US 20150027078A1

(19) **United States**

(12) **Patent Application Publication**

Pimentel

(10) **Pub. No.: US 2015/0027078 A1**

(43) **Pub. Date: Jan. 29, 2015**

(54) **POST-INSTALLED SLEEVE DEVICE FOR COMPENSATING LOSS OF SHEAR CAPACITY**

(71) Applicant: **Benjamin Joseph Pimentel**, New York, NY (US)

(72) Inventor: **Benjamin Joseph Pimentel**, New York, NY (US)

(21) Appl. No.: **14/340,714**

(22) Filed: **Jul. 25, 2014**

Related U.S. Application Data

(60) Provisional application No. 61/858,123, filed on Jul. 25, 2013.

Publication Classification

(51) **Int. Cl.**

E04G 23/02 (2006.01)

E04G 21/12 (2006.01)

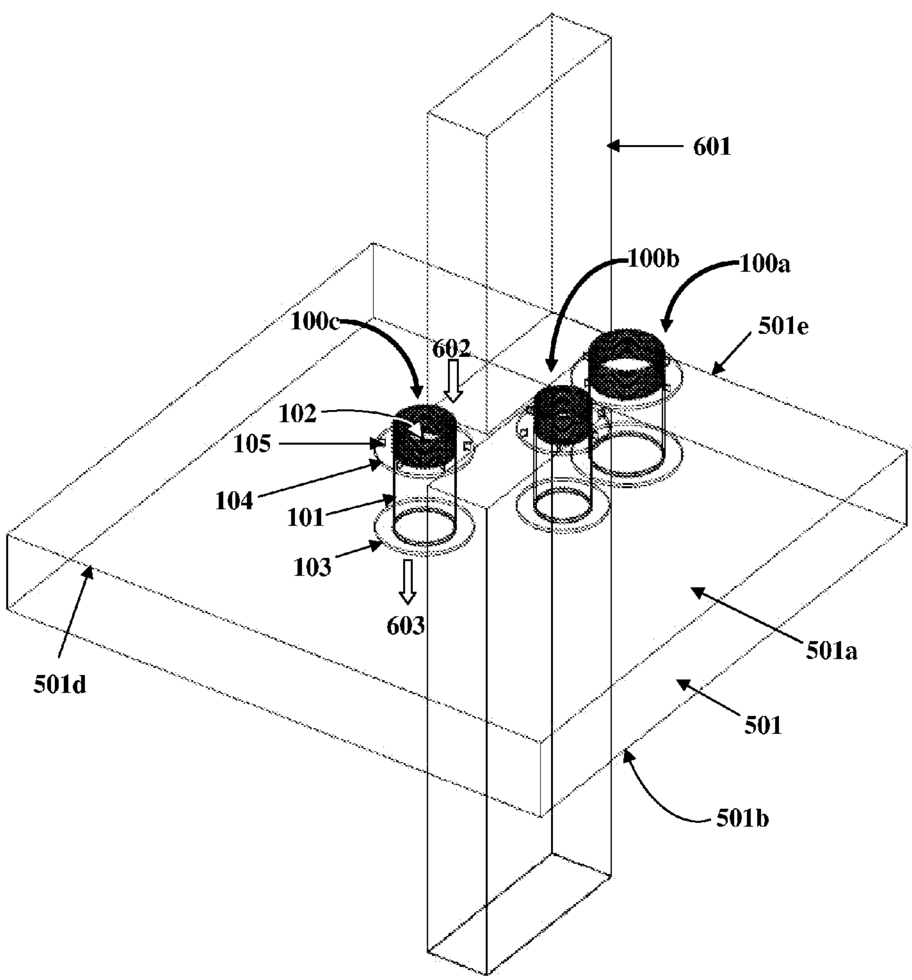
(52) **U.S. Cl.**

CPC ***E04G 23/0225*** (2013.01); ***E04G 21/12*** (2013.01); ***E04G 23/0229*** (2013.01); ***E04G 23/024*** (2013.01); ***E04G 23/0244*** (2013.01)

USPC **52/514**; 52/741.3

(57) **ABSTRACT**

A post-installed sleeve device is provided for compensating loss of shear capacity of a concrete slab due to a hole drilled in the concrete slab. The sleeve device includes a hollow member of, for example, a cylindrical shape, and a lower sandwich member and an upper sandwich member shaped, for example, as ring members. The hollow member is inserted into the drilled hole such that an upper section of the hollow member extends above a top surface of the concrete slab. The lower sandwich member includes an inner edge rigidly attached to a bottom edge of the hollow member. The upper sandwich member includes an inner edge engageably connected to the upper section of the hollow member. The upper sandwich member and the lower sandwich member sandwich the concrete slab surrounding the drilled hole therebetween for compensating the lost shear capacity of the concrete slab due to the drilled hole.



