This invention relates to construction of retaining walls in excavations and more particularly to methods for applying horizontal and diagonal sheeting having full contact with the earth wall.

This application is a continuation of application Serial No. 704,550, filed December 23, 1957, now abandoned.

Prior methods of constructing underground sheeting generally involve sinking vertical H-beams along the line of the wall, then excavating and placing sheathing, such as planks, behind the vertical beams or their flanges. Another method has been to pour concrete piers with notches in them and to place the sheathing in the notches.

Both of these methods involve excavating between the vertical support members. It is practically impossible to do this with machinery, so that hand digging is required. Hand work of this type is extremely expensive, and furthermore, is not as effective since a smooth surface cannot readily be achieved by hand digging. This results in space voids between the sheeting wall and the earth wall.

The present invention provides a method for eliminating all hand digging between driven vertical supports and places the sheeting in contact with or at a distance from the outer face (i.e., facing in the direction of the excavation) of the support members and with the earth wall between the support members. With the present method a straight wall can be machine-made, thus eliminating voids between the earth and the sheeting. More specifically, in practicing the method of the invention disclosed herein, a plurality of H-section piles or the like are first installed by driving them or by the equivalent, vertically into the ground about the perimeter of those areas where excavation for the structure is to take place. Ideally, the two parallel flanges which form the sides of the H-section piles should be held parallel to the building line while the pile is being driven in in order that horizontal sheeting members may be readily attached to those flanges which face the excavation.

As a practical matter, it has been found inherently a part of the pile driving operation that these flanges are quite often driven into positions of angular misalignment with the building line because there is a marked tendency for a substantial portion of piles in a given set to rotate while being driven. It is also inherent in pile-driving vertical supports that some of a given set will not adhere to a line parallel to the proposed wall of sheeting.

The method of the present invention accommodates any angular misalignment of the H-section flanges and also variations in the distances by which individual piles may be set back from a proposed straight line of sheeting. When attaching horizontally extending sheeting members to the H-piles according to one sequence, sheeting fastener means is placed against the outside face of a sheeting member, H-flange fastener means is secured to one of the flanges and is attached at an angle to at least one of the fastener means which is a complementary angle to the angle of misalignment (viz., the sum of these two angles equals 90°) and thus compensates for the angle of misalignment.

The present method also provides that the planks or sheeting must be cut and fitted between the vertical support members. If the vertical support members are not equally spaced, this involves custom fitting of all the sheeting. The present method is versatile in that any size sheeting may be used since the sheeting may be affixed to the beams at any point along the sheeting. Also, the sheeting may be installed in a diagonal direction. Therefore, a single plank may be fastened to three or more vertical supports at one time so that one can cut and install it between the supports. This method of continuous sheeting with staggered joints provides a generally stronger wall.

This invention relates to methods of applying underground sheeting in excavations and more particularly to methods for applying horizontal and diagonal sheeting having full contact with the earth wall.

The application is a continuation of application Serial No. 704,550, filed December 23, 1957, now abandoned.

Prior methods of constructing underground sheeting generally involve sinking vertical H-beams along the line of the wall, then excavating and placing sheathing, such as planks, behind the vertical beams or their flanges. Another method has been to pour concrete piers with notches in them and to place the sheeting in the notches.

Both of these methods involve excavating between the vertical support members. It is practically impossible to do this with machinery, so that hand digging is required. Hand work of this type is extremely expensive, and furthermore, is not as effective since a smooth surface cannot readily be achieved by hand digging. This results in space voids between the sheeting wall and the earth wall.

The present invention provides a method for eliminating all hand digging between driven vertical supports and places the sheeting in contact with or at a distance from the outer face (i.e., facing in the direction of the excavation) of the support members and with the earth wall between the support members. With the present method a straight wall can be machine-made, thus eliminating voids between the earth and the sheeting. More specifically, in practicing the method of the invention disclosed herein, a plurality of H-section piles or the like are first installed by driving them or the equivalent, vertically into the ground about the perimeter of those areas where excavation for the structure is to take place. Ideally, the two parallel flanges which form the sides of the H-section piles should be held parallel to the building line while the pile is being driven in in order that horizontal sheeting members may be easily attached to those flanges which face the excavation.

