

STRUT ASSEMBLY AND METHOD

TECHINICAL FIELD

The present disclosure relates to the field of building construction equipment and
5 operation, and in particular a strut assembly and a method.

BACKGROUND

In basement constructions, steel piles or steel sheets are provided as a support for
earth surfaces such as walls of dugout area. In support of such steel piles, horizontally
10 running walers are attached to the steel piles in gaining structural integrity. Typically,
concrete are provided between the steel piles and the walers. However, further support is
required for the walers in providing a strong and reliable strut assembly to the earth surfaces.

SUMMARY

15 In one aspect, the present disclosure provides a strut assembly for providing support
to a pair of spaced-apart surfaces along a longitudinal axis. The strut assembly includes a
first strut segment having a first support end and a first connection end opposite to the first
support end; a second strut segment coupled to the first strut segment along the longitudinal
axis, the second strut segment having a second connection end and a second support end
20 opposite to the second connection end, the second connection end being fastened to the first
connection end of the first strut segment. The second support end is movable relative to the
second connection end to vary a support length between the first support end and the second
support end to bring the first support end into engagement with one of the pair of surfaces
and to bring the second support end into engagement with another one of the pair of surfaces.
25 The second support end is fixable to the second connection end to secure the first strut
segment and the second strut segment between the pair of surfaces.

In another aspect, a method of supporting a pair of spaced-apart surfaces is disclosed.
The method includes aligning a first strut segment and a second strut segment along a
30 longitudinal axis; coupling a first connection end of the strut segment to a second connection
end of the second strut segment; moving the second support end away from the second
connection end to engage a first support end of the first strut segment to one of the pair of

spaced-apart surfaces and to engage a second support end of the strut segment to another one of the pair of spaced-apart surfaces; urging the second support end away from the second connection end to exert an out-facing force against the pair of spaced-apart surfaces; and fixing the second support end relative to the second connection end to secure the first strut
 5 segment and the second strut segment between the pair of surfaces.

The advantages of these and other aspects and features of various embodiments will be described with reference to the appended drawings.

10 BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is an isometric view of an embodiment of a construction site;

Fig. 2 is an isometric view of an assembly area of the embodiment of Fig. 1;

Fig. 3 is an isometric view of the embodiment of Fig. 1 under construction;

Fig. 4 is an isometric view of a waler attached to a steel pile of the embodiment of
 15 Fig. 1;

Fig. 5 is an isometric view of the embodiment of Fig. 1 under construction;

Fig. 6 is a top view of an embodiment of a strut assembly;

Fig. 7 is a side view of the embodiment of Fig. 6;

Fig. 8 is a side view of a waler coupled to a steel pile according to the embodiment
 20 of Fig. 6;

Fig. 9 is side view of a strut assembly coupled to a waler according to the embodiment of Fig. 6;

Fig. 10A is a top view of Fig. 9;

Fig. 10B is an exploded view of an embodiment of a strut assembly providing
 25 support for a pair of spaced-apart surfaces;

Fig. 10C is a side view of the embodiment of Fig. 10B in engagement with the pair of spaced-apart surfaces;

Fig. 11 is an embodiment of a strut assembly;

Fig. 12 is an exploded view of the strut assembly of Fig. 11;

Fig. 13A is an isometric view of a second strut segment of the strut assembly of Fig.
 30 11;

Fig. 13B is a sectional view of the second strut segment of Fig. 13A;

Fig. 14A is an exploded view of the second strut segment of Fig. 13A;

Fig. 14B is another exploded view of the second strut segment of Fig. 13A;

Fig. 15A is an isometric view of the second strut segment of Fig. 13A coupling with a waler;

5 Fig. 15B is another isometric view of the second strut segment of Fig. 13A coupling with a waler;

Fig. 16 is an isometric view of a strut member of the strut assembly of Fig. 11;

Fig. 17 is an isometric view of an adaptor of the strut assembly of Fig. 11;

Fig. 18 is an isometric view of a fixed end of the strut assembly of Fig. 11;

10 Fig. 19 is another isometric view of a fixed end of the strut assembly of Fig. 11;

Fig. 20 is a top view of a construction site including a strut assembly according to another embodiment;

Fig. 21 is a side view of an end of the strut assembly with a waler;

Fig. 22 is a side view of another end of the strut assembly with another waler;

15 Fig. 23 is a sectional view of the strut member of Fig. 20;

Fig. 24 is a top view of a construction site including stiffening plates according to the embodiment of Fig. 20;

Fig. 25 is a top view of a construction site with a two transverse wall including a strut assembly therebetween according to another embodiment;

20 Fig. 26 is a side view of an end of the strut assembly with a waler according to the embodiment of Fig. 25;

Fig. 27 is a side view of another end of the strut assembly with another waler according to the embodiment of Fig. 25;

25 Fig. 28A shows a top view of an angular box according to the embodiment of Fig. 25;

Fig. 28B shows a sectional view of the angular box of Fig. 28A;