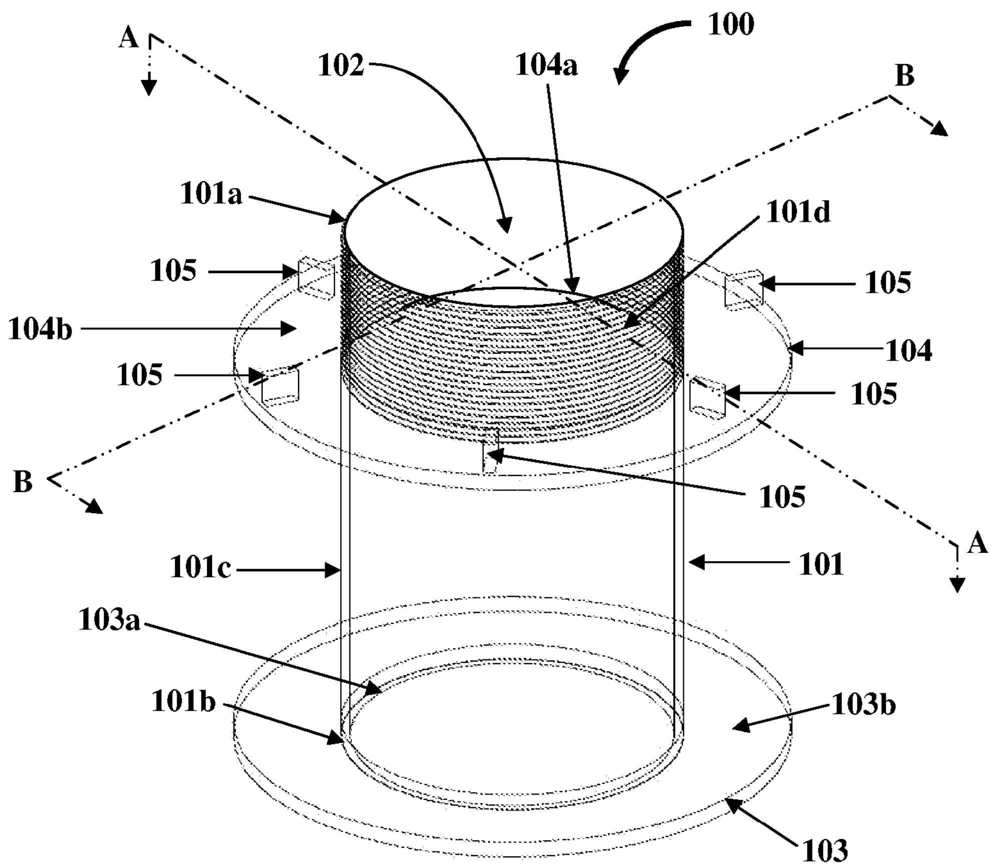

100
A
102
104a
B
101a
101d
105
105
104b
104
105
105
B
105
A
101c
101
103a
101b
103b
103

FIG. 1

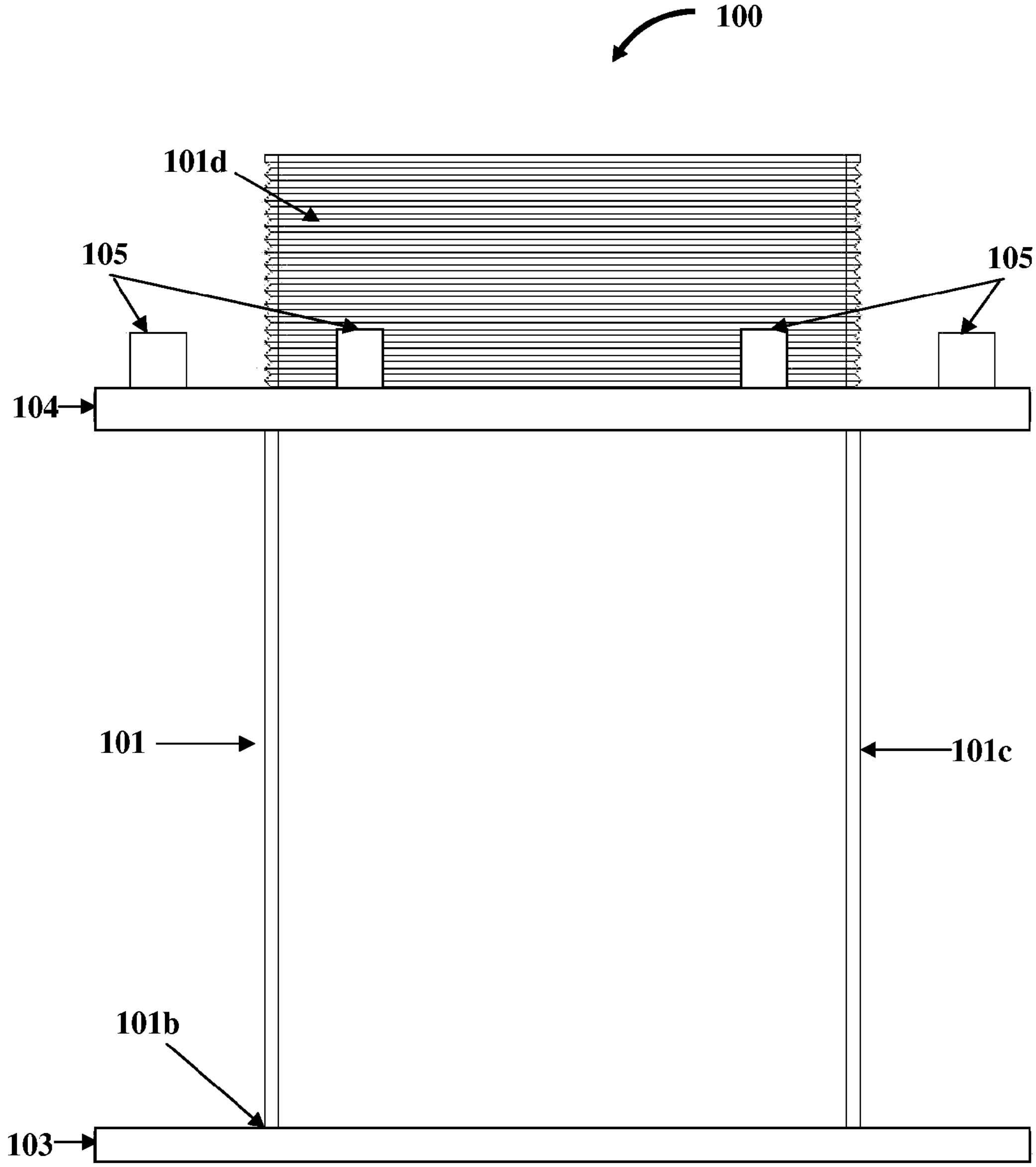


FIG. 2

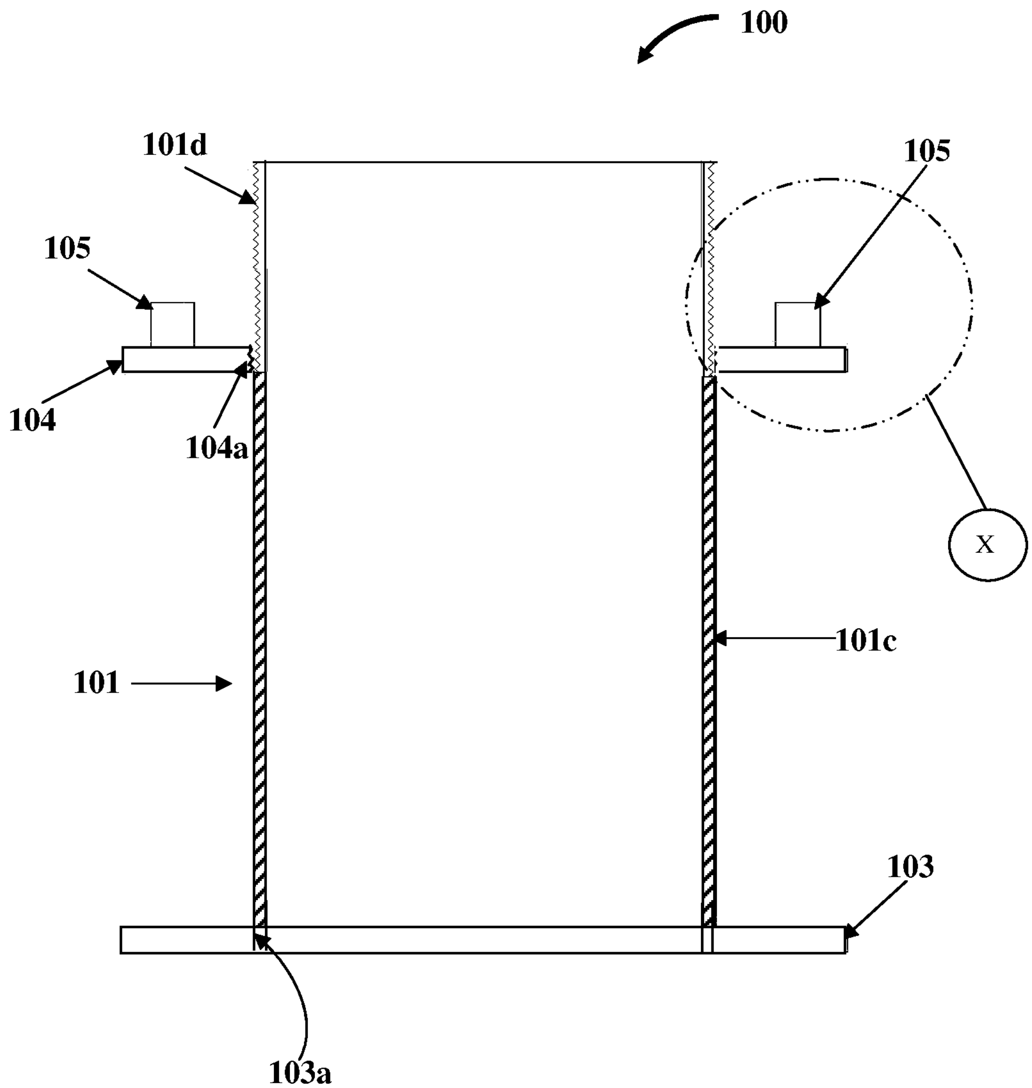


FIG. 3A

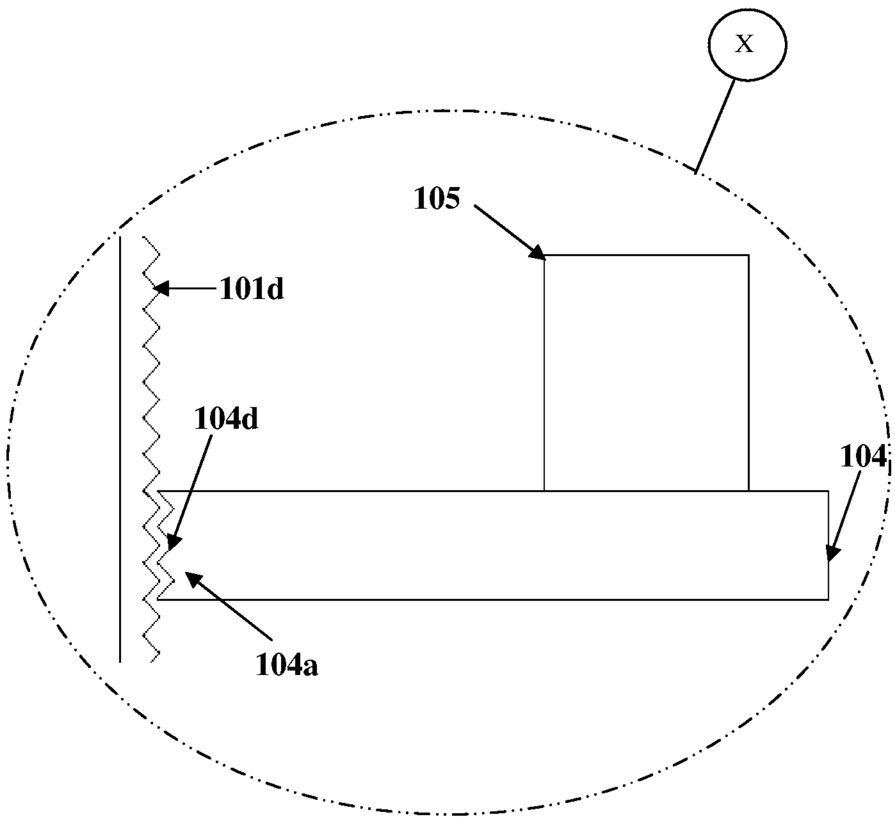


FIG. 3B

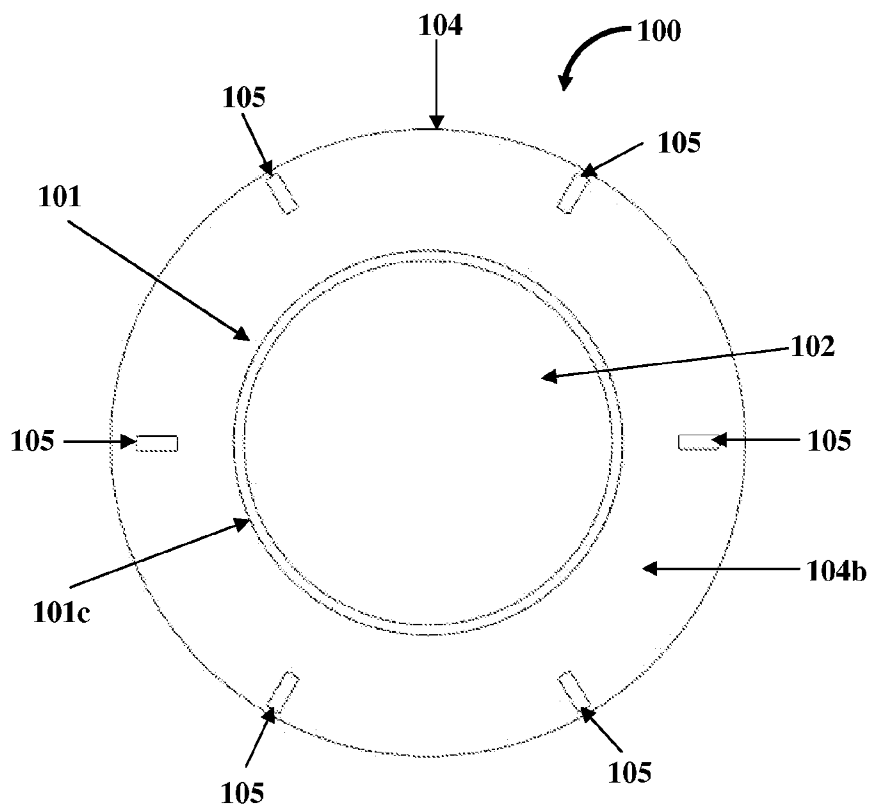


FIG. 4

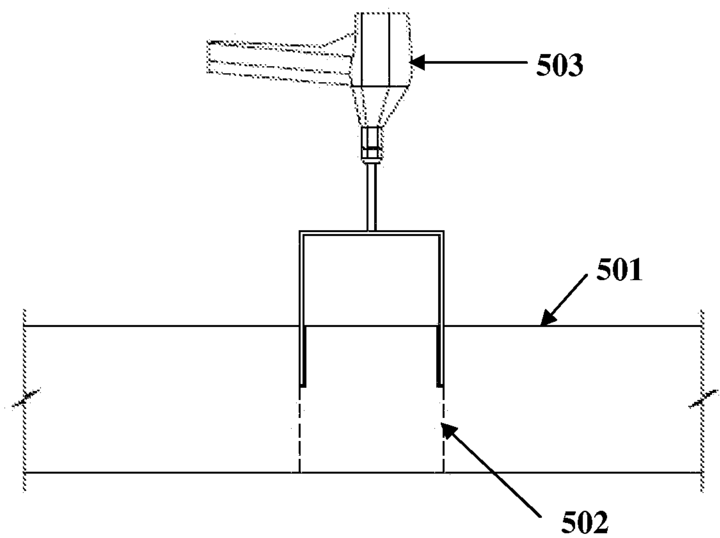


FIG. 5A

