

DESCRIPTION

Invention Title: BOLT-ASSEMBLED STRUT-TIE BASIC REINFORCEMENT

5 **Technical Field**

[0001] The present disclosure relates to a bolt-assembled strut-tie foundation reinforcement, in which a strut and a strut, a strut and a tie, a tie and a stud, and a tie and a stud are fitted together by fastening of
10 fastening bolts and fastening nuts.

Background Art

[0002] As buildings become taller, load applied to the ground by tall buildings increases, and the size of
15 foundation structures for safely transferring the load to the ground also increases. The thickness of the foundation corresponding to the load of the building structure is determined by the magnitude of shear force and bending moment. In the case of mat foundations which are often used
20 in high-rise buildings, the thickness of the foundation is determined by the magnitude of the shear force. In other words, as the height of the building structure increases, the thickness and scale of the mat foundation in which upper and lower reinforcement bars 10 and 20 are distributed also
25 increase to support the buildings, and the thickness of the

mat foundation gradually increases from 1.0 to 2.0 meters to 2 meters, 3 meters, and more than 5 meters. When the thickness and scale of the mat foundation increases in this manner, a punching shear phenomenon occurs due to a compressive force acting in a diagonal direction from the outer circumference of the column as shown in FIG. 1 (a) due to a load applied by a column erected on the upper surface of the foundation structure, and a tensile force that causes a crack acts on the lower surface of the foundation structure, i.e., a portion where the lower reinforcement bars are distributed. Therefore, as shown in FIG. 1 (c), reinforcement is required for the portion of the foundation structure where the compressive force is applied and the portion where the tensile force is applied.

[0003] In order to solve the above-described situations, the applicant of this application has applied for and received registered patent No. 10-0624075 "FOUNDATION REINFORCEMENT" and registered patent No. 10-2429445 "FOUNDATION REINFORCEMENT FOR CRANE CONSTRUCTION AND METHOD OF DISPOSING SAME". As shown in FIG. 2 of the previously registered patent No. 10-2429445, a shear reinforcement including a plurality of reinforcement plates with a space in the center, steel rods corresponding to ties provided along the longitudinal direction of the reinforcement plates, and settlement flanges at opposite ends is proposed.

This reinforcement may effectively transfer the compressive load from the column to the ground therethrough to improve the two-way shear resistance, and the ties, which are long steel rods distributed in the horizontal direction and
5 subjected to the tensile force, may enable the shear reinforcement to efficiently resist the tensile force received by the shear reinforcement, thereby reducing the thickness of the existing foundation.

[0004] However, in the reinforcement plate of the
10 related art, the wing-shaped steel plates are provided in the outer direction of the column and the connecting steel plates C connecting the steel plates with each other around the column are integrated by welding, and the ties, which are steel rods provided at the bottom of the reinforcement,
15 are fixed to the fixing flanges by welding. Such a structure requires one or more connecting plates C to be superimposed on each other on each side of the column according to changes in the size of the column, thereby resulting in a very inconvenient process of cutting or adding and then
20 welding the connecting plates. In addition, the foundation reinforcement of each of the previous inventions has problems, such as increases in cost due to addition of connecting steel plates C, and thus is not efficiently applied according to changes in column size.

[0005] Furthermore, in the previous inventions, the steel bars corresponding to the ties are welded to the settlement flanges which are coupled to the ends of the shear stiffener corresponding to the struts. This results in stress losses in the members and even causes the steel bars to disengage from the shear reinforcement. Stud bolts are welded to the surface of the reinforcement, which is a compression plate, to prevent slipping, but this also causes the strut, which are compression plates, to distort due to the imbalance of the welding heat during welding.

[0006] Therefore, a simplified prefabricated strut tie foundation reinforcement was required, which may economically speed up construction by responding to changes in the size of the columns disposed on the strut tie foundation reinforcement while maintaining the reinforcement principle of the strut tie foundation reinforcement of the related art, and minimize the deformation or distortion of the structural members and simplify the fabrication method while increasing economic efficiency by reducing members and enabling unit modularization.

Disclosure

Technical Problem

[0007] Accordingly, the disclosure has been made keeping in mind the above problems occurring in the prior art, and

an objective of the present disclosure is to remove the connecting steel plates connecting the struts which are unit modular steel plates and separately disposed in the outer direction of the foundation of the column surface and
5 integrate the struts by connecting the struts with angles, angled connectors each implemented as a band-shaped steel plate, or band-shaped steel plate connectors, and then fastening the resultant structure with fastening bolts and fasteners. The disclosure may allow for easy and simple
10 fitting together of struts, which are compression members, by adjusting the struts in accordance with changes in the size of the column in the field, thereby reducing members, simplifying construction without a separate fabrication process or welding process, and increasing economic
15 efficiency in mass production.

[0008] Another objective of the disclosure is to enable anchors which are coupled to the struts and the ties fixed to the opposite ends of the lower portions of the struts to be coupled to the struts with fastening bolts and nuts
20 without welding, thereby speeding up coupling of the ties and the struts.

[0009] Another objective of the disclosure is to enable opposite ends of a pair of ties to be fastened to struts with bolts and nuts using prefabricated anchors, thereby
25 providing structural performance without welding loss and

preventing stress interference between the struts and the ties.

[0010] Another objective of the disclosure is to eliminate residual stress or residual deformation of studs, which are compression plates, caused by welding the studs to the struts as in the related art, because the studs fixed on opposite sides of the struts are implemented as double-headed bolts that do not require welding.

