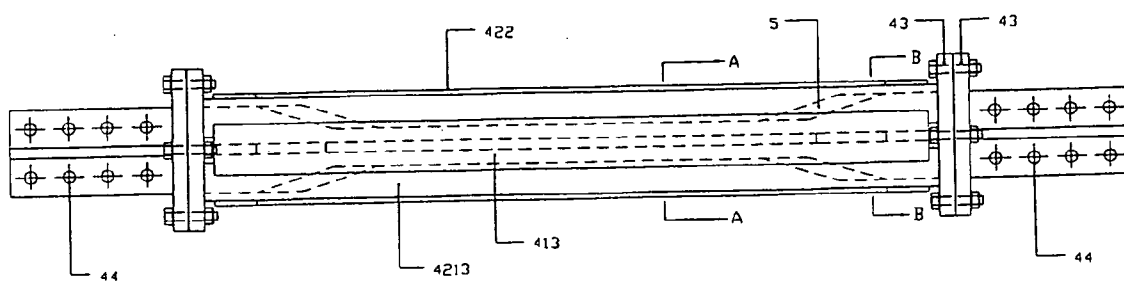


FIG. 13A

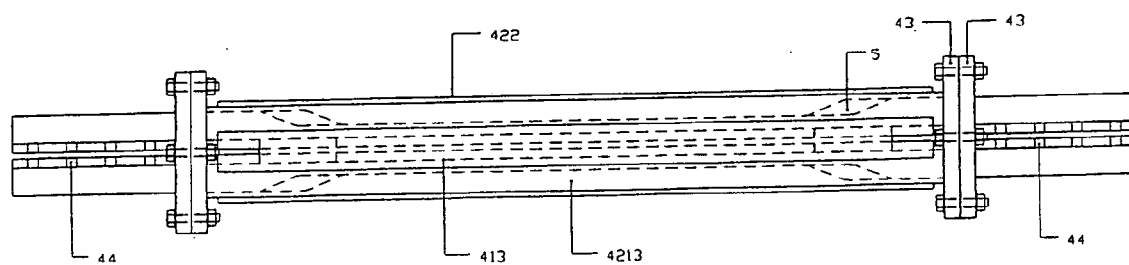


FIG. 13B

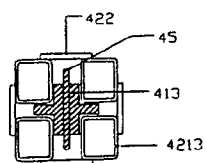


FIG. 13C

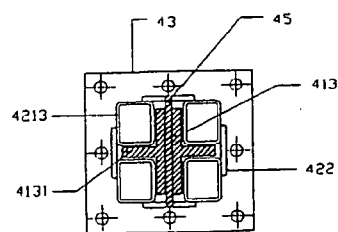


FIG. 13D

BUCKLING-RESTRAINED DIAGONAL BRACE USING LAPPING AND IMPROVED PLUGGING CONNECTION

BACKGROUND OF THE INVENTION

[0001] (a) Technical Field of the Invention

[0002] The present invention generally relates to buckling-restrained diagonal braces and, more particularly, to buckling-restrained diagonal braces using lapping and improved plugging types of connection.

[0003] (b) Description of the Prior Art

[0004] Conventional diagonal bracing members would suffer global and local buckling when subjected to an axial force. The hysteretic curves of these conventional diagonal bracing members exhibit decreasing strength and contracting behaviors. In addition, before their energy dissipation capacity is fully utilized, conventional diagonal bracing members would be broken due to excessively focused stress and strain. As such, for many years, seismic engineering researchers have been investigating improvements to the performance of diagonal braces, and various buckling-restrained diagonal braces are proposed to replace and enhance conventional diagonal braces.

[0005] As shown in **FIG. 1**, buckling-restrained diagonal braces mainly contain a core element **11** and a restraining element **12**. The axial force (tension and compression) exerted on a diagonal brace is mainly taken by its core element **11**. The restraining element **12**, on the other hand, provides lateral strut so as to prevent the core element **11** from buckling under the axial forces. If the core element **11** wouldn't buckle under axial force, the axial strength and ductility of the core element **11** could be effectively developed and the energy dissipation capacity of its steel material could be fully utilized.