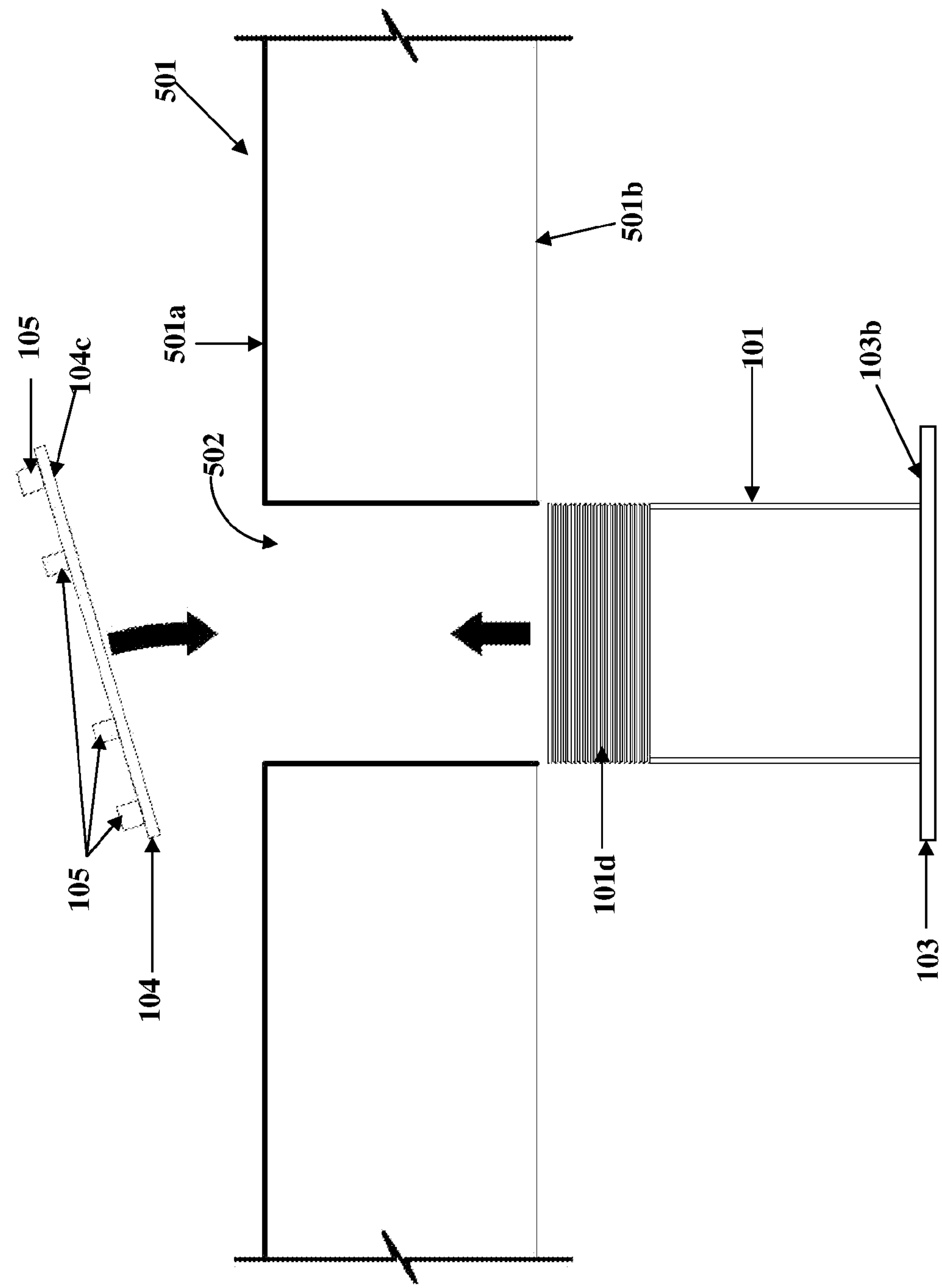


FIG. 5B

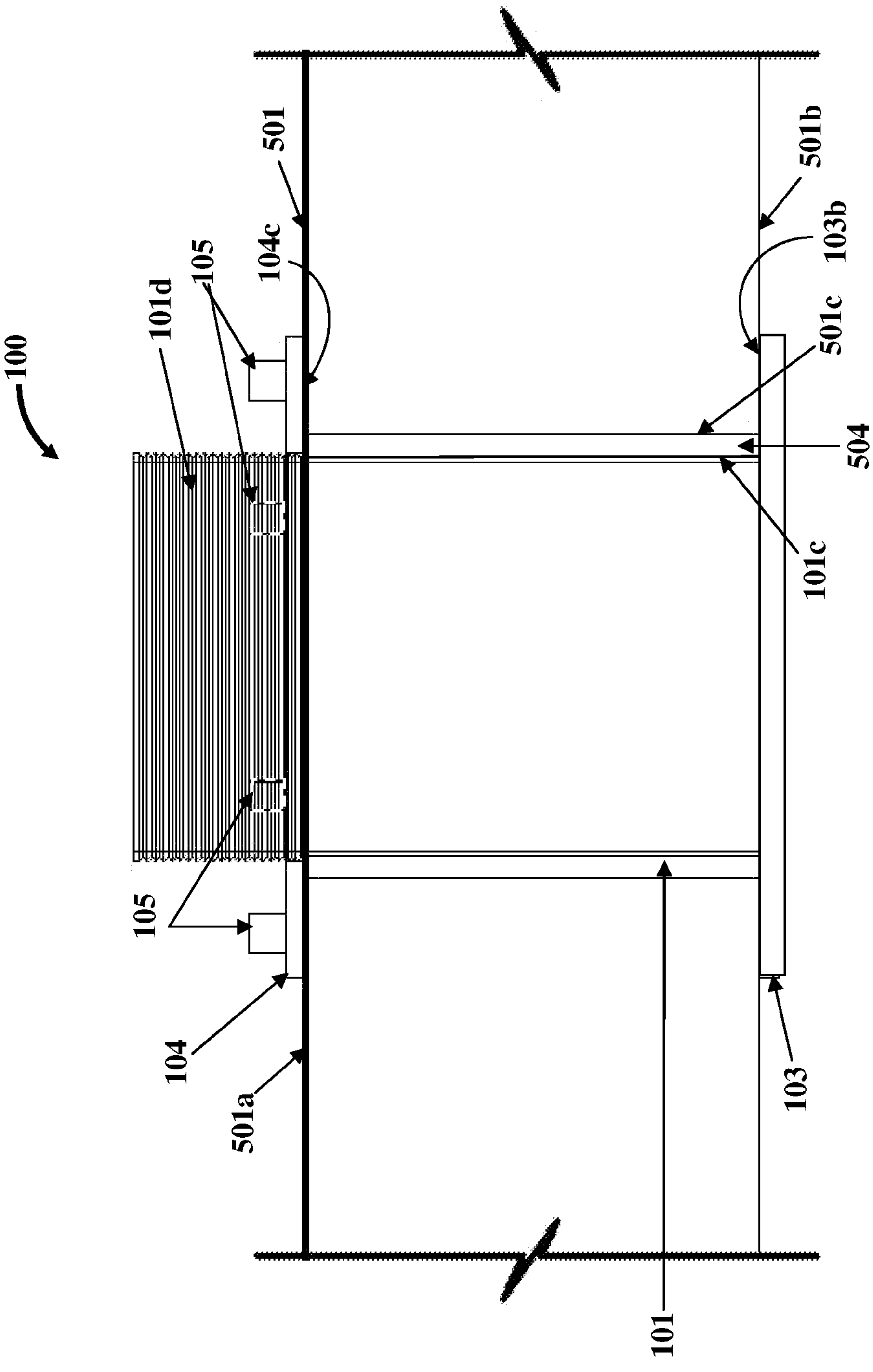

100
101d
105
104c
501
501b
103b
501c
504
101c
105
104
501a
103
101

FIG. 5C

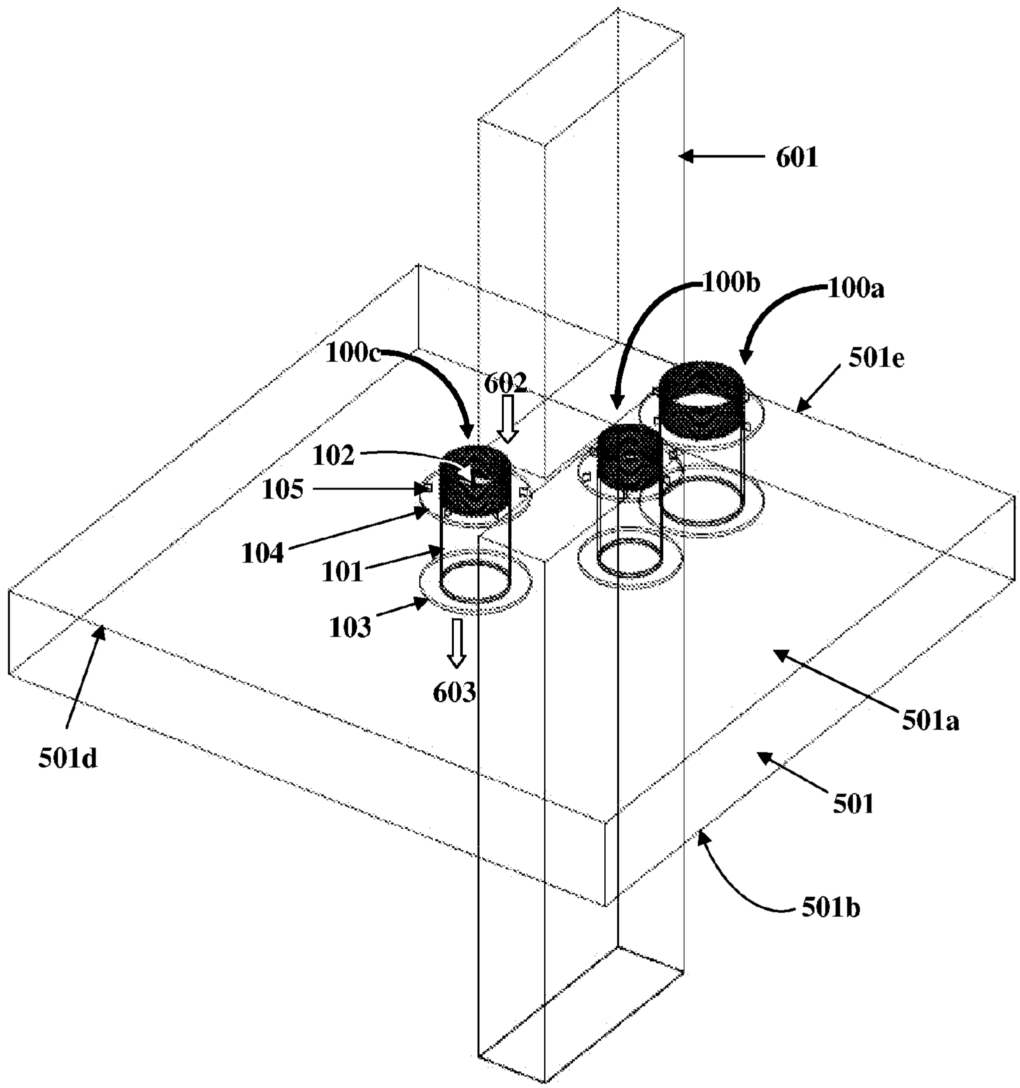

601
100b
100a
100c
501e
602
102
105
104
101
103
603
501d
501a
501
501b

FIG. 6

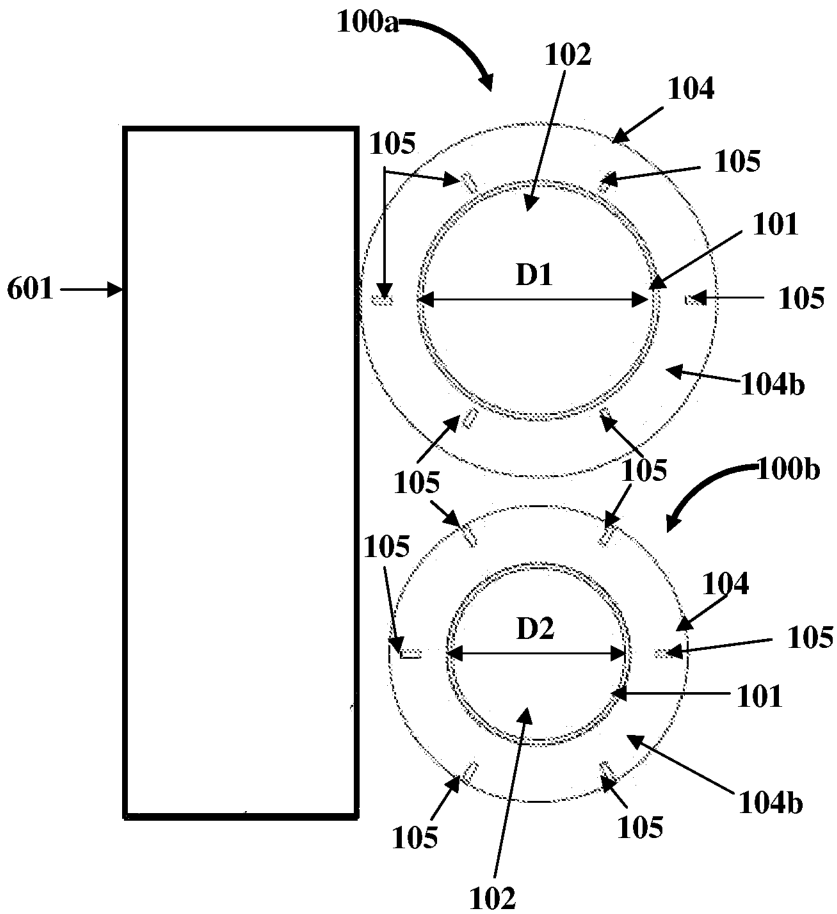

100a
102
104
105
105
101
601
D1
105
104b
105
105
100b
105
105
104
105
D2
101
105
105
104b
102