Fig. 29 is a top view of a construction site with two non-parallel wall including a strut assembly according to yet another embodiment;

30 Fig.30 is a side view of an end of the strut assembly with a waler according to the embodiment of Fig. 29;

Fig. 31 is a side view of an embodiment of a fixed end of a strut assembly;

Fig. 32 is a top view of a construction site including a strut assembly with make up pieces according to another embodiment;

Fig. 33 is a top view of a construction site including a strut assembly with make up pieces according to a further embodiment;

5 Fig. 34 is a side view of an end of the strut assembly with a waler according to the embodiment of Fig. 32;

Fig. 35 is a side view of an end of the strut assembly with a waler according to the embodiment of Fig. 33;

Fig. 36 is a sectional view of a cross head according to the embodiment of Fig. 33;

10 Fig. 37 is a top view of a construction site with a two transverse wall including a strut assembly with make up pieces according to another embodiment;

Fig. 38 is a top view of a construction site with a two transverse wall including a strut assembly with make up pieces according to yet another embodiment;

15 Fig. 39 is a side view of an end of the strut assembly with a waler according to the embodiment of Fig. 37;

Fig. 40 is a side view of an end of the strut assembly with a waler according to the embodiment of Fig. 38;

Fig. 41 is a front view of a cross head according to an embodiment;

Fig. 42 is a sectional view of the cross head according to the embodiment of Fig. 41;

20 Fig. 43 is another sectional view of the cross head according to the embodiment of Fig. 41;

Fig. 44 is a side view of the cross head according to the embodiment of Fig. 41;

Fig. 45 is another side view of the cross head according to the embodiment of Fig. 41;

25 Fig. 46 is a top view of a corner piece according to an embodiment;

Fig. 47 is a detailed view of the corner piece according to the embodiment of Fig. 46;

Fig. 48 is a sectional view of the corner piece according to the embodiment of Fig. 46;

30 Fig. 49 is a top view of a strut assembly with stiffening bars according to another embodiment;

Fig. 50 is a side view of an end of the strut assembly with a waler according to the embodiment of Fig. 49;

Fig. 51 is a side view of another end of the strut assembly with another waler according to the embodiment of Fig. 49;

5 Fig. 52 is a sectional view of the strut assembly according to the embodiment of Fig. 49;

Fig. 53 is an isometric view of the embodiment of Fig. 49;

Fig. 54 is a detailed view of Fig. 53; and

Fig. 55 is a flowchart illustrating a method of supporting a pair of wall surfaces.

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DETAILED DESCRIPTION

Figs. 1 to 5 illustrates a construction site, for the preparation, installation & removal of a strut assembly and a strut system according to the present invention. As an example, the construction site may be a basement construction site, in which the strut assembly and
15 strut system are provided to support walls of the basement construction site.

Example of Walers and Struts Installation (with reference to FIGS. 1 to 5)

A. Preparation/Mobilization of Equipment & Manpower to site for Installation:

(1) Delivery of the required materials for Struts 300, Walers 200 and other ancillaries
20 for storage at the Temporary Holding Area;

(2) The walers 200/struts 300 are steel beam members to be installed with vertical temporary structure, to form a complete Earth Retaining Structural Steel for Basement construction;

(3) Monitor the excavation level & area for our work is about 1- metre below the
25 centre of first level Struts, which shall similar the next level of struts/walers work. Localise excavation for waler brackets installation at designated locations (if required).

B. Installation of walers 200:

(1) Install walers 200 on the already installed waler brackets.
(2) The gaps between the walers 200 and the sheet pile wall 52 will be filled with
30 concrete packing based on the approved design grade.

C. Installation of struts 300:

(1) Assembly of Struts

The strut components are pre-assembled outside the excavation area in accordance to the standard lengths by bolting the end plate. All bolts shall be tightened manually or by using electric impact wrench. Where possible the struts 300 may be assembled in manageable lengths, transported and hoisted into positions by cranes. The bolting connections used in assembling the strut 300 to the required length shall be tightened by hand or impact wrench.

(2) Installation of Struts

A crawler crane shall be used for major installation and excavator, as auxiliary machine where it is required and applicable. The pipe struts 300 shall be installed at one end against the waler. The strut alignment and straightness are continuously monitored or otherwise the strut will need to be adjusted. After the full length is installed and bolting/welding work completed with the pre-loading jacks in place, the strut is ready for pre-loading.

(3) Pre-loading of Struts

Preloading heads components are included in the assembly of struts 300 to facilitate preloading. Pre-loading position is normally near waler or runner beams.

After the struts 300 have been placed in position and bolting/welding works are completed, hydraulic jack(s) shall be placed in between the preloading heads. The hydraulic pump (manual pump or electric pump) connected to the jacks apply the pressure to pre-load the struts. The pressure gauge indicates the applied pre-load.

As an example, the strut will be preloaded to 100% of the specified pre-load. The gap arise will be measured, follow by shimming of the gap. A slightly higher pressure up to 110% of the specified pre-load will be applied when necessary to enable shim plates to be inserted into the gaps arising from pre-loading.