As a practical matter, it has been found inherently a part of the pile driving operation that these flanges are quite often driven into positions of angular misalignment with the building line because there is a marked tendency for a substantial portion of piles in a given set to rotate while being driven. It is also inherent in pile-driving vertical supports that some of a given set will not adhere to a line parallel to the proposed wall of sheeting.

The method of the present invention accommodates any angular misalignment of the H-section flanges and also variations in the distances by which individual piles may be set back from a proposed straight line of sheeting. When attaching horizontally extending sheeting members to the H-piles according to one sequence, sheeting fastener means is placed against the outside face of a sheeting member, H-flange fastener means is secured to one of the flanges and is attached at an angle to at least one of the fastener means which is a complementary angle to the angle of misalignment (viz., the sum of these two angles equals 90°) and thus compensates for the angle of misalignment. The link is secured to both fastener means, and is of a selected length such that at least one of the links is attached to two members when attached to the piles as described will form a substantially straight line of sheeting entirely within the excavation and outside the flanges of the piles, thus forming a strong and quickly assembled wall on the desired line, which will retain the unexcavated earth. The fastening may be by bolting, welding, with studs, or clamping with clips as will be further discussed.

With the present method the sheeting need not be cut to fit between the vertical supports but may overlap to eliminate all cutting of the sheeting, and by using the present method, it is also easier to install sheeting in diagonal, viz., off-horizontal directions.

These and other aspects of the invention will become apparent from the following specification and drawings, of which:

FIGURES 1 and 2 are plan sectional views of prior methods of construction;

FIGURE 3 is a detail view showing one form of clip connection useful in the present invention;

FIGURE 4 is a vertical view of the clip fastener of FIGURE 3;

FIGURE 5 is a plan sectional view illustrating the method of this invention; and

FIGURES 6 and 6A show another clip construction for use in the invention.

Referring to FIGURES 1 and 2, there are shown two prior methods of construction. FIGURE 1 shows vertical beams 1, 2 and 3 having a cross-section similar to a capital H which are driven into the ground to provide support for the sheeting or planks 4, 5 and 6 which are placed between them, the ends of the planks or sheeting extending behind the flanges of the vertical support members.

FIGURE 2 shows another prior method of construction wherein concrete piers 10 and 11 are poured having notches 12 and 13 into which the sheeting 14 is placed. One of the difficulties with these methods of construction is that the areas between the vertical supports must be dug out to place the planks, and this must be done by hand digging between the vertical supports. Hand digging for practical purposes cannot provide the smooth earth wall that could be provided with machine scrapers. Therefore, there are many voids or spaces between the sheeting and the earth wall. This gives rise to minor displacements of the earth, which may become dangerous in some cases.

If the voids are not filled, the sheeting system may be endangered by increased stresses due to jarring, vibration, rain, flow of water, and lateral pressure of superimposed loads.

Also, with the prior method the planks or sheeting must be cut and fitted between the vertical support members. If the vertical support members are not equally spaced, this involves custom fitting of the entire sheeting.

The new method of construction permits machine digging since there is no excavating required between the supports. Machine scraping can provide a relatively smooth earth wall so that there will be almost complete contact between the earth wall and the sheeting. This eliminates voids or spaces behind the sheeting and minimizes any earth movement.

The present method is versatile in that any size sheeting may be used since the sheeting may be affixed to the beams at any point along the sheeting. Also, the sheeting may be installed in a diagonal direction. Therefore, a single plank may be fastened to three or more vertical supports, so that even if one connection fails, there will still be some supporting strength remaining. This method of continuous sheeting with staggered joints provides a generally stronger wall.

The present method also provides that the planks may be spaced at any spacing that is desired, for instance, to allow for water drainage. With the present method individual planks or sheets of sheeting may be removed and replaced, or the sheeting may be removed from the bottom up if it is desired to fill in the excavation.

FIGURES 3 and 4 show the clamping means of the
The present invention for fastening the sheeting 29 to I beams or H beams 26. H-sections are illustrated because their flanges are of uniform thickness, which is preferable. The clip comprises a U-shaped member 27, for instance of half-inch sheet steel, which fits over the flange 28 of the vertical pile and which is clamped to the sheeting 29 by means of the bolt 30, cross-piece or plate 31 and nut 32. The bolt may be connected through both sides of the curved or U-shaped member if desired. The clip, as shown, fits between two spaced planks 29 and 33 as shown in FIGURE 4. It is designed to eliminate any spacing, the sheeting may be grooved or notched to accommodate the thickness of the clip member, or mounted on the outside of the clip.