FIG. 7

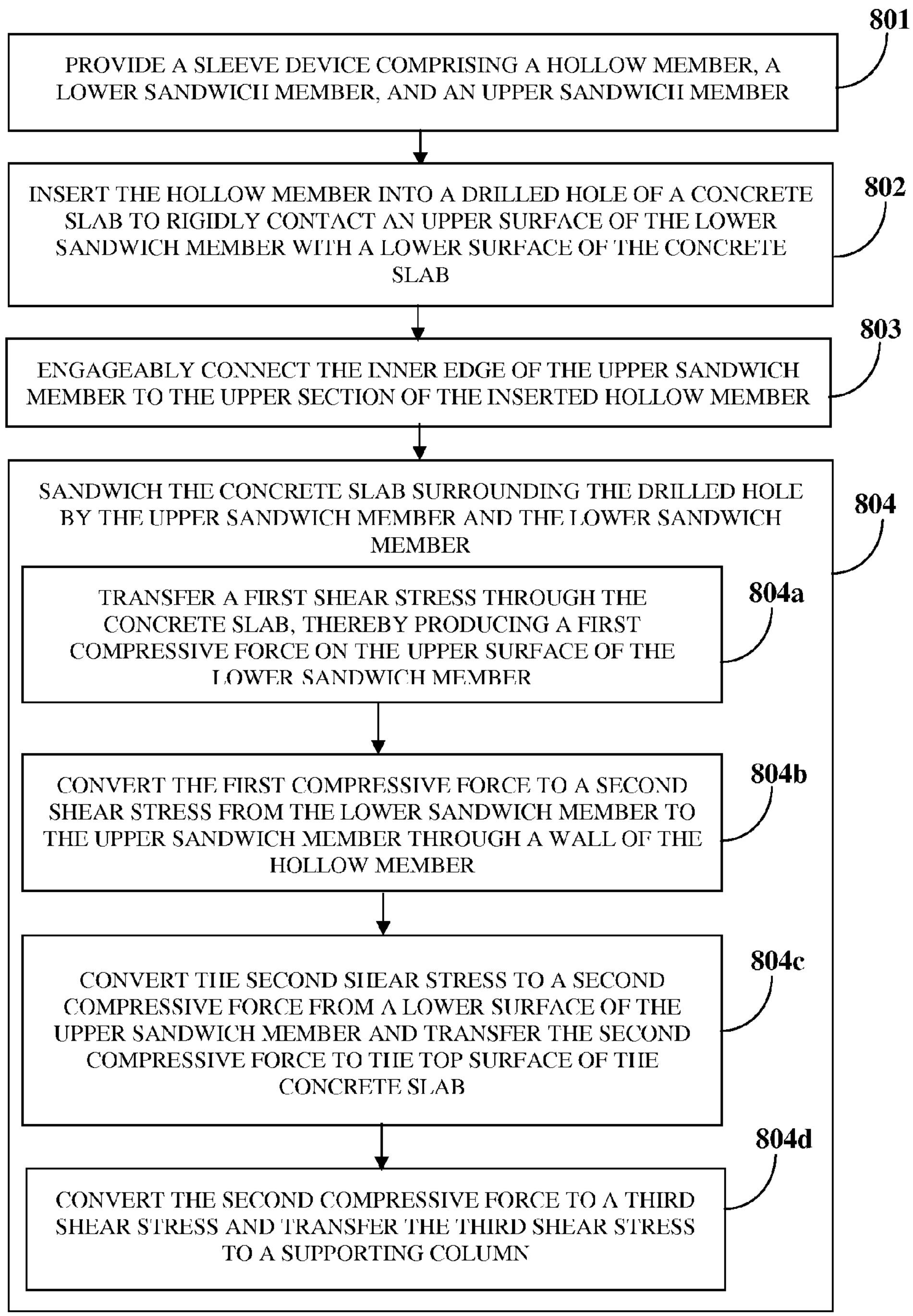
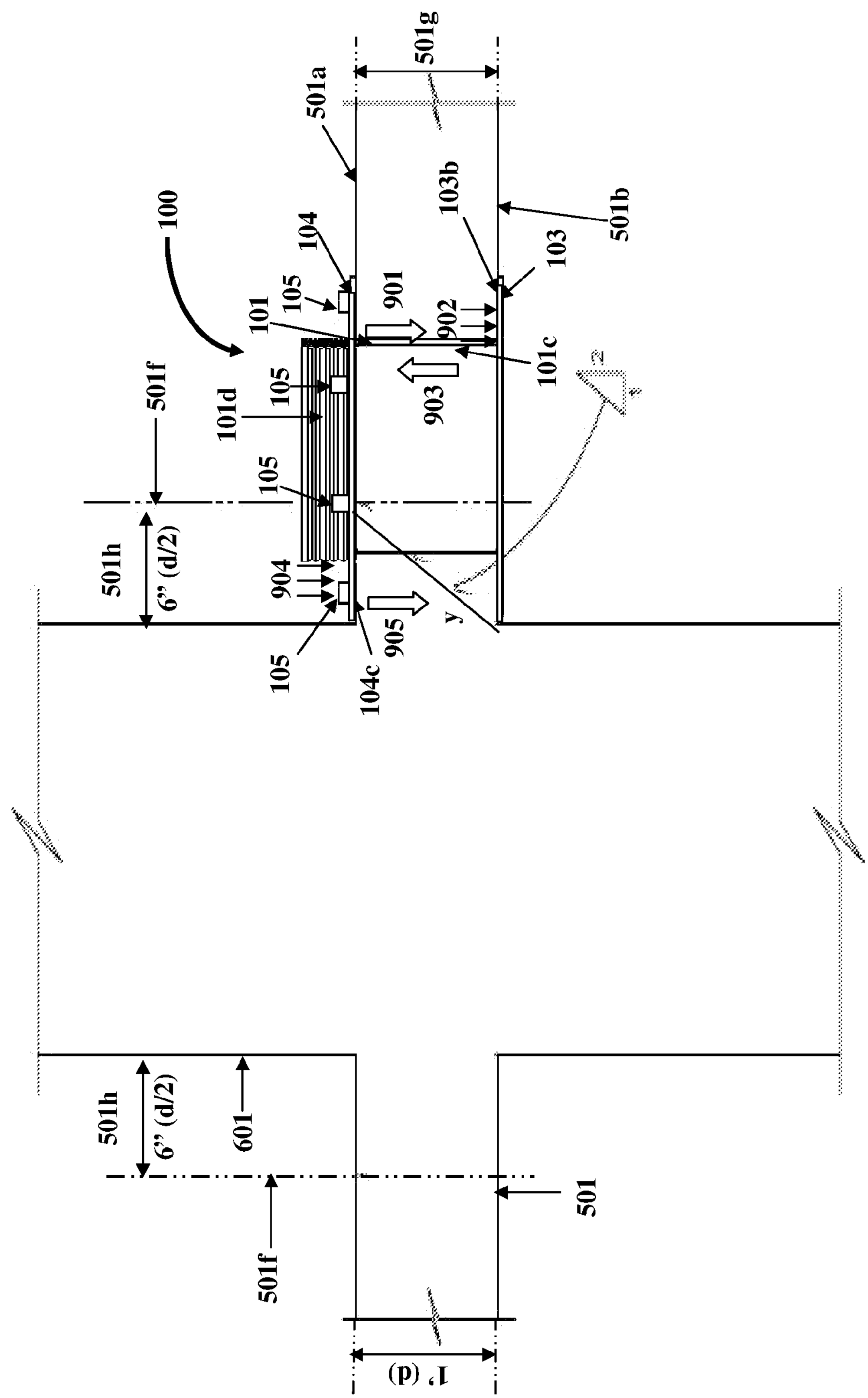

801
PROVIDE A SLEEVE DEVICE COMPRISING A HOLLOW MEMBER, A LOWER SANDWICH MEMBER, AND AN UPPER SANDWICH MEMBER
802
INSERT THE HOLLOW MEMBER INTO A DRILLED HOLE OF A CONCRETE SLAB TO RIGIDLY CONTACT AN UPPER SURFACE OF THE LOWER SANDWICH MEMBER WITH A LOWER SURFACE OF THE CONCRETE SLAB
803
ENGAGEABLY CONNECT THE INNER EDGE OF THE UPPER SANDWICH MEMBER TO THE UPPER SECTION OF THE INSERTED HOLLOW MEMBER
804
SANDWICH THE CONCRETE SLAB SURROUNDING THE DRILLED HOLE BY THE UPPER SANDWICH MEMBER AND THE LOWER SANDWICH MEMBER
804a
TRANSFER A FIRST SHEAR STRESS THROUGH THE CONCRETE SLAB, THEREBY PRODUCING A FIRST COMPRESSIVE FORCE ON THE UPPER SURFACE OF THE LOWER SANDWICH MEMBER
804b
CONVERT THE FIRST COMPRESSIVE FORCE TO A SECOND SHEAR STRESS FROM THE LOWER SANDWICH MEMBER TO THE UPPER SANDWICH MEMBER THROUGH A WALL OF THE HOLLOW MEMBER
804c
CONVERT THE SECOND SHEAR STRESS TO A SECOND COMPRESSIVE FORCE FROM A LOWER SURFACE OF THE UPPER SANDWICH MEMBER AND TRANSFER THE SECOND COMPRESSIVE FORCE TO THE TOP SURFACE OF THE CONCRETE SLAB
804d
CONVERT THE SECOND COMPRESSIVE FORCE TO A THIRD SHEAR STRESS AND TRANSFER THE THIRD SHEAR STRESS TO A SUPPORTING COLUMN

FIG. 8



501g
501a
100
104
105
101
901
902
103b
501b
103
101c
101d
903
501f
105
501h
6” (d/2)
904
105
104c
905
y
601
501h
6” (d/2)
501f
501
1’ (d)