The pressure in the hydraulic jacks is then released and the jack removed. The bolted connections are checked and re-tightened further by Impact wrench to eliminate any slack.

Repeat the above procedures with subsequent levels of struts.

Example of Dismantling Walers and Struts

As an example, in dismantling, the installation procedures are reversed to the removal of each level of struts taking place when the permanent structure is constructed to approximately 0.5m below the corresponding level of struts.

The removal sequence for typical strut is indicated as follows:

Step 1: Removal of lowest level struts upon completion of base slab as per temporary work sequence.

Step 2: A hydraulic jack is re-installed within the strut and a load applied to marginally above the design pre-load.

Step 3: Remove the shim plates that were used to in-fill the gaps during the pre-loading operations.

Step 4: Gradually releases the applied load and removes the hydraulic jacks.

Alternative method can be used for releasing the main strut by replacing Step 2 to Step 4 is:

Step 5: Establish the length of strut to be removed in each lifting operations.

Step 6: Sling wires are fastened to the section being removed. The hoisting crane provides the necessary tension to remove any slack in the wires.

Step 7: Disconnect the length of strut to be removed from the adjoining members.

Step 8: Attach guide ropes to the ends of the strut.

Step 9: Crane hoists strut to designated location where strut is further disassembled into its component lengths.

Step 10: Repeating steps 5-9, remove the balance of the strut in manageable lengths until the strut is completely removed.

Step 11: When all the struts supported by a particular runner beam have been removed, identify the length of runner beam to be removed and support this section from the crane using sling wires, lifting clamps etc.

Step 12: Remove any bolted or welded connection between the runner beam and the king post.

Step 13: Attach guide ropes to the runner beam.

Step 14: Crane removes runner beam to designated location.

Step 15: Identify the appropriate length of steel waler beam(s) if applicable to be removed.

Step 16: Secure the waler to the crane by means of the sling wire, lifting clamps etc.

Step 17: Remove any welded connections to adjacent walers.

Step 18: Attach guide wires to ends of the waler.

Step 19: Lift up the waler and move to designate location using the crane.

Step 20: Remove the brackets that were supporting the walers.

Strut assembly

5 Further disclosed herein is a strut assembly for spanning between and exerting a pressure on a pair of walls spaced-apart from each other. The strut assembly comprises a strut assembly disposed between a first surface and a second surface. The strut assembly comprises a first strut segment having a first length; and a second strut segment engaged to the first strut segment. The first strut segment defines a longitudinal axis. The second strut
10 segment has a length variable along the longitudinal axis.

FIGs. 5 to 10A illustrate an embodiment of a strut system 100 for use with a dugout for basement construction, such as a recess 50, installed to act against and to provide structural support to opposing surfaces 52 of the recess 50. The strut system 100 comprises
15 a pair of support members such as walers 200 each abutting against one of the sidewalls 52 of the recess 50, and a strut assembly such as one or more strut assemblies 300 spanning across the recess 50 between the pair of walers 200, respectively. Walers 200 may be in the form of a beam, such as an I-beam or a H-beam, disposed spanning across the surface of the opposing sidewalls 52 of the recess 50. Corresponding one or more strut assemblies 300 act
20 to provide support for the walers 200 in maintaining the position of the walers 200 on the sidewalls 52 of the recess 50 and therefore, the strut assemblies 300 provide structural supports to the sidewalls 52. In an example, there may be multiple rows of walers 200 and corresponding strut assemblies 300 disposed on opposing sidewalls 52 of the recess 50.

25 FIGs. 10B and 10C illustrates an embodiment of a strut assembly 300. The strut assembly 300 provides support to a pair of spaced-apart surfaces 52 along a longitudinal axis 90. The strut assembly 300 includes a first strut segment 302 and a second strut segment 304 coupled to the first strut segment 304 along the longitudinal axis 90. The first strut segment 302 has a first support end 3022 and a first connection end 3024 opposite to the
30 first support end 3022. The second strut segment 304 has a second connection end 3044 and a second support end 3042 opposite to the second connection end 3044. The second connection end 3044 is fastened to the first connection end 3024 of the first strut segment

302. The second support end 3042 is movable relative to the second connection end 3044 to vary a support length between the first support end 3022 and the second support end 3042 to bring the first support end 3022 into engagement with one of the surfaces 52 and to bring the second support end 3042 into engagement with another one of the surfaces 52. The
 5 second support end 3042 is fixable to the second connection end 3044 to secure the first strut segment 302 and the second strut segment 304 between the pair of surfaces 52. As an example, hydraulic pressure is applied to the first support end 3022 and second support end 3042 to bring to the first support end 3022 and second support end 3042 in engagement with the respective surfaces 52. A spacer 3150 is then provided to fix the second support end
 10 3042 to the second connection end 3044.