Other specific variations of the clip may be used. For instance, the outer plate 31 could be curved to support the planks underneath or may be made long enough to clamp more than two planks.

This method makes feasible the re-driving of vertical supports, which could not be driven to proper depth due to sub-surface obstructions, after excavation and sheeting have been partially completed. Prior methods of sheeting below flanges of supports prevented re-driving, as sheeting would be carried down and dislodged with subsequent loss of ground as re-driving proceeded. Since the present invention permits continuous sheeting over two or more supports, it is a simple matter to remove clips placed on alternate supports, thus freeing the sheeting.

Obstructions can be removed from beneath the bottom of the supports by normal excavating methods. Then the support may be re-driven without dislocating sheeting. Following re-driving, clips or other fastenings can be replaced.

The present invention provides a method for fastening horizontal or diagonal sheeting members to vertically driven support members such as H-section piles which are, as is likely, out of alignment. The misalignment, as shown in FIGURE 5, may be of two kinds: spatial misalignment, e.g., variations in lateral spacing or set-back from a proposed line of sheeting; and angular misalignment of the pile flanges relative to the line of sheeting to which they are to be attached.

As shown in FIGURE 5, three H-section piles 39, 40 and 41 have been driven into the earth adjacent to an area to be excavated. Although ideally, it is best perhaps to drive the respective piles 39-41 in a single line, i.e., at a common distance from the proposed centerline, which the retaining wall is to be constructed, nevertheless, more often than not, this is not possible because of earth conditions. As illustrated, the piles 39, 40 and 41 are set back different distances from the proposed line of sheeting. Again, it has been found to be inherently a part of any pile driving operation when using flange piles of this type, that a substantial portion of a given set of piles will tend to rotate while being driven despite attempts to restrain them. When this happens, the outer or sheeting-attaching flange will be in angular misalignment with the proposed line of sheeting. This effect has been indicated in the illustrated pile 41 which is in misalignment approximately 10° relative to the proposed line of sheeting. During the driving of piles, the amount of angular misalignment will necessarily be dependent upon certain conditions of the soil, including rock, gravel, water, etc., the exact force and direction used in driving the pile, the effectiveness of restraining rotation thereof, and slight dimensional differences between adjacent flanges of the piles which tend to induce a rotation thereof.

As shown in FIGURE 5, the present new method of constructing a retaining wall by attaching horizontal sheeting members to flanges of the vertically driven pile will accommodate angular (flange rotation) and also lateral (setback variance) misalignment of the piles with respect to the plane of the sheeting. The figure shows how this method may be practiced preferably, but not necessarily by using flange clips which are somewhat different from the clips described in connection with FIGURES 3 and 4. The sheeting, plate and interconnecting bolt are the same as shown in FIGURES 3 and 4 and have thus been given the same reference numerals. One method of assembly is as follows:

In the instance where a horizontal sheeting member or members, is to be attached to a pile such as pile 41, which has rotated during the driving thereof, the sheeting may be fastened to an angularly misaligned flange in such a manner as to compensate both for the angle of misalignment and for the amount of lateral setback. This may be done, more specifically, by placing one of two horizontal adjacent sheeting members 29, 33 coincident with the proposed line of sheeting. Then a clip 42 having a bolt 39 extending therethrough as shown, will be placed with the slotted portion thereof over a part of the misaligned flange 44. It should be noted that the preferred H-section piles have the adjacent surfaces of all flanges disposed at right angles to each other and the outer ends of the flanges form sharp edges. These piles are preferred because they permit the use of clips, such as clip 42, the front edge of which will "bite" into the flange or pile. Also, the upper end of the flange will tend to "bite" into the clip, as shown. This effect would not occur to the same extent were sloping inner flange surfaces or bevelled edges, as in I-beams, used.