FIG. 9

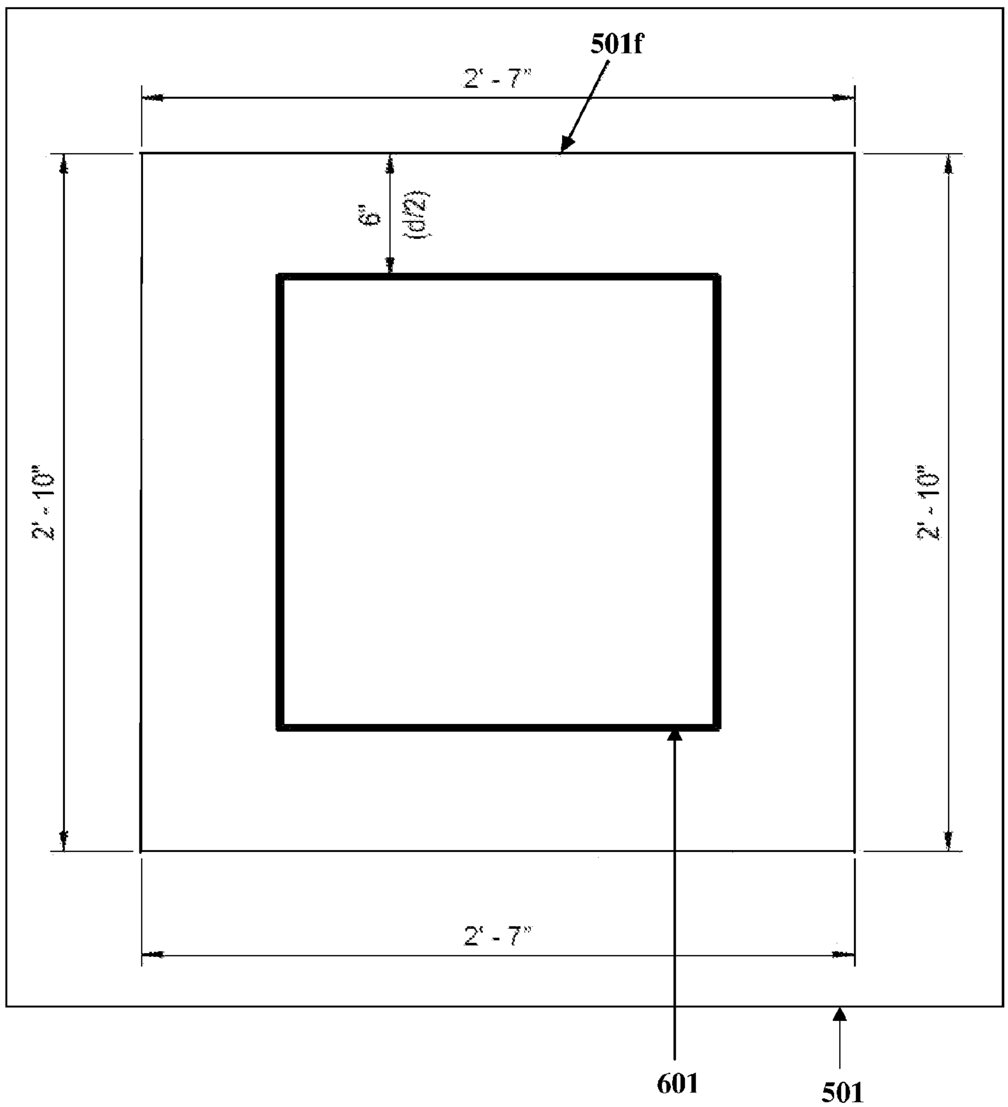


FIG. 10A

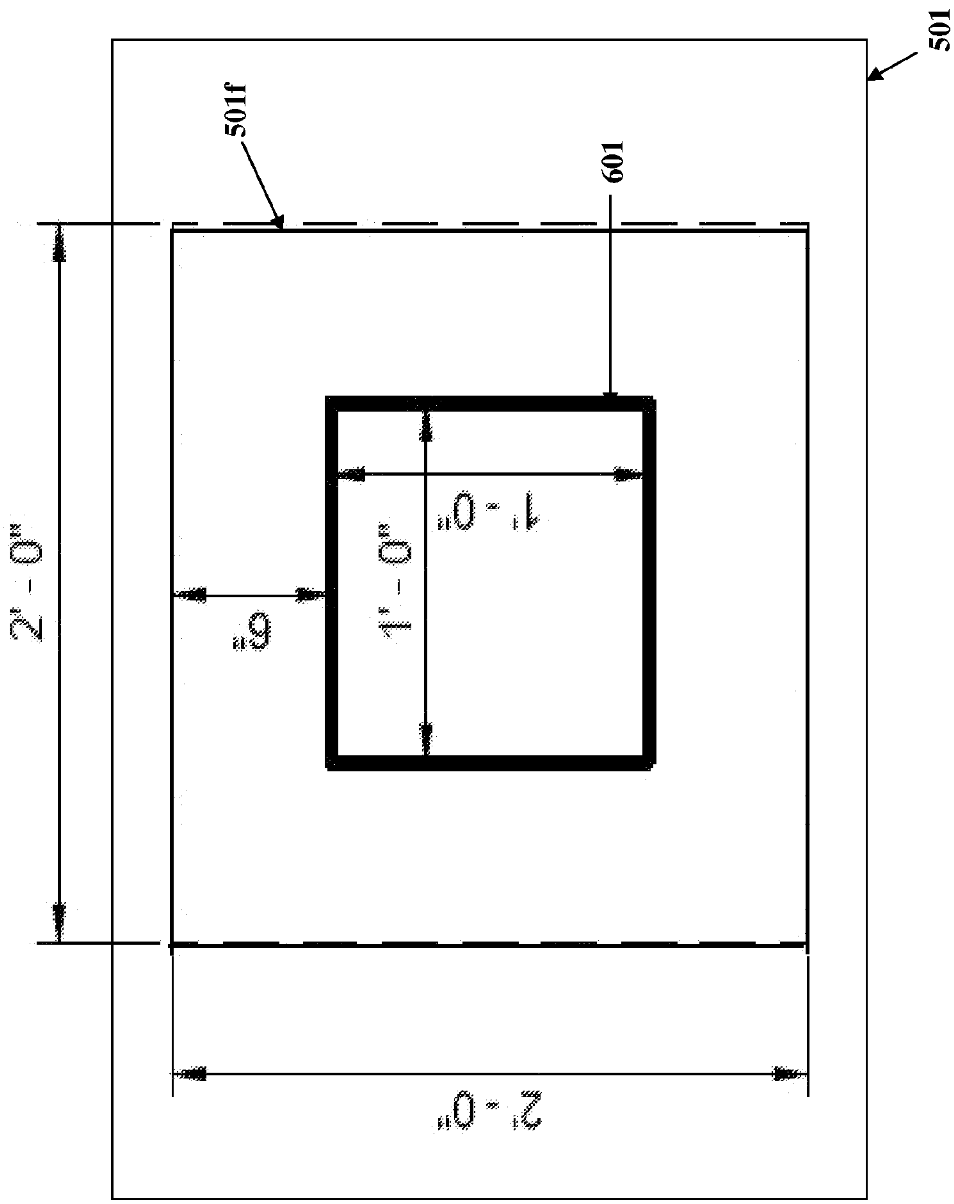


FIG. 10B

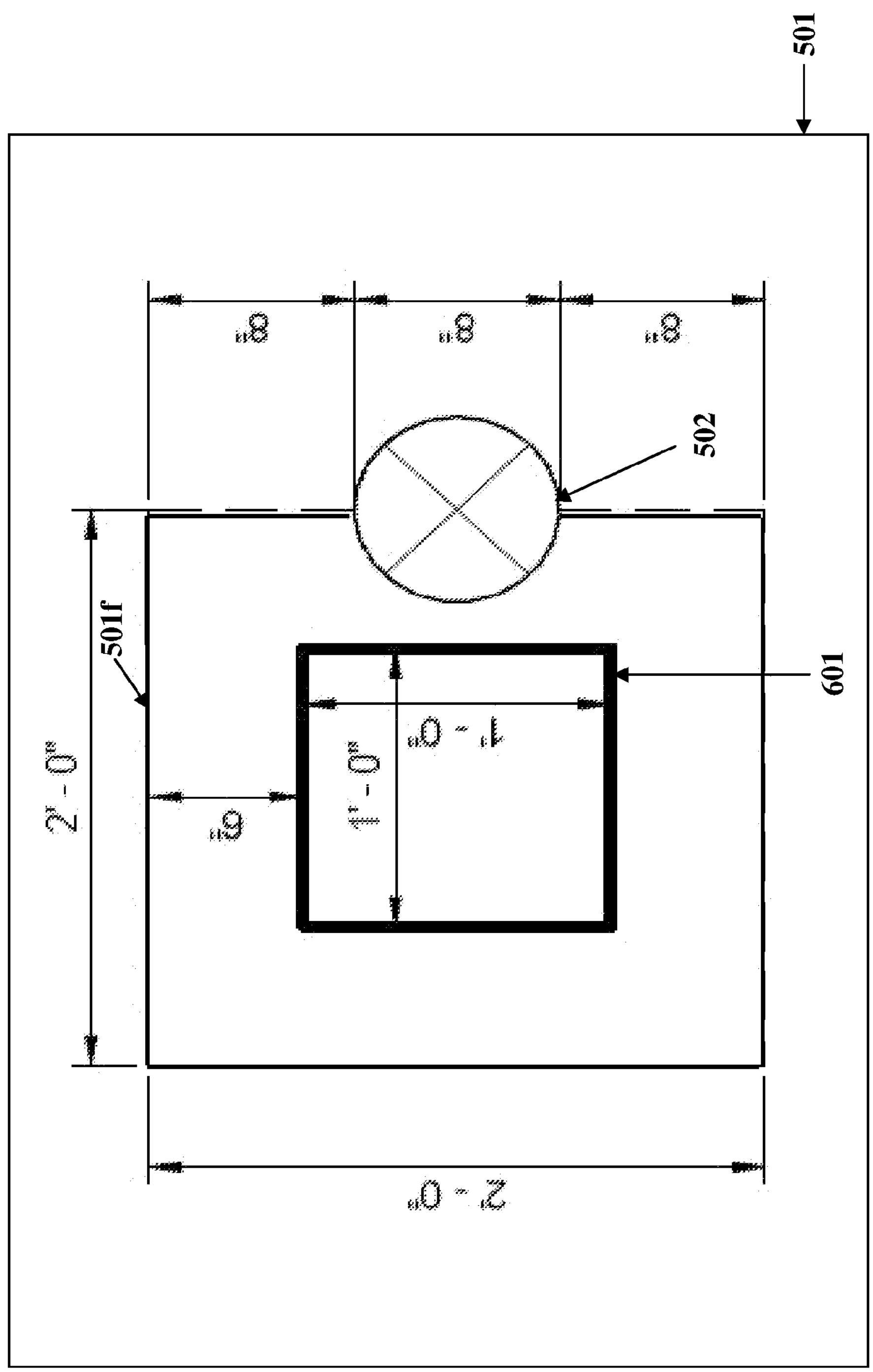


FIG. 10C

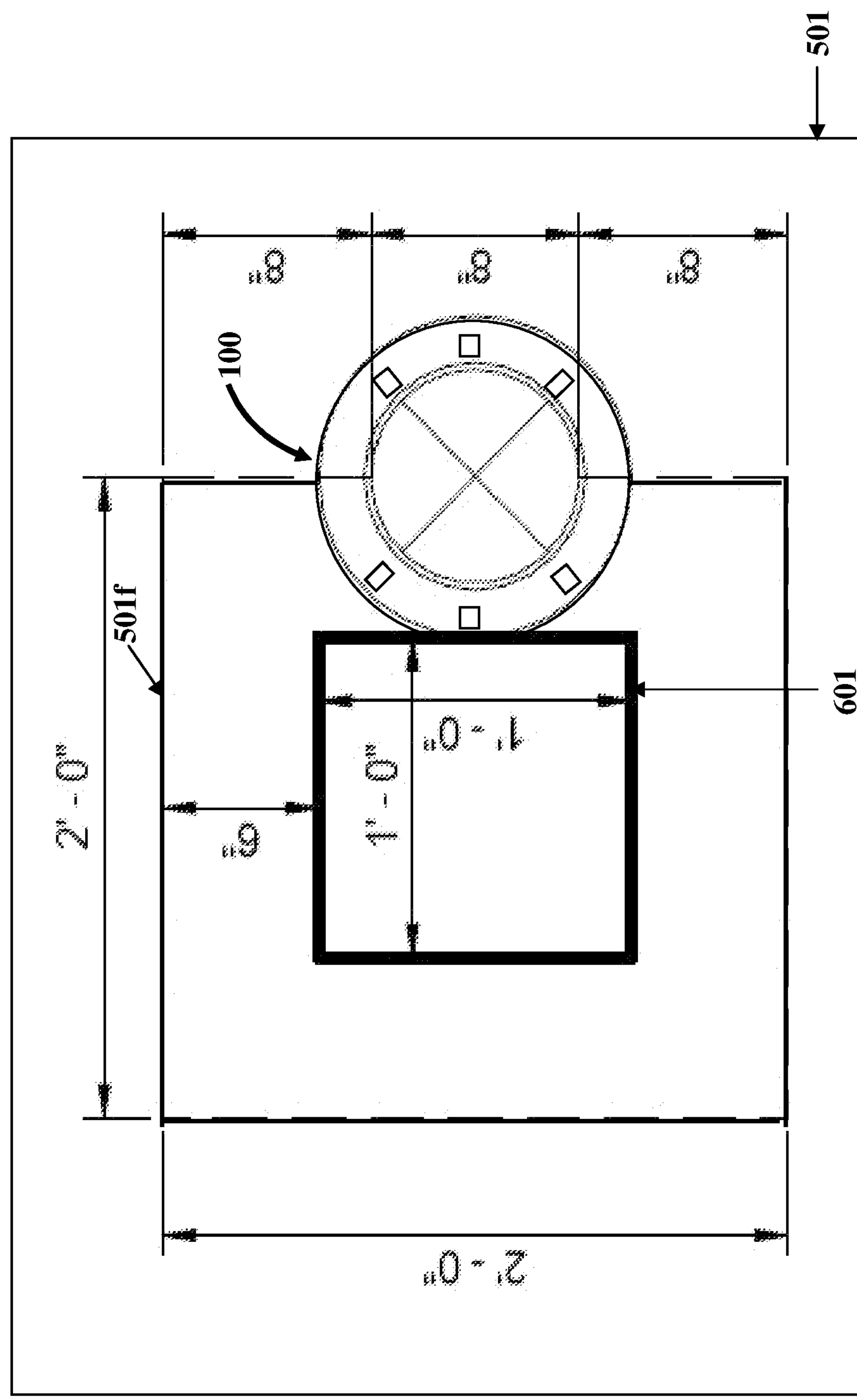


FIG. 10D

POST-INSTALLED SLEEVE DEVICE FOR COMPENSATING LOSS OF SHEAR CAPACITY

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of provisional patent application No. 61/858,123 titled "Post-installed Sleeve Device For Compensating Loss Of Shear Capacity", filed in the United States Patent and Trademark Office on Jul. 25, 2013. The specification of the above referenced patent application is incorporated herein by reference in its entirety.

BACKGROUND

[0002] Concrete structures, for example, reinforced concrete flat slabs or concrete slabs are extensively used in the building construction industry. In conventional building renovations, vertical utility pipes are typically positioned adjacent to concrete columns due to architectural or mechanical requirements. To position vertical utility pipes in a concrete slab, holes have to be created in the existing concrete slab. Manual drilling is a widely adopted method to create a hole in a concrete slab, where a drill bit of a specific size is used to drill a hole of a predetermined radius and depth in the concrete slab. However, holes created by drilling reduce the shear capacity of the concrete slabs. Engineers must recalculate moment and shear capacities of the concrete slabs when sleeves are placed in close proximity to supports or concrete columns. In many cases, structural changes are required to compensate for the loss of shear capacity caused by pipe penetrations. A pipe penetration in a concrete slab may substantially reduce the shear capacity of the concrete slab and in some cases cause a shear failure.

[0003] Hence, there is a long felt but unresolved need for a post-installed sleeve device that compensates for loss of shear capacity of a reinforced concrete slab, after a hole is drilled in the reinforced concrete slab proximal to a supporting column. Moreover, there is a need for a post-installed sleeve device that allows architects and mechanical engineers more flexibility in locating mechanical piping with minimal work and effort.