FIG. 11 and 12 illustrates another embodiment of a strut assembly 300. The strut assembly 300 comprises a first strut segment 302 defining a longitudinal axis such as a first axis 90, and a second strut segment 304 coupled to the first strut segment 304 along the first
 15 axis 90. The first strut segment includes a strut member 320a defining a longitudinal axis such as a first axis 90, a connecting segment such as an adaptor 330 coupled between the strut member 320a and a second strut member 320b, and a fixed end 340 coupled to the second strut member 320b. The length of the second strut segment 310 is variable along the first axis 90. In another example, there may be one strut member 320 coupled between the
 20 second strut segment 310 and the fixed end 340. In another example, there may be multiple strut members 320 and corresponding adaptors 330 coupled between the second strut segment 310 and the fixed end 340. The strut assembly 300 acts to transfer load onto the waler 200.

FIG. 13A, 13B, 14A and 14B illustrates an embodiment of the second strut segment 310. The second strut segment 310 includes a seat 312 such as a cylindrical body and a slider 314 movably or slideably coupled to the seat 312, such that a length (L1) of the second strut segment 310 is variable. The seat 312 includes a first surface plate 3122 formed on one end, a second surface plate 3124 formed on an opposite end, and a pair of openings 3126 formed
 30 on the first surface plate 3122. The second surface plate 3124 may have a cross section generally larger than a cross section of the seat 312. The second surface plate 3124 couples with a main support member, such as a strut member 320.

The slider 314 has a third surface plate 3144 and a pair of legs 3142 formed on the third surface plate 3144. The pair of legs 3142 are slidably coupled to the pair of openings 3126 along the first axis 90. The third surface plate 3144 abuts against the waler 200. The pair of legs 3142 are slidable relative to the pair of openings 3126, allowing the slider 314 to slide relative to the seat 312 along the first axis 90. The pair of legs 3142 and the seat 312 forms a gap 316 therebetween for receiving at least one spacer, wherein load from the seat 312 acts on the slider 314 via the at least one spacer.

The third surface plate 3144 may have a cross section generally larger than a cross section of the legs 3142. Legs 3142 may be configured with a hollow rectangular cross section as shown in FIG. 14A. The gap 316 is generally rectangular in cross section with a length (L2), allowing better force transfer between the seat 312, the slider 314 and one or more spacer(s) 3150 disposed in the gap 316. Further, such rectangular gap 316 allows easy manufacture of corresponding spacer(s) 3150 with regular geometry. In another example, the legs may have a solid rectangular cross section. Optionally, there may be stiffening ribs 3128 formed between the surface plates 3124 and body 310. Optionally, there may be stiffening ribs 3146 formed between the surface plate 3144 and the slider 314.

Referring to FIG. 15A and 15B, when the legs 3142 are received in the openings 3126, the third surface plate 3144 is brought into contact with a waler 200. A hydraulic jack 500 is placed between the third surface plate 3144 and the first surface plate 3122, to force the third surface plate 3144 to act against the waler 200, by counteracting against the first surface plate 3122. A force generated by the hydraulic jack 500 adds a preload onto the strut assembly 300 which, in turn, applies the preload against the sidewalls 52 to meet the structural supporting requirements. Upon the preload reaching a predetermined level, one or more spacer(s) 3150 is inserted into the gap 316 with the one or more spacer(s) 3150 abutting the first surface plate 3122 and the third surface plate 3144, to maintain the preload. Thereafter, the upon insertion of the spacer(s) 3150, the hydraulic jacks may be removed and reused in the installation of a subsequent strut assembly thus providing the technical advantage of reusability of hydraulic jacks. The spacer 3150 may have a length (L3) substantially equal to the length of the gap (L2), wherein the pair of legs constrain the spacer

3150 from moving in a lateral direction 98. The seat 312 may further include a groove 3123 formed thereon between the pair of legs for guiding the spacer 3150 into the gap 316. The spacer 3150 is guided by the groove 3123 and slides into the gap 316. The groove 3123 may have a width substantially equal to a thickness of the spacer 3150.

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FIG. 16 illustrates an embodiment of a strut member 320. Strut member 320 includes a body portion 322 defining a first axis 90, a first surface plate 324 formed on one end of the body portion 322, and a second surface plate 326 formed on an opposing end of the body portion 322. In an example, the body portion 322 is a tubular member and surface plates 324/326 are disc members. The surface plates 324/326 may have a cross section generally larger than a cross section of the body portion 322. The surface plates 324/326 are configured to couple with the second strut segment 310. Optionally, there may be stiffening plates 325 (ribs) formed between the surface plate 324 and the body portion 322. Optionally, there may be stiffening plates 327 formed between the surface plate 326 and the body portion 322.

FIG. 17 illustrates an embodiment of an adaptor 330. The adaptor 330 includes a body portion 332, a first surface plate 334 disposed on one end of the body portion 332, and a second surface plate 336 disposed on an opposing end of the body portion 332. In an example, the body portion 332 is a tubular member and surface plates 334/336 are disc members. The surface plates 334/336 may have a cross section generally larger than a cross section of the body portion 332. As an example, the surface plates 334/336 are coupleable with the strut member 320. Optionally, there may be stiffening plates 337 formed between the surface plates 334/336 and body portion 332. The adaptor 330 may be configured with body portion 332 having various lengths, i.e. a series of body portions 332 with various length may be pre-fabricated, and assembled to first and second surface plates 334, 336 to form a corresponding series of length adjustors.