[0006] Accordingly, how to precisely control the core element **11**'s behavior under axial forces and how to increase the restraining effect have become the focus of studying and enhancing buckling-restrained diagonal braces.

[0007] Conventional buckling-restrained diagonal braces usually use a rectangular steel tube filled with concrete as the restraining element **12**, and the core element **11** usually has an "I" or "+" cross-sectional shape. Because of the cross-sectional shape and the arrangement of the connecting bolt holes at the end of the core element **11**, the core element **11** relies on the use of a gusset plate **14**, a joining plate **13**, and bolts for butting connection with the structure frame. The joining plate **13** also has a "+" shape. In addition, besides using the gusset plate **14** for connection, reinforcing plates have to be welded and bolt holes have to be drilled to the two sides of the joining plate **13**.

[0008] However, this kind of connection not only imposes a heavy welding workload, but also complicates and jams the connecting parts of the buckling-restrained diagonal braces. In addition, in order to jointly transfer axial force equally, the number of bolts required by using joining plate **13** is twice of that required by lapping connection. Therefore, the installation of conventional buckling-restrained diagonal braces is very labor-intensive, time-consuming, operationally inefficient, and is more difficult to control the quality.

[0009] On the other hand, as shown in **FIG. 2**, a plugging-type buckling-restrained diagonal brace has been proposed to reduce the number of bolts and to avoid the use of joining plates. However, in this conventional buckling-restrained diagonal braces, two parallel, equal-length, band-like steel bars spaced apart by a fixed distance are encased in a restraining element **22** of steel tube and concrete. When the concrete is filled, it is difficult to position the two band-like steel bars in the restraining element **22** so as to maintain a precise spaced distance. In addition, the installation of this plugging-type buckling-restrained diagonal brace is directional sensitive. If the two band-like steel plates are not well spaced, and the length of the diagonal brace is often greater than the beam width or column height in a single slant direction, the installation efficiency is inevitably decreased and sometimes the installation is impossible.

SUMMARY OF THE INVENTION

[0010] Accordingly, to overcome the foregoing disadvantages and limitations of conventional buckling-restrained diagonal braces, the present invention provides more efficient, economical, and convenient in installation seismic-proof, energy-dissipating diagonal braces.

[0011] The foregoing object and summary provide only a brief introduction to the present invention. To fully appreciate these and other objects of the present invention as well as the invention itself, all of which will become apparent to those skilled in the art, the following detailed description of the invention and the claims should be read in conjunction with the accompanying drawings. Throughout the specification and drawings identical reference numerals refer to identical or similar parts.

[0012] Many other advantages and features of the present invention will become manifest to those versed in the art upon making reference to the detailed description and the accompanying sheets of drawings in which a preferred structural embodiment incorporating the principles of the present invention is shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is an elevation diagram of a conventional buckling-restrained diagonal brace having a "+" cross-section and using butting connection.

[0014] **FIGS. 2A and 2B** are a top view and a side view of a conventional plugging-type buckling-restrained diagonal brace.

[0015] **FIG. 3** is an elevation diagram of a conventional plugging-type buckling-restrained diagonal brace.

[0016] **FIG. 4** is an elevation diagram of a buckling-restrained diagonal brace using lapping connection according to the present invention.

[0017] **FIG. 5A** is a front view of the first embodiment of the present invention.

[0018] **FIG. 5B** is a top view of the first embodiment of the present invention.

[0019] **FIG. 5C** is a cross-sectional view along the A-A line of **FIG. 5A**.

[0020] **FIG. 5D** is a cross-sectional view along the B-B line of **FIG. 5A**.

[0021] FIG. 6A is a front view of the second embodiment of the present invention.

[0022] FIG. 6B is a top view of the second embodiment of the present invention.

[0023] FIG. 6C is a cross-sectional view along the A-A line of FIG. 6A.

[0024] FIG. 6D is a cross-sectional view along the B-B line of FIG. 6A.

[0025] FIG. 7A is a front view of the third embodiment of the present invention.

[0026] FIG. 7B is a top view of the third embodiment of the present invention.

[0027] FIG. 7C is a cross-sectional view along the A-A line of FIG. 7A.

[0028] FIG. 7D is a cross-sectional view along the B-B line of FIG. 7A.