10 **Technical Solution**

[0011] In order to accomplish the above objective, the present disclosure provides a bolt-assembled strut-tie foundation reinforcement for a foundation which transfers load from a column to the ground, the bolt-assembled strut-tie foundation reinforcement including: unit struts each including a hexagonal steel plate configured such that upper outer two corner surfaces are horizontal and vertical and lower outer two corner surfaces symmetrical and opposite to the upper outer two corner surfaces are horizontal and vertical, the hexagonal steel plate having an inclined upper sloping surface provided between ends of the upper outer horizontal corner surfaces and ends of the lower outer vertical corner surfaces and an inclined lower sloping surface provided between the ends of the upper outer vertical corner surface and the lower outer horizontal corner surface,

and inclined stiffener plates fixed to the upper and lower slopes at right angles; ties each including a pair of steel bars symmetrically spaced apart from each other such that the struts are opposite to each other, the steel bars being
5 tightly fixed to opposite side surfaces of the lower portions of the pair of struts; and a connector configured to connect the struts which are spaced apart from each other, the connector connecting the struts with angled connecting bars or band-shaped steel plate connectors and
10 being assembled with fastening bolts and fastening nuts.

[0012] The struts may include struts may be located to be symmetrically spaced apart from each other at a distance and other struts symmetrically spaced apart from each other at a distance to be perpendicular to the struts, and the struts
15 and the other struts are connected and fitted together by the connector to form an overall appearance having a shape of a cross symbol "+".

[0013] The struts may include two struts spaced apart at a distance from and arranged parallel to each other, two
20 other struts located symmetrically to the two struts, two further struts located perpendicularly to the struts and spaced apart at a distance from and arranged parallel to each other, and two further other struts located symmetrically to the two further struts, and the struts are fitted and

connected to each other by the connector to form an overall appearance having a shape of a sharp symbol “#”.

[0014] The struts may include three struts spaced apart at distances from and arranged parallel to each other, three
5 other struts located symmetrically to the three struts, three further struts located perpendicularly to the three struts and spaced apart at distances from and parallel to each other, and three further other struts located symmetrically to the three further struts, and the struts are fitted and
10 connected to each other by a connector to form a shape of Chinese letter “田” in overall appearance.

[0015] The ties may be hooked ties each having a straight central portion and hook-shaped hook portions provided at opposite ends, wherein the hook portions anchored to form
15 hooked tie anchors, and ends of the hook portions of the hooked ties may be fixed to the inclined stiffener plates by welding (W).

[0016] At least one stud having a bolt-head shaped end may be provided on opposite surfaces of the strut. The stud
20 may include a double-headed bolt placed on one surface of the strut, the double-headed bolt including a bolt head at one end, a bolt head located on a surface of the steel plate, and a male thread extending from the bolt head and configured to extend through a hole in the strut, a double-
25 headed bolt placed on the opposite surface, the double-

headed bolt including a bolt head at one end, a bolt head located in the surface of the steel plate, a male thread provided inside the bolt head, and a female thread engaging with the male thread, wherein the double-headed bolts are
5 closely fitted to the opposite surfaces of the strut to be fastened and fixed thereto.

[0017] The stud may include a full threaded bolt fitted into a hole in the strut to have equal protrusion lengths on opposite surfaces of the strut, two nuts closely fitted and
10 fixed to the opposite surfaces of the strut, and two other nuts fixed on ends of the full threaded bolt at distances from the strut.

[0018] The stud may include a double-headed bolt placed on one surface of the strut, the double-headed bolt
15 including a bolt head at one end, a bolt head located on the surface of the steel plate, and a bolt portion extending from the bolt head and configured to extend through a hole in the strut, and nuts placed such that one of the nuts is fastened to the bolt portion and closely fitted to the strut and the
20 other one of the nuts is fastened and fixed to one end of the bolt. The stud may include stud bolts each having a bolt head and welded to opposite surfaces of the stud which face each other.

[0019] Opposite ends of the straight portion connected to
25 the hook portion of the hooked tie may be welded (W) to

close-fitting pieces having two or more holes, and the close-fitting pieces coupled to the hooked tie may be closely fitted to opposite ends of the steel plate and fixed with the fastening bolts and the fastening nuts.

5 **[0020]** The hooked tie closely fitted to opposite side surfaces of the lower portion of the steel plate may be fitted between U-shaped bolts penetrating the steel plate and fastening plates, and may be tightly fixed to the steel plate by fastening the bolt portions of the U-shaped bolts and the
10 fastening nuts

[0021] The straight portion of the hooked tie may be slid into openings of one or more retaining clips having a shape of an omega symbol "Ω" for mounting, the retaining clips being fixed to opposite side surfaces of the lower portion of
15 the steel plate by welding. The hooked tie may be closely fitted to opposite side surfaces of the lower portion of the steel plate (110) and fixed by welding (W).

[0022] Each of the ties may include linear ties each of which is straight and has bolt portions at opposite ends,
20 wherein the bolt portions of the linear ties extend through holes in end portions of anchoring members having a shape of Korean Letter "ㄷ" of a linear tie anchor, are fastened with fastening nuts, and are anchored to the steel plates by fastening of fastening bolts and fastening nuts, the

fastening bolts extending through holes in close-fitting portions of the anchoring members

[0023] Each of the ties may include linear ties each of which is straight and has bolt portions at opposite ends, wherein the bolt portions of the linear ties extend through holes in end portions of L-shaped anchoring members of a straight tie anchor, which face each other, are fastened with fastening nuts, and are anchored by fastening of fastening bolts extending through holes in close-fitting pieces of the anchoring members and fastening nuts. A tie fastener may be configured to bind intersecting portions of the ties. The tie fastener may include an upper cap and a lower cap located above and below the intersecting ties, tie receiving recess configured to receive the ties, and fastening bolts and fastening nuts configured to fasten the upper and lower caps. The tie fastener may include a pair of U-clips placed in parallel to the intersecting ties to wrap around lower steel bars of the steel bars of the ties, with cover pieces of the U-clips wrapping around the upper steel bars and fastened and fixed to bolt portions provided at ends of the U-clips with fastening nuts

Advantageous Effects

[0024] The disclosure may allow easy and simple fitting together of struts, which are unit modular steel plates,

together by adjusting the struts in accordance with changes in the size of the column in the field, thereby reducing members, simplifying construction without a separate fabrication process or welding process, and increasing
5 economic efficiency in mass production.