FIG. 18 and 19 illustrates an embodiment of a fixed end 340. The fixed end 340 includes a body portion 342, a first surface plate 344 disposed on one end of the body portion 342, and a second surface plate 346 disposed on an opposing end of the body portion 342. In an example, the first surface plate 344 has a larger diameter relative to the second surface

plate 346. In an example, the first surface plate 344 has a larger surface area relative to the second surface plate 346. In an example, the body portion 342 is of a truncated cone-shaped, and surface plates 344/346 are disc members. The surface plates 344/346 may have a cross section generally larger than a cross section of the body portion 342. The surface plates
 5 344/346 are configured to couple with a periphery member, such as the second strut segment 310. Optionally, there may be stiffening plates 345 formed between the surface plates 344 and the body portion 342. Optionally, there may be stiffening plates 347 formed between the surface plates 346 and the body portion 342.

10 Referring again to FIG. 12, as an example, the second strut segment 310 and the first strut member 320a are mounted to each other through corresponding surface plates, first strut member 320a and the adaptor 330 are mounted to each other through corresponding surface plates, the adaptor 330 and the second strut member 320b are mounted to each other through corresponding surface plates, and the second strut member 320b and the fixed end
 15 340 are mounted to each other through corresponding surface plates.

FIG. 20 to 24 illustrates another embodiment of a strut system 110. The strut system 110 comprises a pair of support members such as walers 200 and supporting beams such as a strut assembly 300 coupled between the pair of walers 200. The walers 200 may be
 20 provided with stiffening plates 210 at contact regions where the strut assembly 300 coupled with the waler 200. The strut assembly 300 comprises a strut member 320 defining a first axis 90, a second strut segment 310 engaged to the strut member 320 along the first axis 90, and a fixed end 340 coupled to the strut member 320. As an example, the second strut segment 310 and the first strut member 320a couples to each other through surface plates.
 25 The strut member 320 and the fixed end 340 also couples to each other through surface plates.

The second strut segment 310 includes a seat 312 and a slider 314 movably or slideably coupled to the seat 312, such a length of the second strut segment 310 is variable.
 30 An actuator such as a hydraulic jack 500 is placed between the seat 312 and the slider 314 of the second strut segment 310, and the hydraulic jack 500 applies a force to move the seat 312 away from the slider 314, thereby varying a length of the second strut segment 310.

This causes the strut assembly 300 to abut against and bear on the walers 200, in an action referred to in the context as preloading. When the strut assembly 300 is sufficiently preloaded, a spacer is inserted into the gap 316 with the spacer abutting the seat and the slider to fix the seat to the slider, so as to maintain the preload after the hydraulic jack 500 is eventually removed.

FIG. 25 to 28B illustrates another embodiment of a strut system 120 for a pair of corner walls or corner surfaces. The strut system 120 comprises a pair of support members such as walers 200a/200b disposed substantially transverse to each other abutting the corner walls, and a supporting beam such as a strut assembly 300 coupled between the pair of walers 200a/200b. Similarly, the walers 200 may be provided with stiffening plates 210 at contact regions where the strut assembly 300 coupled with the waler 200. The strut assembly 300 comprises a first strut member 320a defining a first axis 90, a second strut segment 310 coupled to the first strut member 320a, an adaptor 330 coupled between the first strut member 320a and a second strut member 320b, and a fixed end 340 coupled to the second strut member 320b. The first axis 90 forms a first oblique angle 92 with the waler 200a and the first axis 90 forms a second oblique angle 94 with the waler 200b. The strut assembly 300 engages the pair of walers 200a/200b with the first axis 90 obliquely oriented with respect to the waler 200a and the waler 200b. Additionally, the strut assembly 300 includes a first angular interface, such as an angular box 350a coupled between the second strut segment 310 and corresponding waler 200a, and a second angular interface, such as an angular box 350b coupled between the fixed end 340 and corresponding waler 200b.

When the strut assembly 300 is used to provide support for walers 200a/200b positioned transverse to each other, the angular box 350a is configured to act as an interface between the second strut segment 310 and the waler 200a. Similarly, the angular box 350b is configured to act as an interface between the fixed end 310 and the waler 200b by transmitting forces from the strut assembly 300 to the walers 200a/200b.

FIG. 29 illustrates another embodiment of a strut system 130 for supporting a pair of spaced-apart surfaces. The strut system 130 comprises a waler 200 disposed at an angle 96 relative to a first axis 90 of a strut assembly 300, the strut assembly 300 angularly coupled

to the waler 200. Similarly, the walers 200 may be provided with stiffening plates 210 at contact regions where the strut assembly 300 coupled with the waler 200. As an example, the strut assembly 300 comprising an angular interface, such as an angular box 360 coupled between a fixed end 340 and the waler 200. The angular box 360 is configured to act as an interface between the fixed end 340 and the waler 200 by transmitting forces from the strut assembly 300 to the walers 200.