SUMMARY OF THE INVENTION

[0004] This summary is provided to introduce a selection of concepts in a simplified form that are further disclosed in the detailed description of the invention. This summary is not intended to identify key or essential inventive concepts of the claimed subject matter, nor is it intended for determining the scope of the claimed subject matter.

[0005] The post-installed sleeve device disclosed herein addresses the above stated need for compensating loss of shear capacity of a reinforced concrete slab, after a hole is drilled in the reinforced concrete slab proximal to a supporting column. Moreover, the sleeve device disclosed herein allows architects and mechanical engineers more flexibility in locating mechanical piping with minimal work and effort. The sleeve device disclosed herein is a device, for example, made of metal used in an existing cast-in-place concrete structure to reinforce shear capacity of the concrete structure by attaching two sandwich members, for example, ring shaped members to an upper section and a bottom edge of the sleeve device. The sleeve device disclosed herein is configured to transfer shear stresses in the concrete slab.

[0006] The sleeve device disclosed herein comprises a hollow member, for example, of a generally cylindrical shape, a lower sandwich member, and an upper sandwich member. The hollow member is inserted into a hole drilled in the concrete slab such that an upper section of the inserted hollow member extends above the top surface of the concrete slab. The lower sandwich member comprises an inner edge rigidly attached to a bottom edge of the hollow member. The upper sandwich member comprises an inner edge engageably connected to the upper section of the hollow member. The upper sandwich member and the lower sandwich member are configured to sandwich the concrete slab surrounding the drilled hole therebetween for compensating the lost shear capacity of the concrete slab due to the drilled hole. In an embodiment, the upper sandwich member and the lower sandwich member are configured as an upper ring member and a lower ring member respectively. In this embodiment, the hollow member comprises a threaded upper section, and the upper ring member comprises an inner threaded edge that is engageably connected to the threaded upper section of the hollow member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The foregoing summary, as well as the following detailed description of the invention, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, exemplary constructions of the invention are shown in the drawings. However, the invention is not limited to the specific methods and structures disclosed herein. The description of a method step or a structure referenced by a numeral in a drawing carries over to the description of that method step or structure shown by that same numeral in any subsequent drawing herein.

[0008] FIG. **1** exemplarily illustrates a top perspective view of a post-installed sleeve device for compensating lost shear capacity of a concrete slab due to a hole drilled in the concrete slab.

[0009] FIG. **2** exemplarily illustrates a front elevation view of the post-installed sleeve device.

[0010] FIG. **3**A exemplarily illustrates a sectional view of the post-installed sleeve device taken along a sectional line A-A shown in FIG. **1**.

[0011] FIG. **3**B exemplarily illustrates an enlarged view of a portion of the post-installed sleeve device marked X in FIG. **3**A, showing threaded sections of the post-installed sleeve device.

[0012] FIG. **4** exemplarily illustrates a top plan view of the post-installed sleeve device.

[0013] FIGS. **5**A-**5**C exemplarily illustrate insertion and assembly of the post-installed sleeve device in a hole drilled in a concrete slab for compensating loss of shear capacity of the concrete slab due to the drilled hole.

[0014] FIG. **6** exemplarily illustrates a top perspective view of multiple post-installed sleeve devices positioned in a concrete slab proximal to a supporting column.

[0015] FIG. **7** exemplarily illustrates a top plan view, showing post-installed sleeve devices of different diameters positioned in a concrete slab proximal to a supporting column.

[0016] FIG. **8** illustrates a method for compensating loss of shear capacity of a concrete slab due to a hole drilled in the concrete slab.

[0017] FIG. **9** exemplarily illustrates a side view of a concrete slab with the post-installed sleeve device inserted into a hole drilled in the concrete slab, showing a shear critical section of the concrete slab.

[0018] FIGS. **10**A-**10**B exemplarily illustrate top plan views of a supporting column and a concrete slab of different dimensions, showing shear critical sections of the concrete slabs.

[0019] FIG. **10**C exemplarily illustrates a top plan view of a supporting column and a concrete slab with a hole drilled proximal to the supporting column, and showing a shear critical section of the concrete slab.

[0020] FIG. **10**D exemplarily illustrates a top plan view of a supporting column and a concrete slab with the post-installed sleeve device inserted into a hole drilled in the concrete slab, proximal to the supporting column, and showing a shear critical section of the concrete slab.

DETAILED DESCRIPTION OF THE INVENTION

[0021] FIG. **1** exemplarily illustrates a top perspective view of a post-installed sleeve device **100** for compensating lost shear capacity of a concrete slab **501** due to a hole **502** drilled in the concrete slab **501** exemplarily illustrated in FIGS. **5**A-**5**C. As used herein, "shear capacity" refers to maximum shear stress that a concrete structure, for example, the concrete slab **501** can withstand before shear failure of the concrete structure. Also, as used herein, "shear stress" refers to an external force per unit area acting on a structure or a surface parallel to a plane of the structure or the surface. The sleeve device **100** disclosed herein is, for example, a steel sleeve device used in an existing cast-in-place reinforced concrete slab **501**.

[0022] The sleeve device **100** is made of, for example, multiple types of steel with multiple tensile strengths, an alloy, or other structural material. The sleeve device **100** disclosed herein comprises a hollow member **101**, a lower sandwich member, for example, a lower ring member **103**, and an upper sandwich member, for example, an upper ring member **104**. As used herein, "sandwich member" refers to a mechanical structure used for rigidly sandwiching the concrete slab **501** surrounding the drilled hole **502**. The sandwich member is, for example, a ring shaped member, a load transfer plate, etc. For purposes of illustration, the detailed description refers to the sandwich members being configured as ring members **103** and **104** for transferring shear stresses through the hollow member **101** to compensate loss of shear capacity of the concrete slab **501** due to the drilled hole **502**; however, the scope of the sleeve device **100** disclosed herein is not limited to the sandwich members being configured as the ring members **103** and **104**, but may be extended to include sandwich members configured as alternate affixations comprising, for example, plates, bars, bonding agents such as epoxy adhesives, etc., and other functionally equivalent structures to transfer shear stresses from the concrete slab **501** through the hollow member **101**. In an embodiment, the lower sandwich member and the upper sandwich member can be of the same type, for example, ring members **103** and **104**, or of different types, for example, a combination of a ring member **103** or **104** and a plate, a combination of a ring member **103** or **104** and bars, etc.

[0023] As exemplarily illustrated in FIG. **1**, the hollow member **101** is of a generally cylindrical shape. A cross section B-B of the hollow member **101** is, for example, of a circular geometric shape or another geometric shape that allows the upper sandwich member, for example, **104** to be engageably connected to the upper section **101***d* of the hollow member **101**. The hollow member **101** defines an inner void **102** therewithin for inserting, for example, plumbing piping, mechanical piping, heavy gauge wiring, etc. The hollow member **101** is configured in multiple shapes that allow multiple insertions, for example, mechanical structures and electrical components to be inserted through the inner void **102** of the hollow member **101** that is inserted into the hole **502** drilled in the concrete slab **501**, or insertions that require an opening for mechanical, architectural, or other purposes.

[0024] The hollow member **101** is inserted into a hole **502** drilled in the concrete slab **501** exemplarily illustrated in FIGS. **5**A-**5**C. The hollow member **101** comprises a threaded upper section **101***d* proximal to a top edge **101***a* of the hollow member **101**. The threaded upper section **101***d* of the inserted hollow member **101** extends above a top surface **501***a* of the concrete slab **501**. The lower ring member **103** comprises an inner edge **103***a* also exemplarily illustrated in FIG. **3**A, rigidly attached to a bottom edge **101***b* of the hollow member **101**. The upper ring member **104** comprises an inner threaded edge **104***a* engageably connected to the threaded upper section **101***d* of the hollow member **101**. In an embodiment, the sleeve device **100** comprises multiple gripping members **105** positioned on and attached to an upper surface **104***b* of the upper ring member **104**. The gripping members **105** provide a grip for engageably connecting the upper ring member **104** to the hollow member **101**. In an embodiment, the gripping members **105** are configured as rectangular tabs. The upper ring member **104** and the lower ring member **103** sandwich the concrete slab **501** surrounding the drilled hole **502** therebetween for compensating the lost shear capacity of the concrete slab **501** due to the drilled hole **502**. The lower ring member **103** and the upper ring member **104** transfer shear stresses through the hollow member **101** to compensate loss of the shear capacity of the concrete slab **501** due to the drilled hole **502**. In an embodiment, the shear stresses are transferred from the concrete slab **501** to the lower ring member **103** and the upper ring member **104** of the sleeve device **100**, through the hollow member **101** as disclosed in the detailed description of FIG. **9**.

[0025] FIG. **2** exemplarily illustrates a front elevation view of the post-installed sleeve device **100**. The sleeve device **100** disclosed herein is constructed by attaching two sandwich members, for example, the ring members **103** and **104** or plates to the bottom edge **101***b* and the threaded upper section **101***d* of the hollow member **101** respectively. The hollow member **101** is inserted into a hole **502** drilled in a concrete slab **501** exemplarily illustrated in FIGS. **5**A-**5**C, to reinforce the concrete slab **501**. The hollow member **101** is, for example, made of steel. The lower ring member **103** is, for example, a metallic ring shaped plate welded to the bottom edge **101***b* of the hollow member **101**. Welding is performed between the inner edge **103***a* of the lower ring member **103** exemplarily illustrated in FIG. **1**, and the bottom edge **101***b* of the hollow member **101**. The upper ring member **104** is threadably engaged to the upper section **101***d* of the hollow member **101**.

[0026] FIG. **3**A exemplarily illustrates a sectional view of the post-installed sleeve device **100** taken along a sectional line A-A shown in FIG. **1**. FIG. **3**B exemplarily illustrates an enlarged view of a portion of the post-installed sleeve device **100** marked X in FIG. **3**A, showing threaded sections, for example, a threaded upper section **101***d* of the hollow member **101** and a threaded section **104***d* on an inner threaded edge **104***a* of the upper ring member **104** of the post-installed sleeve device **100**. The upper ring member **104** is, for example, a metallic ring shaped plate with the threaded section **104***d* defined along the inner threaded edge **104***a* of the ring shaped plate. The threaded section **104***d* along the inner threaded edge **104***a* of the upper ring member **104** is engaged with the threaded upper section **101***d* of the hollow member **101** within a predetermined thickness **501***g* of the concrete slab **501** exemplarily illustrated in FIG. **9**.

[0027] FIG. **4** exemplarily illustrates a top plan view of the post-installed sleeve device **100**. The upper ring member **104** and the lower ring member **103** of the sleeve device **100** extend outward from an outer wall **101***c* of the hollow member **101** of the sleeve device **100** as exemplarily illustrated in FIGS. **1-2**. An inner void **102** defined within the hollow member **101** of the sleeve device **100** allows insertions, for example, plumbing piping, mechanical piping, heavy gauge wiring, etc., through the hole **502** drilled in the concrete slab **501** exemplarily illustrated in FIGS. **5**A-**5**C. The lower ring member **103** and the upper ring member **104** attach the sleeve device **100** to the concrete slab **501**. The gripping members **105** attached to the upper surface **104***b* of the upper ring member **104** are also exemplarily illustrated in FIG. **4**.

[0028] FIGS. **5**A-**5**C exemplarily illustrate insertion and assembly of the post-installed sleeve device **100** in a hole **502** drilled in a concrete slab **501** for compensating loss of shear capacity of the concrete slab **501** due to the drilled hole **502**. As exemplarily illustrated in FIG. **5**A, a hole **502** is drilled in the concrete slab **501** using a drill apparatus **503**. After the hole **502** is drilled in the concrete slab **501**, the sleeve device **100** is inserted through the drilled hole **502** from a lower surface **501***b* of the concrete slab **501** such that the threaded upper section **101***d* of the inserted hollow member **101** extends above a top surface **501***a* of the concrete slab **501** as exemplarily illustrated in FIGS. **5**B-**5**C. The upper surface **103***b* of the lower ring member **103** is held in rigid contact with the lower surface **501***b* of the concrete slab **501**. The inner threaded edge **104***a* of the upper ring member **104** exemplarily illustrated in FIG. **3**B, is engageably connected to the threaded upper section **101***d* of the inserted hollow member **101** to sandwich the concrete slab **501** surrounding the drilled hole **502** in the concrete slab **501** between the upper ring member **104** and the lower ring member **103**. The gripping members **105** are used for tightening the upper ring member **104** down to the concrete slab **501**.