[0025] The disclosure may also remove the connecting steel plates connecting the struts separately disposed in the outer direction of the foundation of the column surface and integrate the struts by connecting the struts with angles,
10 angled connectors each implemented as a band-shaped steel plate, or band-shaped steel plate connectors, and then fastening the resultant structure with fastening bolts and fasteners, thereby reducing members, simplifying construction without a separate fabrication process or welding process,
15 and increasing economic efficiency in mass production.

[0026] The disclosure may also enable opposite ends of a pair of ties to be fastened to struts with bolts and nuts using prefabricated anchors, thereby providing high structural performance and preventing stress interference
20 between the struts and the ties due to bolt-nut fastening without welding loss.

[0027] The disclosure may also eliminate residual stress or residual deformation of studs, which are compression plates, caused by welding the studs to the struts as in the
25 related art, since the studs fixed on opposite sides of the

struts are implemented as double-headed bolts that do not require welding.

Description of Drawings

5 [0028] FIG. 1 is a cross-sectional view illustrating the state of a typical mat foundation caused by the action of compressive and tensile forces.

[0029] FIG. 2 is a perspective view of a related-art foundation reinforcement.

10 [0030] FIG. 3 is a perspective view of a first embodiment of the disclosure.

[0031] FIG. 4 is a partially exploded perspective view of the first embodiment of the disclosure.

15 [0032] FIG. 5 is a cross-sectional view of a foundation on which the first embodiment of the disclosure is disposed.

[0033] FIG. 6 is a perspective view of the first embodiment of the disclosure in which the band-shaped steel plate connectors are provided in place of the angled connecting bars.

20 [0034] FIG. 7 is a partially enlarged view of FIG. 3, FIG. 8 is a partially enlarged view of FIG. 6, and FIG. 9 is a partial perspective view of another example tie fastener of the first embodiment.

[0035] FIG. 10 is a partial view of the hooked tie
25 anchor according to the first embodiment of FIG. 3, FIG. 11

is a view of another implementation of the hooked tie anchor according to the first embodiment of FIG. 3, FIG. 12 is a view of another implementation of the hooked tie anchor according to the first embodiment of FIG. 3, and FIG. 13 is
5 a view of another implementation of the hooked tie anchor according to the first embodiment of FIG. 3.

[0036] FIG. 14 is a partially exploded perspective view linear tie anchors coupled to linear ties in place of the hooked tie anchors of the first embodiment of FIG. 3.

10 **[0037]** FIG. 15 is a coupled front view of FIG. 14.

[0038] FIG. 16 is an exploded perspective view of other linear tie anchors coupled to linear ties in place of the hooked tie anchors of the first embodiment of FIG. 3.

[0039] FIG. 17 (a) to (d) show implementations of studs
15 disposed on the steel plates of each strut.

[0040] FIG. 18 shows a second embodiment of the disclosure, the overall appearance of which has a # shape.

[0041] FIG. 19 shows a third embodiment of the disclosure, the overall appearance of which has a # shape.

20 **[0042]** FIG. 20 shows a fourth embodiment of the disclosure, the overall appearance of which has the shape of the Chinese letter “田”.

[0043] FIG. 21 shows a fifth embodiment of the disclosure, the overall appearance of which has the shape of
25 the Chinese letter “田”.

[0044] FIG. 22 is an image for comparing foundation reinforcements of the related art and bolt-assembled strut-tie foundation reinforcements of the disclosure, FIGS. 23 and 24 show the results of performance evaluation tests of FIG. 22.

[0045]

Best Mode

[0046] Hereinafter, the disclosure will be described in detail with reference to the accompanying drawings.

10 **[0047]** FIG. 3 is a perspective view of a first embodiment of the disclosure, FIG. 4 is a partially exploded perspective view of the first embodiment of the disclosure, and FIG. 5 is a cross-sectional view of a foundation on which the first embodiment of the disclosure is disposed.

15 Compared to the related-art foundation reinforcement, the disclosure simplifies the assembly regardless of the change in the size of columns by connecting entire respective members with bolts and nuts, thereby speeding up construction. The economy may be increased and the efficiency

20 of stress may be improved by reducing members due to the removal of the connecting steel plates C. In addition, the structures of struts 100 are standardized as unit modules to increase the economy in mass production, the members are coupled by simple bolt-nut fastening instead of welding in a

25 fixing method of ties 200, and a fixing method of studs 500

also includes a bolt fastening method using bolts having a double-headed bolt structure instead of welding.

[0048] In the disclosure, each of unit struts 100 of a strut-tie reinforcement of a foundation structure that
5 transfers load from a column 10 to the ground, as shown in FIG. 5, is implemented as a unit module configured to be coupled with bolts, and includes a hexagonal steel plate 110 and inclined stiffener plates 120 having a width. The hexagonal steel plate 110 is configured such that upper outer
10 two corner surfaces are horizontal and vertical and lower outer two corner surfaces symmetrical and opposite to the upper outer two corner surfaces are also horizontal and vertical. The hexagonal steel plate 110 has an inclined upper sloping surface 110a provided between the ends of the upper
15 outer horizontal corner surfaces and the ends of the lower outer vertical corner surfaces and an inclined lower sloping surface 110b provided between the ends of the upper outer vertical corner surface and the ends of the lower outer horizontal corner surface. The inclined stiffener plates 120
20 are fixed to the upper and lower slopes 110a and 110b at right angles.