Referring to FIG. 30, in an example, for an efficient load transfer, the surface plate 3144 of the second strut segment 310 has a diameter (D) smaller or equal to a height (H) of the waler 200. In another example, the surface plate 3144 of the second strut segment 310 has a circular cross sectional area wherein the circular cross sectional area brought into full contact with the waler 200. In another example, the surface plate 3144 of the second strut segment 310 has a rectangular cross sectional area wherein the rectangular cross sectional area brought into full contact with the waler 200. In another example, the surface plate 3144 of the second strut segment 310 has an elliptical cross sectional area wherein the elliptical cross sectional area bears fully on the waler 200. In another example, the surface plate 3144 of the second strut segment 310 has a polygonal cross sectional area wherein the polygonal cross sectional area bears fully on the waler 200. In another example, the surface plate 3144 of the second strut segment 310 has an irregular cross sectional area wherein the irregular cross sectional area bears fully on the waler 200.

Referring to FIG. 31, in an example, for an efficient load transfer, the surface plate 346 of the fixed end 340 has a diameter (D) smaller or equal to a height (H) of the waler 200. In another example, the surface plate 346 of the fixed end 340 has a circular cross sectional area wherein the circular cross sectional area bears fully on the waler 200. In another example, the surface plate 346 of the fixed end 340 has an elliptical cross sectional area wherein the elliptical cross sectional area bears fully on the waler 200. In another example, the surface plate 346 of the fixed end 340 has a polygonal cross sectional area wherein the polygonal cross sectional area bears fully on the waler 200. In another example, the surface plate 346 of the fixed end 340 has an irregular cross sectional area wherein the irregular cross sectional area bears fully on the waler 200.

FIG. 32 to 36 illustrates another embodiment of a strut system 140 for supporting a pair of spaced-apart surfaces. The strut system 140 comprises a pair of support members such as walers 200, and supporting beams such as a strut assembly 300 coupled between the pair of walers 200. The strut assembly 300 includes a first strut segment such as a strut member 320 and a second strut segment 310 engaged to the first strut segment 320 through cross heads 700 coupled between the first strut segment 320 and the second strut segment 600. Further, the second strut segment 310 includes make up pieces 600 coupled between the waler 200 and respective cross head 700. The make up pieces 600 are coupled to the strut assembly 300 to increase the length of the strut assembly 300 in adapting the strut assembly 300 to the pair of surfaces. As an example, make up pieces 600 are provided on each end of the strut assembly 300. Alternatively, make up pieces are provided on one end of the strut assembly 300. A plurality of make up pieces 600a/600b defines a second axis 95, the make up piece 600a stacking with make up piece 600b along the second axis. In an example, the second axis 95 is off set with respect to the first axis 90.

In an example, make up pieces 600 are sized such that make up pieces 600 are brought into full contact with the waler 200 for efficient load transfer. Referring to FIG. 32, the waler 200 may be acting on soldier pile with sheet pile lagging. As an alternative as shown in FIG. 33, the waler 200 may act on sheet pile alone. For efficient load transfer, the cross head 700 has a first surface on one end in contact with the strut assembly 300, and a second surface on another end in contact with the make up pieces 600. The first surface having a larger cross section relative to the second surface. This results in efficient load transfer between the waler 200, the make up pieces 600, the cross head 700 and strut member 320. Referring to FIG. 36, it can be seen that the strut assembly 300 bears fully on the larger contact surface of the cross head 700. In an example, a hydraulic jack may be provided between the cross head 700 and the waler 200 to apply pre-loading to the strut assembly 300.

FIG. 37 to 42 illustrates another embodiment of a strut system 150 for a corner wall or a pair of spaced-apart corner surfaces. The corner strut system 150 comprises a pair of support members such as walers 200 disposed substantially transverse to each other, and a supporting beam such as a strut assembly 300 coupled between the pair of walers 200. The

corner strut system 150 further comprising cross heads 700a/700b coupled to both ends of the strut member 320. Additionally, make up pieces 600 are coupled between cross head 700a and another cross head 700c and corner pieces 800a/800b coupled to both the cross heads 700b/700c. The corner pieces 800a/800b act as interface between the cross heads
 5 700b/700c and walers 200 which are transversely positioned. In an example, a hydraulic jack may be provided between the cross heads 700a and 700c to apply pre-loading to the strut assembly 300. Referring to FIG. 37, the waler 200 may act on soldier pile with sheet pile lagging. As an alternative as shown in FIG. 38, the waler 200 may act on sheet pile alone. As shown in FIG. 39 and 40, the cross head 700a/700b has a larger contact surface
 10 on one end in contact with the strut assembly 300, and a smaller cross section on another end in contact with the corner piece 800a/800b.