[0029] FIG. 8 is an elevation diagram of a buckling-restrained diagonal brace using improved plugging type of connection according to the present invention.

[0030] FIG. 9A is a front view of the fourth embodiment of the present invention.

[0031] FIG. 9B is a top view of the fourth embodiment of the present invention.

[0032] FIG. 9C is a cross-sectional view along the A-A line of FIG. 9A.

[0033] FIG. 9D is a cross-sectional view along the B-B line of FIG. 9A.

[0034] FIG. 10A is a front view of the fifth embodiment of the present invention.

[0035] FIG. 10B is a top view of the fifth embodiment of the present invention.

[0036] FIG. 10C is a cross-sectional view along the A-A line of FIG. 10A.

[0037] FIG. 10D is a cross-sectional view along the B-B line of FIG. 10A.

[0038] FIG. 11A is a front view of the sixth embodiment of the present invention.

[0039] FIG. 11B is a top view of the sixth embodiment of the present invention.

[0040] FIG. 11C is a cross-sectional view along the A-A line of FIG. 11A.

[0041] FIG. 11D is a cross-sectional view along the B-B line of FIG. 11A.

[0042] FIG. 12A is a front view of the seventh embodiment of the present invention.

[0043] FIG. 12B is a top view of the seventh embodiment of the present invention.

[0044] FIG. 12C is a cross-sectional view along the A-A line of FIG. 12A.

[0045] FIG. 12D is a cross-sectional view along the B-B line of FIG. 12A.

[0046] FIG. 13A is a front view of the eighth embodiment of the present invention.

[0047] FIG. 13B is a top view of the eighth embodiment of the present invention.

[0048] FIG. 13C is a cross-sectional view along the A-A line of FIG. 13A.

[0049] FIG. 13D is a cross-sectional view along the B-B line of FIG. 13A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0050] The following descriptions are of exemplary embodiments only, and are not intended to limit the scope, applicability or configuration of the invention in any way. Rather, the following description provides a convenient illustration for implementing exemplary embodiments of the invention. Various changes to the described embodiments may be made in the function and arrangement of the elements described without departing from the scope of the invention as set forth in the appended claims.

[0051] Besides improving the shortcomings of the conventional buckling-restrained diagonal braces, the present invention further provides various enhanced and innovative installations, which conform more closely to the requirements of seismic engineering and practical application. Please refer to FIGS. 4 to 13. The major features of the present invention are described as follows.

[0052] An embodiment of the present invention is a buckling-restrained diagonal brace using lapping connection. The present embodiment mainly contains a pair of independently formed core members 311, 411, and a pair of independently formed restraining members 3211, 4211. The core elements 31, 41 have members whose cross-sections are of "T", "C", "I", or other shapes having single symmetry feature. The core members 311, 411 have larger cross-sections at the ends than at their medial sections. The core members 311, 411 are encased in the restraining members 3211, 4211 of the restraining elements 32, 42. During fabrication, two assemblies of core and restraining members are manufactured separately. At the construction site, the two assemblies of core and restraining members are lapped to the structure frame. In other words, each of the two assemblies of core and restraining members are lifted at the two sides of separating plates 34, 46, and lapped to the separating plates 34, 46 with bolts. Then, bonding plates 322, 422 are welded to bond the two restraining members 3211, 4211 and complete the installation. As such, there is no problem of difficult positioning and installation. The restraining elements 32, 42 could be lateral support members made of pure steel, or the restraining elements 32, 42 could use common restraining members of steel tubes filled with concrete or mortar. The restraining elements 32, 42 prevent the core elements from buckling when under compression.