[0029] In an embodiment, on inserting the hollow member **101** into the drilled hole **502**, if there is a gap **504** defined between the outer wall **101***c* of the hollow member **101**, the upper surface **103***b* of the lower ring member **103**, and an inner surface **501***c* of the concrete slab **501**, grout is filled in the gap **504** to ensure full contact of the sleeve device **100** with the drilled hole **502**, if required. After filling the grout in the gap **504**, the upper ring member **104** is engageably connected to the hollow member **101** to sandwich the concrete slab **501** surrounding the drilled hole **502** between the upper ring member **104** and the lower ring member **103**.

[0030] FIG. **6** exemplarily illustrates a top perspective view of multiple post-installed sleeve devices **100***a*, **100***b*, and **100***c* positioned in a concrete slab **501** proximal to a supporting column **601**. The sleeve devices **100***a*, **100***b*, and **100***c* are positioned adjacent to each other in the concrete slab **501** with the threaded upper section **101***d* of each hollow member **101** extending above a top surface **501***a* of the concrete slab **501**. As exemplarily illustrated in FIG. **6**, the sleeve device **100***c* is positioned in a perpendicular direction with respect to the other two sleeve devices **100***a* and **100***b*. The sleeve devices **100***a*, **100***b*, and **100***c* are used in an existing concrete slab **501** to increase slab shear capacity when penetrations, for example, drill holes **502** exemplarily illustrated in FIGS. **5**A-**5**B, are made in the vicinity of supporting columns **601**. The lower ring member **103** and the upper ring member **104** increase the size of a shear critical section **501***f* exemplarily illustrated in FIG. **9**. As used herein, "shear critical section" refers to a section in the concrete slab **501**, which defines a slab-column joint punching shear capacity. Also, as used herein, the term "shear capacity" refers to an ability of a concrete structure to withstand a maximum shear stress before occurrence of a shear failure in the concrete structure. The lower ring member **103** and the upper ring member **104** can prevent shear failure within a predefined threshold range of the sleeve device **100***a*, or **100***b*, or **100***c*, thereby reinforcing the shear capacity of the concrete slab **501**. The "threshold range" of the sleeve device **100***a*, or **100***b*, or **100***c* is defined by the American Concrete Institute (ACI) in Building Code Requirements for Structural Concrete, ACI 318, chapter 11.

[0031] Consider an example where a concrete slab **501** is positioned such that an edge **501***e* of the concrete slab **501** is proximal to a supporting column **601**, and an edge **501***d* of the concrete slab **501** is distal to the supporting column **601**. A hole **502** exemplarily illustrated in FIGS. **5**A-**5**B, proximal to the supporting column **601**, is drilled in the concrete slab **501**. After drilling the hole **502**, the concrete slab **501** experiences shear stresses **602** and **603** around the drilled hole **502** that are perpendicular to the top surface **501***a* of the concrete slab **501**. As loads on the edge **501***d* of the concrete slab **501** increase, the shear stresses **602** and **603** at the drilled hole **502** also increase, thereby increasing risk of a shear failure in the concrete slab **501** at the drilled hole **502**. To prevent the shear failure of the concrete slab **501**, the post-installed sleeve device, for example, **100***c* exemplarily illustrated in FIG. **6**, is inserted into the drilled hole **502** such that the upper surface **103***b* of the lower ring member **103** is held in rigid contact with the lower surface **501***b* of the concrete slab **501**. The inner threaded edge **104***a* of the upper ring member **104** is then engageably connected to the threaded upper section **101***d* of the hollow member **101** as exemplarily illustrated in FIG. **3**B. The upper ring member **104** and the lower ring member **103** of the sleeve device **100***c* sandwich the concrete slab **501** surrounding the drilled hole **502**, thereby increasing area of the shear critical section **501***f* exemplarily illustrated in FIG. **9**, around the drilled hole **502** in the concrete slab **501**.

[0032] An average shear stress (v) is defined as force (F) per unit area (A) in accordance with the formula below:

$$v \equiv (F/A)$$

[0033] The shear force F acts on an area A. This area A is the area of the shear critical section **501***f* around the drilled hole **502** as exemplarily illustrated in FIG. **10**C. As the average shear stress v is inversely proportional to the area A, the shear stress v increases if the area A is decreased. Hence, drilling a hole **502** in the concrete slab **501** proximal to a supporting column **601** reduces the area A, thereby increasing the shear stress v. The lost shear capacity can be defined as the area of the drilled hole **502** multiplied by the original shear stress v that the concrete slab **501** experienced before drilling the hole **502**. By introducing the sleeve device **100***a*, or **100***b*, or **100***c* into the drilled hole **502**, the lost shear capacity can be compensated for through the added shear capacity of the sleeve device **100***a*, or **100***b*, or **100***c*. Hence, as a result of sandwiching of the concrete slab **501** surrounding the drilled hole **502**, by the upper ring member **104** and the lower ring member **103** of the sleeve device **100***a*, or **100***b*, or **100***c*, the area A or the area of the shear critical section **501***f* around the drilled hole **502** increases, thereby decreasing the shear stresses **602** and **603** at the drilled hole **502**. Since the upper ring member **104** and the lower ring member **103** increase the area of the shear critical section **501***f* around the drilled hole **502** in the concrete slab **501**, the concentration of the shear stresses **602** and **603** exerted at the drilled hole **502** decreases. The sleeve device **100***a*, and/or **100***b*, and/or **100***c* thus strengthens the shear capacity of the concrete slab **501** surrounding the drilled hole **502** to mitigate risk of a shear failure of the concrete slab **501** by compensating the lost shear capacity of the concrete slab **501** due to the drilled hole **502**.

[0034] FIG. **7** exemplarily illustrates a top plan view, showing post-installed sleeve devices **100***a* and **100***b* of different diameters D1 and D2 respectively, positioned in a concrete slab **501** exemplarily illustrated in FIG. **6**, proximal to a supporting column **601**. In an embodiment, the hollow member **101** of the sleeve device **100***a* or **100***b* is configured as an extensible hollow member **101** to be inserted into a drilled hole **502** exemplarily illustrated in FIGS. **5**A-**5**B, of different dimensions and to enable the upper ring member **104** and the lower ring member **103** of each of the sleeve devices **100***a* and **100***b* to adjustably sandwich the concrete slab **501** surrounding the drilled hole **502** of multiple dimensions. The diameters of the extensible hollow members **101** of the post-installed sleeve devices **100***a* and **100***b* may be D1 or D2 based on multiple parameters, for example, physical dimensions such as diameter or circumference of the drilled hole **502**, thickness **501***g* of the concrete slab **501** exemplarily illustrated in FIG. **9**, etc.

[0035] FIG. **8** illustrates a method for compensating loss of shear capacity of a concrete slab **501** due to a hole **502** drilled in the concrete slab **501** exemplarily illustrated in FIGS. **5**A-**5**C. A post-installed sleeve device **100** comprising a hollow member **101**, an upper sandwich member, for example, an upper ring member **104**, and a lower sandwich member, for example, a lower ring member **103** as exemplarily illustrated in FIGS. **1**-**4** and as disclosed in the detailed description of FIGS. **1**-**7**, is provided **801**. The hollow member **101** of the sleeve device **100** is inserted **802** into the drilled hole **502** of the concrete slab **501** to rigidly contact an upper surface **103***b* of the lower sandwich member of the sleeve device **100** with a lower surface **501***b* of the concrete slab **501**. The upper section **101***d* of the inserted hollow member **101** extends above a top surface **501***a* of the concrete slab **501**. An inner edge **104***a* of the upper sandwich member of the sleeve device **100** is engageably connected **803** to the upper section **101***d* of the inserted hollow member **101**. The upper sandwich member and the lower sandwich member sandwich **804** the concrete slab **501** surrounding the drilled hole **502** therebetween for compensating the loss of shear capacity of the concrete slab **501** due to the drilled hole **502**. Due to the sandwiching **804** of the concrete slab **501** surrounding the drilled hole **502** by the upper sandwich member and the lower sandwich member of the sleeve device **100**, a shear stress is transferred **804***a* through the concrete slab **501**, thereby producing a compressive force caused by shear in the concrete slab **501** on an upper surface **103***b* of the lower sandwich member. As used herein, "compressive force" refers to a force resulting from compression of two members against each other, causing transfer of load through bearing from one member to the other member. For example, a compressive force results from the compression in between the lower surface **501***b* of the concrete slab **501** and the upper surface **103***b* of the lower ring member **103** exemplarily illustrated in FIG. **9**. The shear stress in the concrete slab **501** causes the compressive force. The compressive force is then converted **804***b* to a shear stress from the lower sandwich member to the upper sandwich member through the outer wall **101***c* of the hollow member **101**. The shear stress is then converted **804***c* to a compressive force from the lower surface **104***c* of the upper sandwich member. The compressive force is transferred **804***c* to the top surface **501***a* of the concrete slab **501**. The compressive force is then converted **804***d* to a shear stress which is transferred **804***d* to a supporting column **601** exemplarily illustrated in FIG. **9**.

[0036] FIG. **9** exemplarily illustrates a side view of a concrete slab **501** with the post-installed sleeve device **100** inserted into a hole **502** drilled in the concrete slab **501** exemplarily illustrated in FIGS. **5**A-**5**B, showing a shear critical section **501***f* of the concrete slab **501**. The shear critical section **501***f* is defined as an area located at a distance (d/2), referenced by **501***h* in FIG. **9**, from a supporting column **601**, where "d" is the thickness **501***g* of the concrete slab **501**. The positioning of the shear critical section **501***f* in the concrete slab **501** at a distance "y" from the supporting column **601** is therefore, defined by a 1:2 slope triangle of height equal to the thickness **501***g* of the concrete slab **501** and base **501***h* equal to half of the thickness **501***g* of the concrete slab **501**, where "y" is the hypotenuse of the 1:2 slope triangle. The sandwiching of the concrete slab **501** surrounding the drilled hole **502** by the upper ring member **104** and the lower ring member **103** of the sleeve device **100**, transfers a shear stress **901** through the concrete slab **501**, thereby producing a compressive force **902** on an upper surface **103***b* of the lower ring member **103**. The compressive force **902** is then converted to a shear stress **903** from the lower ring member **103** to the upper ring member **104** through an outer wall **101***c* of the hollow member **101**. The shear stress **903** is then converted to a compressive force **904** from the lower surface **104***c* of the upper ring member **104**. The compressive force **904** is transferred to the top surface **501***a* of the concrete slab **501**. Thus, the compressive force **902** occurs distal to the supporting column **601**, while the compressive force **904** occurs proximal to the supporting column **601**. The concrete slab **501** imposes the compressive force **902** from the lower surface **501***b* of the concrete slab **501** onto the upper surface **103***b* of the lower ring member **103**, and the sleeve device **100** imposes the compressive force **904** from the lower surface **104***c* of the upper ring member **104** onto the top surface **501***a* of the concrete slab **501**. The compressive force **904** is converted to a shear stress **905**. The shear stress **905** is transferred to the supporting column **601**. Thus, by sandwiching the concrete slab **501** at the drilled hole **502**, the shear stress **901** distal to the supporting column **601** is transferred through the hollow member **101** and proximal to the supporting column **601**.

[0037] FIGS. **10**A-**10**B exemplarily illustrate top plan views of a supporting column **601** and a concrete slab **501** of different dimensions, showing shear critical sections **501***f* of the concrete slabs **501**. The concrete slabs **501** exemplarily illustrated in FIGS. **10**A-**10**B are free of penetrations. Consider an example where a concrete slab **501** of thickness (d), for example, 1 foot ('), that is, 12 inches (") is supported by a supporting column **601** as exemplarily illustrated in FIG. **9**.

Consider the shear critical section **501*f*** to be at a distance (d/2) away from the supporting column **601** and is therefore 6" from the supporting column **601**. The area (A) of the shear critical section **501*f*** can be calculated by multiplying the perimeter (P) of the shear critical section **501*f*** at a distance (d/2) from the supporting column **601** with the thickness (d) of the concrete slab **501** in accordance with the formula below:

$$A=(P*d)$$

[0038] Therefore, as exemplarily illustrated in FIG. **10**A, the area (A) of the shear critical section **501*f*** is [(34"+34"+31"+31")*12"]=1560 square inches.