[0049] In the disclosure, each of the ties 200 is a pair of steel bars symmetrically spaced apart from each other such that the struts 100 are opposite to each other, and are
25 tightly fixed to opposite side surfaces of the lower

portions of the pair of struts 100. A connector 300 connects the struts 100 which are spaced apart from each other. As shown in FIGS. 7 and 8, the connector 300 includes angled connecting bars 310 or band-shaped steel plate connectors 320. The struts 100 are connected by fastening fastener bolts 100a and fastening nuts 100b, and the connector 300 is assembled with a fastening bolt 310a or 320a and a fastening nut 310b or 320b. That is, intersecting portions of the angled connecting bars 310 are fastened with the fastening bolt 310a and the fastening nut 310b, or intersecting portions of the band-shaped steel plate connectors 320 are fastened with the fastening bolts 320a, the fastening nuts 320b, an L-shaped fixing bar 321. Because the struts 100 are connected using the angled connecting bars 310 or the band-shaped steel plate connectors 320 and are fitted together by bolt-nut fastening, the struts 100 may be easily and simply adjusted for assembly in the field to match changes in the size of a pole 40, thereby simplifying construction without a separate fabrication or welding process and increasing economic efficiency in mass production.

[0050] Referring to FIGS. 3 to 5, struts 100 are symmetrically spaced apart from each other at a distance, and other struts 100 are symmetrically spaced apart from each other at a distance to be perpendicular to the struts 100. As described above, the struts 100 and the other struts 100 are

connected and fitted together by the connector 300 to form an overall appearance having the shape of the cross symbol "+". The ties 200 are hooked ties 210 each having a straight central portion 211 and hook portions 212 provided at opposite ends and having the shape of a hook J. The hook portions 212 anchored to form hooked tie anchors 600. The hook portions 212 having have the shape of a hook J formed at the ends of the hooked tie 210 has the effect of improving the anchoring ability by bonding with concrete poured, thereby increasing the stress. The hook portions 212 may have a hook shape (J) that is formed as a standard hook bent 180°, as shown in the disclosure, in accordance with building structure standards that prescribe the setting length and shape of steel bars subjected to tensile force. The hook portions 212 may also have a hook shape (J) that is formed as a standard hook bent 90°, which is not shown in the disclosure, in accordance with building structure standards. The hook portions are determined by the field conditions of the application of the hooked tie 210.

20 **[0051]** FIG. 6 is a perspective view of the first embodiment of the disclosure in which the band-shaped steel plate connectors are provided in place of the angled connecting bars. The L-shaped fixing bar 321 is placed on the intersecting portions of the band-shaped steel plate connectors 320 and is fastened and fixed with the fastening

bolts 320a and the fastening nuts 320b to further enhance the connection of the struts 100.

[0052] FIG. 7 is a partially enlarged view of FIG. 3, FIG. 8 is a partially enlarged view of FIG. 6, and FIG. 9 is a partial perspective view of another example tie fastener of the first embodiment. Referring to FIG. 7, the angled connecting bars 310 of the connector 300 connect the struts 100. The struts 100 and the angled connecting bars 310 are connected by fastening of the fastener bolts 100a and the fastening nuts 100b. The angled connecting bars 310 and the angled connecting bars 310 are fixed by fastening of the fastener bolt 310a and the fastening nut 310b. A tie fastener 400 for binding intersecting portions of the ties 200 includes an upper cap 410 and a lower cap 420 located above and below the intersecting ties 200, tie receiving recess 430 configured to receive the ties 200, and fastening bolts 440a and fastening nuts 440b for fastening the upper and lower caps 410 and 420. Referring to FIG. 8, the band-shaped steel plate connectors 320 and the L-shaped fixing bar 321 are fastened and fixed with the fastening bolts 320a and the fastening nuts 320b, as shown in FIG. 6. The tie receiving recesses 430 are provided in the upper cap 410 and the lower cap 420 located above and below the ties 200 intersecting at the tie fastener 400 to receive the ties 200, thereby more firmly fixing the ties 200 when fastening the upper and lower

caps 410 and 420 with the fastening bolts 440a and the fastening nuts 440b.

[0053] FIG. 9 shows the tie fastener 400 in which a pair of U-clips 450 are in parallel to the intersecting ties 200 to wrap around the lower tie steel bars, and cover pieces 460 of the U-clips 450 wrapping around the upper tie steel bars are fastened and fixed to bolt portions 450a provided at the ends of the U-clips 450 with fastening nuts 450b. A pair of U-clips 450 are placed in parallel and slid up around the lower ties 200. The cover pieces 460 are placed on the upper ties 200 in a direction perpendicular to the parallel U-clips 450, and then are fastened and fixed by engaging the fastening nuts 450b with the bolt portions 450a provided on the ends of the U-clips 450. In this manner, the intersecting portions of the ties 200 are more firmly fixed.

[0054] FIG. 10 is a partial view of the hooked tie anchor according to the first embodiment of FIG. 3, FIG. 11 is a view of another implementation of the hooked tie anchor according to the first embodiment of FIG. 3, FIG. 12 is a view of another implementation of the hooked tie anchor according to the first embodiment of FIG. 3, and FIG. 13 is a view of another implementation of the hooked tie anchor according to the first embodiment of FIG. 3.

[0055] The disclosure shows that ends 212a of the hook portion 212 of the hooked tie 210 are fixed to the inclined

stiffener plates 120 by welding W, so that the integration of the hooked tie 210 and the struts 100 prevents the hooked tie 210 and the struts 100 from moving even when concrete is poured, thereby having the effect of increasing the stability of construction. Referring to FIG. 10, the opposite ends of the straight portion 211 connected to the hook portion 21 of the hooked tie 210 are welded W to close-fitting pieces 610 having two or more holes. The close-fitting pieces 610 coupled to the hooked tie 210 are closely fitted to the opposite ends of the steel plate 110 and then fixed with the fastening bolts 611a and the fastening nuts 611b. Because the close-fitting pieces 610 are welded W to the opposite ends of the straight portion 211 of the hooked tie 210, the effect of speeding up construction in assembling and completing the disclosure may be achieved. Referring to FIG. 11, the construction may also be sped up. The hooked tie 210 closely fitted to the opposite side surfaces of the lower portion of the steel plate 110 is fitted between U-shaped bolts 620 penetrating the steel plate 110 and fastening plates 621, and is then tightly fixed to the steel plate 110 by fastening the bolt portions 620a of the U-shaped bolts 620 and the fastening nuts 620b. Referring to FIG. 12, the straight portion 211 of the hooked tie 210 is easily mounted by being slid into openings 631 of one or more retaining clips 630 having the shape of the omega symbol "Ω" welded to the

opposite side surfaces of the lower portion of the steel plate 110, thereby improving the speed of construction at the assembly site. Referring to FIG. 13, the hooked tie 210 is closely fitted to the opposite side surfaces of the lower
5 portion of the steel plate 110 and fixed by welding W. This has the effect of reducing the number of members used for anchoring, thereby reducing costs.