[0053] In another embodiment, the restraining members 3211, 4211 of the restraining elements 32, 42 could also use pure steel or a single steel tube filled with concrete or mortar. Their ends are fixedly locked by end plates 43, in order to match the variations in cross-section and construction of the core elements and restraining element 32, 42. On the other hand, to facilitate their connection and construction, the present embodiment improves the conventional plugging

type of connection. Independent plugging connection plate **34, 44** having end plates **43** are first fixedly locked to the joining plates **34, 46** of the structure frame. Then, the end plate **43** is closely attached to an end plate of the diagonal brace and bolted together to complete the installation at one side. The installation at the other side is completed identically. This type of buckling-restrained diagonal braces, due to the reduced dimension of its media section's cross-section and hence concentrating the energy dissipation at the media section, conforms more closely to the functional requirements of diagonal braces. On the other hand, using joining plates **34, 46** for locking, the restraining elements **32, 42** and core elements **31, 41** could have their cross-sections flexibly chosen based on the requirements of designed strength and material used, without subjecting to the limitations of conventional connection. This, therefore, has significantly increased the applicability and configuration of cross-sections.

[0054] In summary, buckling-restrained diagonal braces using lapping or improved plugging types of connection not only retain the superior mechanics characteristics of conventional buckling-restrained diagonal brace, but also have benefits such as easy installation, simple joining structure, and better manufacturing quality control, etc.

[0055] It will be understood that each of the elements described above, or two or more together may also find a useful application in other types of methods differing from the type described above.

[0056] While certain novel features of this invention have been shown and described and are pointed out in the annexed claim, it is not intended to be limited to the details above, since it will be understood that various omissions, modifications, substitutions and changes in the forms and details of the device illustrated and in its operation can be made by those skilled in the art without departing in any way from the spirit of the present invention.

I claim:

1. Buckling-restrained diagonal braces using lapping and improved plugging types of connection, comprising a core element and a restraining element, said core element being an assembly of steel members having an arbitrary and symmetrical cross-sectional shape, said core element having a larger cross-section at its end than at its medial section, said core element encased in said restraining element, said restraining element being a casing assembled by at least one steel tube member filled with one of concrete, mortar, and reinforcing members, said core element restrained by said restraining element so that said core element would not be buckled and destructed under compression and said buckling-restrained diagonal brace would steadily yield and has a full hysteretic curve so as to increase significantly its energy dissipation capability, to reduce vibration, and to lower seismic impact.

2. The buckling-restrained diagonal brace using lapping connection according to claim 1, characterized in comprising:

a pair of independently formed restraining members;
a pair of independently formed core members, each of said core members having a bar shape and a larger cross-section at said core member's ends than that of said core member's media section, each of said core members encased in one of said restraining members respectively, said core members connected to a structure frame using lapping type of connection; and

a bonding plate for bonding said restraining members.

1. The buckling-restrained diagonal brace using lapping connection according to claim 2, wherein each of said pair of restraining members is a steel tube filled with a material selected from the group consisting of concrete and mortar.

2. The buckling-restrained diagonal brace using lapping connection according to claim 2, wherein said pair of restraining members are made of pure steel and comprise a steel tube, and steel plate and bolts for connecting said steel tube.

3. The buckling-restrained diagonal brace using improved plugging type of connection according to claim 1, characterized in comprising:

a restraining member having at least one steel tube;

a symmetrical core member, said core member having a larger cross-section at said core member's ends than that of said core member's medial section, said core member fixedly locked by end plates at said core member's ends; and

plugging connection plates for connecting said buckling-restrained diagonal brace and a structure frame.

4. The buckling-restrained diagonal brace using improved plugging type of connection according to claim 5, wherein each of said pair of restraining members is a steel tube filled with a material selected from the group consisting of concrete and mortar.

5. The buckling-restrained diagonal brace using improved plugging type of connection according to claim 5, wherein each of said pair of restraining members is made of pure steel, and comprises a steel tube, and steel plate and bolts for connecting said steel tube.

6. The buckling-restrained diagonal brace using improved plugging type of connection according to claim 5, wherein said core element and said restraining element have arbitrary shapes and cross-sections, and are assemblies of an arbitrary number of members.

7. The buckling-restrained diagonal braces using lapping and improved plugging types of connection according to claim 1, wherein said core element is characterized in that said core element is an assembly with a plurality of sections that have different cross-sections respectively and that a medial section has a material strength no greater than that of end sections.

8. The buckling-restrained diagonal braces using lapping and using improved plugging types of connection according to claim 1, wherein said restraining element is characterized in that constituent members of said restraining element are made of a material selected from the group consisting of metallic materials, non-metallic materials, and combinations of metallic and non-metallic materials.

* * * * *