[0039] Consider another example where the concrete slab **501** of thickness (d) 12" is supported by a supporting column **601** of dimensions 1' by 1', that is, 12" by 12" as exemplarily illustrated in FIG. **10**B. Consider the shear critical section **501*f*** to be at a distance (d/2) away from the supporting column **601** and is therefore 6" from the supporting column **601**. The perimeter (P) of the shear critical section **501*f*** can be calculated as 2'*4, that is, 24"*4. The area (A) of the shear critical section **501*f*** is a multiplication product of the perimeter (P) of the shear critical section **501*f*** and the thickness (d) of the concrete slab **501**. Therefore, the area (A) of the shear critical section **501*f*** is [(24"*4)*12"]=1152 square inches.

[0040] Nominal shear capacity (Vn) of the concrete slab **501** at the supporting column **601** is the sum of shear capacity (Vc) of the concrete slab **501** and shear capacity (Vs) of shear reinforcement, that is, the sleeve device **100** in accordance with the formula below:

$$Vn=Vc+Vs$$

[0041] The shear capacity (Vc) of the concrete slab **501** is 4 times the multiplication product of the area (A) of the shear critical section **501*f*** and the square root of the strength (f'c) of the concrete slab **501** in accordance with the formula below:

$$Vc=A*4*\sqrt{f'c}$$

where f'c is the strength of the concrete slab **501**, for example, about 5000 pounds per square inch (psi). Therefore, the shear capacity (Vc) of the concrete slab **501** having the shear critical section **501*f*** exemplarily illustrated in FIG. **10**B, is 1152*4*√5000=325835 lbs. The shear capacity (Vs) of the sleeve device **100** is zero since the concrete slab **501** exemplarily illustrated in FIG. **10**B, is free of penetrations and therefore free of the sleeve device **100**. Therefore, the nominal shear capacity (Vn) of the concrete slab **501** at the supporting column **601** is 325835+0=325835 lbs.

[0042] FIG. **10**C exemplarily illustrates a top plan view of a supporting column **601** and a concrete slab **501** with a hole **502** drilled proximal to the supporting column **601**, and showing a shear critical section **501*f*** of the concrete slab **501**. Consider an 8" core hole **502** drilled in the concrete slab **501** of thickness (d) 12" having a strength of 5000 pounds per square inch (psi) as exemplarily illustrated in FIG. **10**C. The area (A) of the shear critical section **501*f*** is then calculated as A=[(24"*4)−8"]*12"=1056 square inches. The shear capacity (Vc) of the concrete slab **501** can then be calculated as 1056*4*√5000=298682 lbs. Therefore, the nominal shear capacity (Vn) of the concrete slab **501** at the supporting column **601** is 298682+=298682 lbs because the sleeve device **100** is not inserted into the hole **502**. Thus, the 8" core drilled hole **502** reduces the nominal shear capacity (Vn) of the concrete slab **501** at the supporting column **601** by 27153 lbs.

[0043] FIG. **10**D exemplarily illustrates a top plan view of a supporting column **601** and a concrete slab **501** with the post-installed sleeve device **100** inserted into a hole **502** drilled in the concrete slab **501** exemplarily illustrated in FIG. **10**C, proximal to the supporting column **601**, and showing a shear critical section **501*f*** of the concrete slab **501**. The ring members **103** and **104** of the sleeve device **100**, exemplarily illustrated in FIG. **1**, are configured to sandwich the concrete slab **501** surrounding the drilled hole **502**, thereby compensating for the lost nominal shear capacity (Vn) of the concrete slab **501** at the supporting column **601** due to the drilled hole **502**. The relatively stiffer sleeve device **100** confines the sandwiched concrete slab **501** surrounding the drilled hole **502**, thereby eliminating shear failure within the confined concrete slab **501** surrounding the drilled hole **502**. Thus, the sleeve device **100** bridges the penetration created in the concrete slab **501** due to the drilled hole **502** and increases the perimeter (P) of the shear critical section **501*f*** of the slab-column connection. Consider the sleeve device **100** is a rigid sleeve device and the associated deformation of the sleeve device **100** is negligible under shear forces. The enhanced shear capacity of the sleeve device **100** that is required to compensate the lost nominal shear capacity (Vn) is controlled by the thickness of the ring members **103** and **104** of the sleeve device **100**. When the sleeve device **100** is inserted into the drilled hole **502** and is configured to provide for the lost nominal shear capacity (Vn)=27153 lbs of the concrete slab **501** due to the drilled hole **502**, the total nominal shear capacity (Vn) of the concrete slab **501** at the supporting column **601** becomes equal to or larger than the nominal shear capacity (Vn)=325835 lbs of the concrete slab **501** at the supporting column **601** before penetration of the concrete slab **501** with a drilled hole **502**. Thus, the sleeve device **100** compensates the lost shear capacity of the concrete slab **501** due to the drilled hole **502**.

[0044] Consider an example where a sleeve device **100** is configured as a steel sleeve device to provide a shear capacity (Vs)=27153 lbs for compensating the lost nominal shear capacity (Vn) of the concrete slab **501** at the supporting column **601**. To provide this compensation, steel area (As) of each of the ring members **103** and **104** of the steel sleeve device **100** exemplarily illustrated in FIGS. **1-2**, is configured in accordance with the formula below:

$$As=Vs/(0.4*ft)$$

where "fy" is the design yield strength of the steel used to configure the ring members **103** and **104**. Consider "fy" as 60000 psi. Therefore, the steel area (As) is [(27153)/(0.4*60000)]=1.13 square inches. As long as each of the ring members **103** and **104** of the sleeve device **100** is configured with the area (As) required for effective shear force transfer width, the shear capacity (Vn) lost due to penetration of the concrete slab **501** with the drilled hole **502** can be compensated.

[0045] The foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the present invention disclosed herein. While the invention has been described with reference to various embodiments, it is understood that the words, which have been used herein, are words of description and illustration, rather than words of limitation. Further, although the invention has been described herein with reference to particular means, materials, and embodiments, the invention is not intended to be limited to the particulars disclosed herein;

rather, the invention extends to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims. Those skilled in the art, having the benefit of the teachings of this specification, may effect numerous modifications thereto and changes may be made without departing from the scope and spirit of the invention in its aspects.

I claim:

1. A sleeve device for compensating loss of shear capacity of a concrete slab due to a hole drilled in said concrete slab, said sleeve device comprising:

a hollow member inserted into said drilled hole, said hollow member comprising an upper section extending above a top surface of said concrete slab;

a lower sandwich member comprising an inner edge rigidly attached to a bottom edge of said hollow member; and

an upper sandwich member comprising an inner edge engageably connected to said upper section of said hollow member, wherein said upper sandwich member and said lower sandwich member are configured to sandwich said concrete slab surrounding said drilled hole therebetween for compensating said loss of said shear capacity of said concrete slab due to said drilled hole.

2. The sleeve device of claim **1**, wherein said upper sandwich member and said lower sandwich member are configured to increase area of a shear critical section around said drilled hole in said concrete slab for compensating said loss of said shear capacity of said concrete slab due to said drilled hole.

3. The sleeve device of claim **1**, wherein said hollow member is of a generally cylindrical shape.

4. The sleeve device of claim **1**, wherein a cross section of said hollow member is of a geometric shape comprising a circular shape.

5. The sleeve device of claim **1**, wherein one or more of said lower sandwich member and said upper sandwich member are ring members affixed to said hollow member, wherein said ring members are configured to transfer shear stresses through said hollow member to compensate said loss of said shear capacity of said concrete slab due to said drilled hole.

6. The sleeve device of claim **1**, wherein said hollow member is configured as an extensible hollow member to be inserted into said drilled hole of a plurality of dimensions and to enable said upper sandwich member and said lower sandwich member to adjustably sandwich said concrete slab surrounding said drilled hole of said dimensions.

7. The sleeve device of claim **1**, further comprising a plurality of gripping members positioned on and attached to an upper surface of said upper sandwich member, wherein said gripping members are configured to provide a grip for engageably connecting said upper sandwich member to said hollow member.

8. A sleeve device for compensating loss of shear capacity of a concrete slab due to a hole drilled in said concrete slab, said sleeve device comprising:

a hollow member inserted into said drilled hole, said hollow member comprising a threaded upper section extending above a top surface of said concrete slab;

a lower ring member comprising an inner edge rigidly attached to a bottom edge of said hollow member; and

an upper ring member comprising an inner threaded edge engageably connected to said threaded upper section of said hollow member, wherein said upper ring member and said lower ring member are configured to sandwich said concrete slab surrounding said drilled hole therebetween for compensating said loss of said shear capacity of said concrete slab due to said drilled hole.

9. The sleeve device of claim **8**, wherein said upper ring member and said lower ring member are configured to increase area of a shear critical section around said drilled hole in said concrete slab for compensating said loss of said shear capacity of said concrete slab due to said drilled hole.

10. The sleeve device of claim **8**, wherein said hollow member is of a generally cylindrical shape.

11. The sleeve device of claim **8**, wherein a cross section of said hollow member is of a geometric shape comprising a circular shape.

12. The sleeve device of claim **8**, wherein said hollow member is configured as an extensible hollow member to be inserted into said drilled hole of a plurality of dimensions and to enable said upper ring member and said lower ring member to adjustably sandwich said concrete slab surrounding said drilled hole of said dimensions.

13. The sleeve device of claim **8**, further comprising a plurality of gripping members positioned on and attached to an upper surface of said upper ring member, wherein said gripping members are configured to provide a grip for engageably connecting said upper ring member to said hollow member.

14. A method for compensating loss of shear capacity of a concrete slab due to a hole drilled in said concrete slab, said method comprising:

providing a sleeve device comprising:

a hollow member comprising an upper section;

a lower sandwich member comprising an inner edge rigidly attached to a bottom edge of said hollow member; and

an upper sandwich member comprising an inner edge engageably connectable to said upper section of said hollow member;

inserting said hollow member of said sleeve device into said drilled hole of said concrete slab to rigidly contact an upper surface of said lower sandwich member of said sleeve device with a lower surface of said concrete slab, wherein said upper section of said inserted hollow member extends above a top surface of said concrete slab;

engageably connecting said inner edge of said upper sandwich member of said sleeve device to said upper section of said inserted hollow member; and

sandwiching said concrete slab surrounding said drilled hole by said upper sandwich member and said lower sandwich member of said sleeve device for compensating said loss of said shear capacity of said concrete slab due to said drilled hole.

15. The method of claim **14**, wherein said sandwiching of said concrete slab surrounding said drilled hole by said upper sandwich member and said lower sandwich member of said sleeve device comprises:

transferring a first shear stress through said concrete slab, thereby producing a first compressive force on an upper surface of said lower sandwich member;

converting said first compressive force to a second shear stress from said lower sandwich member to said upper sandwich member through a wall of said hollow member;

converting said second shear stress to a second compressive force from a lower surface of said upper sandwich member, said second compressive force being transferred to said top surface of said concrete slab; and

converting said second compressive force to a third shear stress, said third shear stress being transferred to a supporting column.

16. The method of claim **14**, wherein said upper sandwich member and said lower sandwich member of said sleeve device are configured to increase area of a shear critical section around said drilled hole in said concrete slab for compensating said loss of said shear capacity of said concrete slab due to said drilled hole.

17. The method of claim **14**, wherein said hollow member of said sleeve device is of a generally cylindrical shape, and wherein a cross section of said hollow member of said sleeve device is of a geometric shape comprising a circular shape.

18. The method of claim **14**, wherein said hollow member of said sleeve device is configured as an extensible hollow member to be inserted into said drilled hole of a plurality of dimensions and to enable said lower sandwich member and said upper sandwich member to adjustably sandwich said concrete slab surrounding said drilled hole of said dimensions.

19. The method of claim **14**, wherein one or more of said lower sandwich member and said upper sandwich member of said sleeve device are configured as ring members affixed to said hollow member to transfer shear stresses through said hollow member to compensate said loss of said shear capacity of said concrete slab due to said drilled hole.

20. The method of claim **14**, further comprising providing a grip for engageably connecting said upper sandwich member of said sleeve device to said hollow member of said sleeve device by a plurality of gripping members positioned on and attached to an upper surface of said upper sandwich member.

* * * * *