[0056] FIG. 14 is a partially exploded perspective view linear tie anchors coupled to linear ties in place of the
10 hooked tie anchors of the first embodiment of FIG. 3, FIG. 15 is a coupled front view of FIG. 14, and FIG. 16 is an exploded perspective view of other linear tie anchors coupled to linear ties in place of the hooked tie anchors of the first embodiment of FIG. 3.

[0057] Referring to FIGS. 14 and 15, the tie 200 includes linear ties 220 each of which is straight and has bolt portions 220a at opposite ends. The bolt portions 220a of the linear ties 220 extend through holes 714 in end portions 711 of anchoring members 710 having the shape of
20 Korean Letter “ㅊ” of the linear tie anchor 700, are fastened with fastening nuts 220b, and are anchored to the steel plates 110 by fastening of fastening bolts 715a and fastening nuts 715b, the fastening bolts 715a extending through holes 713 in close-fitting portions 712 of the anchoring members
25 710. Referring to FIG. 16, the tie 200 includes linear ties

220 each of which is straight and has bolt portions 220a at opposite ends. The bolt portions 220a of the linear ties 220 extend through holes 724 in end portions 721 of L-shaped anchoring members 720 of the straight tie anchor 700, which face each other, are fastened with fastening nuts 220b. The bolt portions 220a are then anchored by fastening of fastening bolts 725a extending through holes 723 in close-fitting pieces 722 of the anchoring members 720 and fastening nuts 725b. All of the above components are fitted with bolts and nuts, which not only may speed up construction, but also may reduce stress losses due to welding by removing welding in the coupling between members. The coupling structure between the tie 200 and the tie anchors 700 may be modified to various structures in addition to the above-described embodiments without loss of stress.

[0058] (a) to (d) parts of FIG. 17 are implementations of studs disposed on the steel plates of each strut, characterized in that at least one stud 500 having a bolt-head shaped end is provided on opposite surfaces of the strut 100.

[0059] According to the first implementation in FIG. 17 (a), the stud 500 is formed by forming a hole in the strut 100, placing a double-headed bolt 510 on one surface of the strut 100 and a double-headed bolt 511 on the opposite surface and closely fitting the double-headed bolts 510 and

511 to the opposite surfaces of the strut 100 to be fastened and fixed thereto. Here, the double-headed bolt 510 has a bolt head 510a at one end, a bolt head 510b located on the surface of the steel plate 110, and a male thread 510C
5 extending from the bolt head 510b and configured to extend through the hole. The double-headed bolt 511 has a bolt head 511a at one end, a bolt head 511b located in the surface of the steel plate 110, a male thread 510c provided inside the bolt head 511b, and a female thread 511c engaging with the
10 male thread 510c.

[0060] According to the second implementation in FIG. 17 (b), the stud 500 is formed by forming a hole in the strut 100, fitting a full threaded bolt 520 into the hole to have equal protrusion lengths on opposite surfaces of the strut
15 100, closely fitting and fixing two nuts 521 to the opposite surfaces of the strut 100, and fixing two other nuts 521 on ends of the full threaded bolt 520 at distances from the strut 100.

[0061] According to the third implementation in FIG. 17 (c), the stud 500 is formed by forming a hole in the strut 100, placing a double-headed bolt 530 on one surface of the strut 100, wherein the double-headed bolt 530 has a bolt head 530a at one end, a bolt head 530b located on the surface of the steel plate 110, and a bolt portion 530c extending
25 from the bolt head 530b and configured to extend through the

hole, placing nuts 531 such that one nut 531 is fastened to the bolt portion 530c and closely fitted to the strut 100 and the other nut 531 is fastened and fixed to one end of the bolt 530c. In FIG. 17 (a) to (c), after the double headed
5 bolt 510 or 53 or the full threaded bolt 520 is extended through the hole formed in the strut 100, fastening is performed quickly and easily using the double-headed bolt 511 having the female thread 511c or the nut 521 or 531 to form the stud 500. According to the fourth implementation in FIG.
10 17 (d), the stud 500 is formed by welding stud bolts 540 each having a bolt head 540a to the opposite surfaces of the stud 500 which face each other, in place of forming a hole in the strut 100.

[0062] FIG. 18 shows a second embodiment of the
15 disclosure, the overall appearance of which has the shape of the sharp symbol "#", and FIG. 19 shows a third embodiment of the disclosure, the overall appearance of which has a # shape.

[0063] Referring to FIGS. 18 and 19, in the same manner,
20 two struts 100 are located to be spaced apart at a distance from and arranged parallel to each other, and two other struts 100 are located symmetrically to the two struts 100. Two further struts 100 are located perpendicularly to the struts 100 and spaced apart at a distance from and arranged
25 parallel to each other, and two further other struts 100 are

located symmetrically to the two further struts 100. The struts 100 are fitted and connected to each other by the connector 200 to form a # shape in overall appearance. In the second embodiment of FIG. 18, for connecting the struts 100 spaced apart, band-shaped steel plate connectors 320 connect the struts 100. In the third embodiment of FIG. 19, the band-shaped steel plate connectors 320 of the connector 300 are connected with a steel plate having a width to form an overall shape of Korean letter "ㅁ" (or an overall square shape), and are fastened and fixed with fastening bolts and fastening nuts to angle-shaped connecting holders 340 closely fitted to corner portions of the overall shape where the steel plates 110 and the band-shaped steel plate connectors 320 meet. The steel plates 110 and the band-shaped steel plate connectors 320 are fixed as a unit. Band-shaped steel plate supports 330 are disposed at the corner portions where the band-shaped steel plate connectors 320 meet.