FIG. 41 to 45 illustrates an embodiment of a cross head 700. The cross head 700 comprises a first contact surface 710, a second contact surface 720 and stiffening plates 730
 15 coupled between the first contact surface 710 and the second contact surface 720. For efficient load transfer, the first contact surface 710 has a smaller surface area as compared to the second contact surface 720. As an example, the second contact surface 720 may be in a square shape. Alternatively, the second contact surface 720 may be in a rectangular shape. Alternatively, the second contact surface 720 may be in an irregular shape. As an example,
 20 the first contact surface 710 may be in a rectangular shape. Alternatively, the first contact surface 710 may be in an irregular shape.

FIG. 46 to 48 shows an embodiment of a corner piece 800 for a strut assembly. The corner piece 800 comprises a pair of first plates 810, a pair of second plates 820, and
 25 connecting member 830a/830b such as an I-beam coupled between the first plates 810 and the second plates 820. First end plates 840 and second end plates 850 may be provided at respective ends of the connecting member 830a/830b such that the end plates 840/850 act to transfer load through the connecting member 830/830b. Connecting member 830a is configured shorter in relative to connecting member 830b such that the first plates 810 forms
 30 an angle relative to second plates 820.

FIG. 49 to 54 illustrates another embodiment of a strut system 160 for supporting a pair of spaced-apart surfaces. The strut system 160 comprises a pair of support members such as walers 200 and supporting beams such as a strut assembly 300 coupled between the pair of walers 200. The walers 200 may be provided with waler mounting plates 202 at contact regions where the strut assembly 300 coupled with the waler 200. The strut assembly 300 comprises a first strut segment such as a strut member 320 defining a first axis 90, a second strut segment 310 engaged to the strut member 320 along the first axis 90, and a fixed end 340 coupled to the strut member 320 on an opposing end. Similar to previous embodiments, the second strut segment 310 includes a seat 312 and a slider 314. Additionally, the seat 312 includes connecting plates 3125. Stiffening bars 370 are provided and fixedly coupled between the seat 312 and the waler 200, wherein load from the seat 312 acts on the waler 200 via the stiffening bars 370. As an example, both the waler mounting plate 202 and the connecting plate 3125 has mounting holes 84 formed thereon. The stiffening bars 370 also include a plurality of holes 372 which are elongated along the first axis 90. The holes 372 are elongated in aid of aligning with the mounting holes 84 on the waler mounting plate 202 and connecting plate 3125, such that any changes in the distance between the waler mounting plate 202 and connecting plate 3125 along the first axis may be compensated by the elongated holes 372. Fasteners 82 are provided through the elongated holes 372 and mounting holes 84 to secure the stiffening bars 370 to the waler 200 and the seat 312. Alternatively, other fastening methods such as use of welding may also be used to secure the stiffening bars 370 to the waler 200 and the seat 312.

FIG. 55 illustrates a method 900 of supporting a pair of spaced-apart surfaces. The method 900 includes in box 910, aligning a first strut segment and a second strut segment along a longitudinal axis; in box 920, coupling a first connection end of the strut segment to a second connection end of the second strut segment; in box 930, moving the second support end away from the second connection end to engage a first support end of the first strut segment to one of the pair of spaced-apart surfaces and to engage a second support end of the strut segment to another one of the pair of spaced-apart surfaces; in box 940, urging the second support end away from the second connection end to exert an out-facing force against the pair of spaced-apart surfaces; and in box 950, fixing the second support end

relative to the second connection end to secure the first strut segment and the second strut segment between the pair of surfaces.

Optionally, the second strut segment includes a seat onto which the second
5 connection end is formed and a slider onto which the second support end is formed. The slider is movably coupled to the seat such that the second support end is movable relative to the second connection end to vary the support length, wherein fixing the second support end relative to the second connection end comprises placing a spacer between the seat and the
10 slider to prevent the slider from moving towards the seat to fix the second support end to the second connection end.

Optionally, the method may further include placing a spacer comprises positioning the spacer between a pair of legs formed on the slider, wherein the pair of legs constrains the spacer from moving in a lateral direction. Optionally, placing a spacer comprises guiding
15 the spacer along a groove formed on the seat.

The method may further include placing a waler between the second support end and one of the pair of spaced-apart surfaces and connecting a stiffening bar to the waler and the seat, wherein fixing the second support end relative to the second connection end
20 comprises fastening the stiffening bar to the seat and the waler.

It will be readily understood that the components of the embodiments, as generally described and illustrated in the figures herein, may be arranged and designed in a wide variety of different configurations in addition to the described example embodiments. Thus,
25 the following more detailed description of the example embodiments, as represented in conjunction with the figures, is not intended to limit the scope of the embodiments, as claimed, but is merely representative of example embodiments.

Reference throughout this specification to “one embodiment”, “another
30 embodiment” or “an embodiment” (or the like) means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the appearance of the phrases “in one embodiment” or “in an

embodiment” or the like in various places throughout this specification are not necessarily all referring to the same embodiment.