[0064] The second and third embodiments of the disclosure, as well as fourth and fifth embodiments to be described below, differ in the number of struts 100. Because the magnitude of the load transferred by the foundation varies with the number of the struts 100 used, the structural performance of the struts 100 may be qualitatively evaluated to determine the optimal number and shape of the struts 100, which varies with the magnitude of the top load.

[0065] FIGS. 20 and 21 show fourth and fifth embodiments of the disclosure, the overall appearance of which has the shape of Chinese letter “田”. Referring to FIGS. 20 and 21, in the same manner, three struts 100 are located to be spaced
5 apart at distances from and parallel to each other, and three other struts 100 are located symmetrically to the three struts 100. Three further struts 100 are located perpendicularly to the three struts 100 and spaced apart at distances from and parallel to each other, and three struts
10 further other 100 are located symmetrically to the three further struts 100. The struts 100 are fitted and connected to each other by the connector 200 to form the shape of Chinese letter “田” in overall appearance.

[0066] In the fourth embodiment of FIG. 20, as in the
15 third embodiment, the band-shaped steel plate connectors 320 of the connector 300 are connected by steel plates having widths to form an overall shape of Korean letter “ㅁ”. The steel plates 110 and the band-shaped steel plate connectors 320 are fastened and fixed with fastening bolts and fastening
20 nuts to the angle-shaped connecting holders 340 closely fitted to the corner portions of the overall shape where the steel plate 110 and the band-shaped steel plate connectors 320 meet. In this manner, the steel plates 110 and the band-shaped steel plate connectors 320 are fixed together. The
25 band-shaped steel plate supports 330 are disposed at the

corner portions where the band-shaped steel plate connectors 320 meet. In the fifth embodiment of FIG. 21, the struts 100 and the band-shaped steel plate connectors 320 are connected and fixed with the connecting holders 340.

5 **[0067]** The first to fifth embodiments of the bolt-assembled strut-tie foundation reinforcement according to the disclosure have been described, the bolt-assembled strut-tie foundation reinforcement may be implemented in various forms by changing the arrangement and coupling of the struts 100 in
10 addition to those embodiments.

[0068] FIG. 22 is an image for comparing foundation reinforcements of the related art and bolt-assembled strut-tie foundation reinforcements of the disclosure fabricated as test subjects for load tests, and FIGS. 23 and 24 show the
15 results of performance evaluation tests on the foundations using the bolt-assembled strut-tie foundation reinforcement by SungKyunKwan University-Industry Cooperation Foundation to demonstrate the field applicability and safety of the disclosure. The upper and lower left images of FIG. 22 relate
20 to strut-tie foundation reinforcements of the related art having + and # shapes, in each of which wing-shaped strut-type steel plates formed in the outer direction of a column to be disposed and connecting steel plates C connecting steel plates to each other around the column to be disposed are
25 integrated by welding, and ties implemented as steel bars are

fixed to fixing flanges by welding. Such a structure, as described above, not only requires one or two or more connecting steel plates C to be superimposed on each other on each side of the column due to changes in the size of the column, but also requires a complicated process of cutting, adding, and welding to be performed to the connecting steel plates C.

[0069] The upper and lower right images of FIG. 22 show the first and second embodiments of the disclosure, in each of which the angled connecting bars 310 and the struts 100 are connected with the fastening bolts 100a and the fastening nuts 110b, and then the connector 300 assembled with the fastening bolt 310a or 320a and the fastening nut 310b or 320b is formed. The ties 200 include the hooked ties 210, each of which has the central straight portion 211 and the hook-shaped hook portions 212 at opposite ends. The hooked tie anchors 600 are provided by means of the anchored hook portions 212. Construction may be sped up by responding to changes in the size of the columns disposed on the strut tie foundation reinforcement while maintaining the reinforcement principle of the strut tie foundation reinforcement of the related art, and the deformation or distortion of the structural members may be minimized and the fabrication method may be simplified while increasing economic efficiency by reducing members and enabling unit modularization, thereby

speeding up and simplifying construction and improving the efficiency of member stress.

[0070] FIG. 23 shows results of load tests performed on the unreinforced foundation reinforcement of the related art, the strut-tie foundation reinforcements of the related art having + and # shapes, and the first and second embodiments of the disclosure, wherein the maximum strength of the unreinforced foundation reinforcement of the related art, 2330 KN, was set as a reference value of 100%, and the maximum strength of the other test subjects was set as a relative percentage (%) of the reference value. Accordingly, the maximum strength of the strut-tie foundation reinforcement of the related art having a + shape was 3225 KN, which is 138%, and the maximum strength of the first embodiment of the disclosure was 3466 KN, which is 149%. In addition, the maximum strength of the strut-tie foundation reinforcement of the related art having a # shape was 4029 KN, which is 173%, and the maximum strength of the second embodiment of the disclosure was 4124 KN, which is 177%. As can be seen, the first and second embodiments of the disclosure have improved manufacturing, constructing, and economical performance than the strut-tie foundation reinforcements of the related art having + and # shapes, while providing greater stress efficiency. This may also be seen in a foundation reinforcement load-displacement test

result table in FIG. 24.