Furthermore, the described features, structures, or characteristics may be combined
5 in any suitable manner in one or more embodiments. In the following description, numerous specific details are provided to give a thorough understanding of embodiments. One skilled in the relevant art will recognize, however, that the various embodiments can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, some or all known structures, materials, or operations may not be
10 shown or described in detail to avoid obfuscation.

As used herein, the singular “a” and “an” may be construed as including the plural “one or more” unless clearly indicated otherwise.

15 This disclosure has been presented for purposes of illustration and description but is not intended to be exhaustive or limiting. Many modifications and variations will be apparent to those of ordinary skill in the art. The example embodiments were chosen and described in order to explain principles and practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various
20 modifications as are suited to the particular use contemplated.

Thus, although illustrative example embodiments have been described herein with reference to the accompanying figures, it is to be understood that this description is not limiting and that various other changes and modifications may be effected therein by one
25 skilled in the art without departing from the scope or spirit of the disclosure.

CLAIMS

1. A strut assembly for providing support to a pair of spaced-apart surfaces along a longitudinal axis, the strut assembly comprising:

5 a first strut segment having a first support end and a first connection end opposite to the first support end;

 a second strut segment coupled to the first strut segment along the longitudinal axis, the second strut segment having a second connection end and a second support end opposite to the second connection end, the second connection end being fastened to the first connection end of the first strut segment;

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 wherein the second support end is movable relative to the second connection end to vary a support length between the first support end and the second support end to bring the first support end into engagement with one of the pair of surfaces and to bring the second support end into engagement with another one of the pair of surfaces, and

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 wherein the second support end is fixable to the second connection end to secure the first strut segment and the second strut segment between the pair of surfaces.

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2. The strut assembly as recited in claim 1, wherein the second strut segment includes a seat onto which the second connection end is formed and a slider onto which the second support end is formed, wherein the slider is movably coupled to the seat such that the second support end is movable relative to the second connection end to vary the support length.
- 25

3. The strut assembly as recited in claim 2, further comprising a spacer disposed between the seat and the slider to prevent the slider from moving towards the seat to fix the second support end to the second connection end.

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4. The strut assembly as recited in claim 3, wherein the seat includes a pair of openings and the slider includes a pair of legs received into the pair of openings, wherein the spacer is disposed between the pair of legs.
5. The strut assembly as recited in claim 4, wherein the seat includes a groove between the pair of openings, the spacer is partially received in the groove.
6. The strut assembly as recited in claim 2, further comprising a waler connected to the second support end and a stiffening bar to fix the seat and the waler.
7. The strut assembly as recited in claim 6, wherein the stiffening bar is movably connected to the waler to allow movement of the waler relative to the seat along the longitudinal direction.
8. The strut assembly as recited in claim 7, wherein the stiffening bar comprises a plurality of elongated holes formed thereon and the strut assembly comprises a plurality of fasteners each being placed to passing through one of the elongated holes to fix the stiffening bar to the waler.
9. The strut assembly as recited in claim 1, further comprising a plurality of makeup pieces engagable to at least one of the first support end and the second support end.
10. The strut assembly as recited in claim 1, further comprising a first waler engagable to the first end and the second waler engagable to the second end.
11. The strut assembly as recited in claim 1, wherein the first strut segment and the second strut segment are engagable to the pair of surfaces with the longitudinal axis obliquely oriented with respect to the first surface and the second surface.

12. The strut assembly as recited in claim 11, further comprising a first angular box engagable to the first support end and a second angular box engagable to the second support end.
- 5 13. A method of supporting a pair of spaced-apart surfaces, the method comprising:
aligning a first strut segment and a second strut segment along a longitudinal axis;
coupling a first connection end of the strut segment to a second connection end of the second strut segment;
10 moving the second support end away from the second connection end to engage a first support end of the first strut segment to one of the pair of spaced-apart surfaces and to engage a second support end of the strut segment to another one of the pair of spaced-apart surfaces;
urging the second support end away from the second connection end to exert an
15 out-facing force against the pair of spaced-apart surfaces;
fixing the second support end relative to the second connection end to secure the first strut segment and the second strut segment between the pair of surfaces.
14. The method as recited in claim 13, wherein the second strut segment includes a seat
20 onto which the second connection end is formed and a slider onto which the second support end is formed, wherein the slider is movably coupled to the seat such that the second support end is movable relative to the second connection end to vary the support length, wherein fixing the second support end relative to the second connection end comprises placing a spacer between the seat and the slider to prevent
25 the slider from moving towards the seat to fix the second support end to the second connection end.
15. The method as recited in claim 14, wherein placing a spacer comprises positioning the spacer between a pair of legs formed on the slider, wherein the pair of legs
30 constrains the spacer from moving in a lateral direction.

16. The method as recited in claim 14, wherein placing a spacer comprises guiding the spacer along a groove formed on the seat.

5 17. The method as recited in claim 14, further comprising placing a waler between the second support end and one of the pair of spaced-apart surfaces and connecting a stiffening bar to the waler and the seat, wherein fixing the second support end relative to the second connection end comprises fastening the stiffening bar to the seat and the waler.