[0071] As set forth above, the disclosure easily and simply fit the struts 100, which are unit modular steel plates, together by adjusting the struts in accordance with changes in the size of the column in the field, thereby reducing members, simplifying construction without a separate fabrication process or welding process, and increasing economic efficiency in mass production. The connecting steel plates C connecting the struts 100 separately disposed in the outer direction of the foundation of the column surface are removed and the struts 100 may be integrated by connecting the struts with angles, angled connectors 310 each implemented as a band-shaped steel plate, or the band-shaped steel plate connectors, and then fastening the resultant structure with the fastening bolts 100a and the fastening nuts 100b, thereby reducing members and increasing economic efficiency. Construction may be sped up by fastening of the fastening bolts and the fastening nuts without welding. The opposite ends of a pair of ties 200 may be fastened to the struts 100 using the prefabricated anchors, thereby providing high structural performance and preventing stress interference between the struts 100 and the ties 200 due to bolt-nut fastening without welding loss. Because the studs 500 fixed on the opposite sides of the struts 100 are implemented as double-headed bolts that do not require

welding, residual stress or residual deformation of the studs 500, which are compression plates, caused by welding the studs 500 to the struts 100 as in the related art may be eliminated.

5 **[0072]** Although the disclosure has been illustrated by the particular embodiments and the drawings as above, the terms and the words used in this specification and the claims are not to be construed in their ordinary or dictionary sense, but rather in a sense and concept consistent with the
10 technical ideas of the disclosure. Accordingly, it is to be understood that the embodiments described herein and the configurations illustrated in the drawings are merely examples of the disclosure and are not exhaustive of the technical ideas of the disclosure, and that there may be a
15 number of variations and modifications without departing from the claims of the disclosure.

CLAIMS

[Claim 1] A bolt-assembled strut-tie foundation reinforcement for a foundation which transfers load from a column to the ground, the bolt-assembled strut-tie foundation reinforcement comprising:

unit struts (100) each comprising a hexagonal steel plate (110) configured such that upper outer two corner surfaces are horizontal and vertical and lower outer two corner surfaces symmetrical and opposite to the upper outer two corner surfaces are horizontal and vertical, the hexagonal steel plate (110) having an inclined upper sloping surface (110a) provided between ends of the upper outer horizontal corner surfaces and ends of the lower outer vertical corner surfaces and an inclined lower sloping surface (110b) provided between the ends of the upper outer vertical corner surface and the lower outer horizontal corner surface, and inclined stiffener plates (120) fixed to the upper and lower slopes (110a, 110b) at right angles;

ties (200) each comprising a pair of steel bars symmetrically spaced apart from each other such that the struts (100) are opposite to each other, the steel bars being tightly fixed to opposite side surfaces of the lower portions of the pair of struts (100); and

a connector (300) configured to connect the struts (100) which are spaced apart from each other, the connector (300) connecting the struts (100) with angled connecting bars (310) or band-shaped steel plate connectors (320) and
5 being assembled with fastening bolts (310a, 320a) and fastening nuts (310b, 320b).

[Claim 2] The bolt-assembled strut-tie foundation reinforcement of claim 1, wherein the struts comprise struts
10 (100) are located to be symmetrically spaced apart from each other at a distance and other struts (100) symmetrically spaced apart from each other at a distance to be perpendicular to the struts (100), and the struts (100) and the other struts (100) are connected and fitted together by
15 the connector (300) to form an overall appearance having a shape of a cross symbol (+).

[Claim 3] The bolt-assembled strut-tie foundation reinforcement of claim 1, wherein the struts comprise two
20 struts (100) spaced apart at a distance from and arranged parallel to each other, two other struts (100) located symmetrically to the two struts (100), two further struts (100) located perpendicularly to the struts (100) and spaced apart at a distance from and arranged parallel to each other,
25 and two further other struts (100) located symmetrically to

the two further struts (100), and the struts are fitted and connected to each other by the connector (200) to form an overall appearance having a shape of a sharp symbol (#).

5 [Claim 4] The bolt-assembled strut-tie foundation reinforcement of claim 1, wherein the struts comprise three struts (100) spaced apart at distances from and arranged parallel to each other, three other struts (100) located symmetrically to the three struts, three further struts (100)
10 located perpendicularly to the three struts (100) and spaced apart at distances from and parallel to each other, and three further other struts (100) located symmetrically to the three further struts (100), and the struts are fitted and connected to each other by a connector (200) to form a shape of Chinese
15 letter “田” in overall appearance.

 [Claim 5] The bolt-assembled strut-tie foundation reinforcement of any one of claims 1 to 4, wherein the ties (200) are hooked ties (210) each having a straight central
20 portion (211) and hook-shaped hook portions (212) provided at opposite ends, wherein the hook portions (212) anchored to form hooked tie anchors (600).

 [Claim 6] The bolt-assembled strut-tie foundation
25 reinforcement of claim 5, wherein ends (212a) of the hook

portions (212) of the hooked ties (210) are fixed to the inclined stiffener plates (120) by welding (W).

[Claim 7] The bolt-assembled strut-tie foundation
5 reinforcement of any one of claims 1 to 4, wherein at least one stud (500) having a bolt-head shaped end is provided on opposite surfaces of the strut (100).

[Claim 8] The bolt-assembled strut-tie foundation
10 reinforcement of claim 7, wherein the stud (500) comprises a double-headed bolt (510) placed on one surface of the strut (100), the double-headed bolt (510) including a bolt head (510a) at one end, a bolt head (510b) located on a surface of the steel plate (110), and a male thread (510c) extending
15 from the bolt head (510b) and configured to extend through a hole in the strut (100), a double-headed bolt (511) placed on the opposite surface, the double-headed bolt (511) including a bolt head (511a) at one end, a bolt head (511b) located in the surface of the steel plate (110), a male
20 thread (510c) provided inside the bolt head (511b), and a female thread (511c) engaging with the male thread (510c), wherein the double-headed bolts (510, 511) are closely fitted to the opposite surfaces of the strut (100) to be fastened and fixed thereto.

[Claim 9] The bolt-assembled strut-tie foundation reinforcement of claim 7, wherein the stud (500) comprises a full threaded bolt (520) fitted into a hole in the strut (100) to have equal protrusion lengths on opposite surfaces of the strut (100), two nuts (521) closely fitted and fixed to the opposite surfaces of the strut (100), and two other nuts (521) fixed on ends of the full threaded bolt (520) at distances from the strut (100).

10 [Claim 10] The bolt-assembled strut-tie foundation reinforcement of claim 7, wherein the stud (500) comprises a double-headed bolt (530) placed on one surface of the strut (100), the double-headed bolt (530) including a bolt head (530a) at one end, a bolt head (530b) located on the surface of the steel plate (110), and a bolt portion (530c) extending from the bolt head (530b) and configured to extend through a hole in the strut (100), and nuts (531) placed such that one of the nuts (531) is fastened to the bolt portion (530c) and closely fitted to the strut (100) and the other one of the nuts (531) is fastened and fixed to one end of the bolt (530c).

[Claim 11] The bolt-assembled strut-tie foundation reinforcement of claim 7, wherein the stud (500) comprises

stud bolts (540) each having a bolt head (540a) and welded to opposite surfaces of the stud (500) which face each other.

[Claim 12] The bolt-assembled strut-tie foundation
5 reinforcement of claim 5, wherein opposite ends of the
straight portion (211) connected to the hook portion (21) of
the hooked tie (210) are welded (W) to close-fitting pieces
(610) having two or more holes, and the close-fitting pieces
(610) coupled to the hooked tie (210) are closely fitted to
10 opposite ends of the steel plate (110) and fixed with the
fastening bolts (611a) and the fastening nuts (611b).

[Claim 13] The bolt-assembled strut-tie foundation
reinforcement of claim 5, wherein the hooked tie (210)
15 closely fitted to opposite side surfaces of the lower portion
of the steel plate (110) is fitted between U-shaped bolts
(620) penetrating the steel plate (110) and fastening plates
(621), and is tightly fixed to the steel plate (110) by
fastening the bolt portions (620a) of the U-shaped bolts
20 (620) and the fastening nuts (620b).

[Claim 14] The bolt-assembled strut-tie foundation
reinforcement of claim 5, wherein the straight portion (211)
of the hooked tie (210) is slid into openings (631) of one or
25 more retaining clips (630) having a shape of an omega symbol

(Ω) for mounting, the retaining clips (630) being fixed to opposite side surfaces of the lower portion of the steel plate (110) by welding.

5 [Claim 15] The bolt-assembled strut-tie foundation reinforcement of claim 5, wherein the hooked tie (210) is closely fitted to opposite side surfaces of the lower portion of the steel plate (110) and fixed by welding (W).

10 [Claim 16] The bolt-assembled strut-tie foundation reinforcement of any one of claims 1 to 4, wherein each of the ties (200) comprises linear ties (220) each of which is straight and has bolt portions (220a) at opposite ends, wherein the bolt portions (220a) of the linear ties (220)
15 extend through holes (714) in end portions (711) of anchoring members (710) having a shape of Korean Letter “ㅊ” of a linear tie anchor (700), are fastened with fastening nuts (220b), and are anchored to the steel plates (110) by fastening of fastening bolts (715a) and fastening nuts
20 (715b), the fastening bolts (715a) extending through holes (713) in close-fitting portions (712) of the anchoring members (710).

 [Claim 17] The bolt-assembled strut-tie foundation
25 reinforcement of any one of claims 1 to 4, wherein each of

the ties (200) comprises linear ties (220) each of which is straight and has bolt portions (220a) at opposite ends, wherein the bolt portions (220a) of the linear ties (220) extend through holes (724) in end portions (721) of L-shaped
5 anchoring members (720) of a straight tie anchor (700), which face each other, are fastened with fastening nuts (220b), and are anchored by fastening of fastening bolts (725a) extending through holes (723) in close-fitting pieces (722) of the anchoring members (720) and fastening nuts (725b).

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[Claim 18] The bolt-assembled strut-tie foundation reinforcement of any one of claims 1 to 4, wherein a tie fastener (400) is configured to bind intersecting portions of the ties (200).

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[Claim 19] The bolt-assembled strut-tie foundation reinforcement of claim 18, wherein the tie fastener (400) comprises an upper cap (410) and a lower cap (420) located above and below the intersecting ties (200), tie receiving
20 recess (430) configured to receive the ties (200), and fastening bolts (440a) and fastening nuts (440b) configured to fasten the upper and lower caps (410, 420).

[Claim 20] The bolt-assembled strut-tie foundation
25 reinforcement of claim 18, wherein the tie fastener (400)

comprises a pair of U-clips (450) placed in parallel to the intersecting ties (200) to wrap around lower steel bars of the steel bars of the ties, with cover pieces (460) of the U-clips (450) wrapping around the upper steel bars and fastened
5 and fixed to bolt portions (450a) provided at ends of the U-clips (450) with fastening nuts (450b).

[Claim 21] The bolt-assembled strut-tie foundation reinforcement of claim 1, wherein intersecting portions of
10 the angled connecting bars (310) are fastened with the fastening bolt (310a) and the fastening nut (310b).

[Claim 22] The bolt-assembled strut-tie foundation reinforcement of claim 1, wherein an L-shaped fixing bar
15 (321) is placed on intersecting portions of the band-shaped steel plate connectors (320) and is fastened and fixed with the fastening bolts (320a) and the fastening nuts (320b).

[Claim 23] The bolt-assembled strut-tie foundation
20 reinforcement of claim 3 or 4, wherein the band-shaped steel plate connectors (320) of the connector (300) are connected with a steel plate having a width to form an overall shape of Korean letter "ㅁ", and are fastened and fixed with fastening bolts and fastening nuts to angle-shaped connecting holders
25 (340) closely fitted to corner portions of the overall shape

where the steel plates (110) and the band-shaped steel plate connectors (320) meet.

[Claim 24] The bolt-assembled strut-tie foundation
5 reinforcement of claim 23, wherein band-shaped steel plate
supports (330) are disposed at the corner portions where the
band-shaped steel plate connectors (320) meet.

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