Once the flange has been located within the slot in the clip 42, the end of the bolt 30 will be brought toward the excavation and between the sheeting members 29, 33. The length of the bolt will be governed by the lateral set-back, if any, as well as by the angle of the pile to which the sheeting is being attached. By "angle of the pile" is meant the angle by which the flange of the pile has deviated from parallelism to the plane of the sheeting. A sufficient length of threaded bolt will be permitted to protrude beyond the outer faces of the sheeting members 29, 33 to accommodate thereon a plate 31 and a nut 32. After the bolt 39 has been so positioned, the plate 31 will be placed against the outer faces of both sheeting members and over the protruding thread end of the bolt 30. The nut 32 may then be threaded onto the end of the bolt so as to cause tension to be applied thereto, thus drawing the clip 42 and the plate 31 together.

When this is done, two effects will be observed. First, the clip 42 will be rotated somewhat and spaced inner parts of the slotted portion thereof will bite into or become wedged against the material of the flange 44 which it encompasses. Secondly, the angle of misalignment of the flange relative to the line of sheeting will be compensated. In the present instance, as shown, the misalignment in the flange is compensated for by the complementary angle which the bolt 30 makes relative to the sheeting-retaining plate 31. Obviously, the complementary angle can be at either end of the bolt or divided between the two ends.

The present invention permits horizontal sheeting to be removed intact from any location without loss of ground, loss of sheeting materials or fastenings. Prior methods of horizontal sheeting would not permit removal of sheeting without cutting or otherwise destroying sheeting.

Sheets can be fastened in a number of ways, both against or away from the support to maintain a reasonably straight line of sheeting. As previously stated, the sequence in which the bolt or link is secured at its respective ends will differ depending on circumstances.

Another embodiment of clip suitable for our purpose is shown in FIGURES 5 and 6A. This clip comprises a right angle steel bracket 51 having a slot 52 for engaging the flange of the support beam. A nut 53 may be welded on the bracket or the hole in the bracket tapped. Various length bolts 30 may be used as required to com-
pensate for spatial misalignment. A clamping member is preferably used in contact with the sheeting, such as piles, as in Fig. 4. This clip can be used with a bolt formed integrally with the bracket #1 or with a tapped hole or welded nut to receive any length bolt or fastening desired. One or more sheets can be fastened with one clip as desired.

The present invention provides not only a method which makes feasible the removal of sheets from any location at any time and, equally important, sheets can be replaced. Prior methods of horizontal sheeting did not permit replacement of sheets. Some engineers have objected to the use of untreated lumber as horizontal sheeting as it decomposes in a great many places leaving voids in the ground, which could result in failure and/or settlement of adjacent structures. Since this method permits removal of sheeting where desired, the above objection is eliminated.

In practicing the present invention sheeting planks can be placed tight against each other if desired to prevent loss of ground in certain types of soil. The sheets can be notched or holes drilled to accommodate the clips and bolts to give a neat fit with little or no space between sheets. Where spaces between sheets permitted it, repacking behind sheets with granular material has been possible, but tight sheeting has heretofore prevented inspection and repacking where unusual sub-surface conditions created voids behind the sheets. The present invention now permits removal of sheets, visual inspection of ground behind adjacent sheeting, repacking, and replacement of sheets.

The present method may be used with various vertical supports, for instance, timber piles, or milled lumber of a variety of sizes and shapes. For irregular shapes, bolting would be more convenient. However, the specific shape of the clip may be modified for particular applications. Clips of the type shown have been tested by placing loads on commonly used sheeting. In every case the sheeting failed without any failure of the clips.

Therefore, the present invention provides new and improved means and methods for constructing underground sheeting for earth retaining walls. The present method is faster and less expensive than the previous methods, and is stronger and safer in all respects. The present method of flush mounting permits the use of random length sheeting which may be connected to three or more vertical supports which may be connected diagonally or with staggered joints from the top down. By using the clip of the present invention, the speed and efficiency of the method is considerably increased. The present system eliminates any necessity for hand digging between the vertical supports and permits machine digging which can provide a smooth earth wall in uniform direct contact with the sheeting.

The disclosed invention thus provides a method of constructing earth retaining walls which avoid many of the difficulties encountered in present commercial practice. Since the above description relates to a particular embodiment, including specific means for carrying out the method of the invention, it is merely illustrative, the scope of the invention being defined in the appended claims.

We claim:

1. A method of constructing a retaining wall for deep excavations comprising the following steps: piling driving a plurality of flanged piles vertically into the ground about the periphery of an area to be excavated with at least one of said piles positioned with its outer longitudinal flange angularly misaligned relative to the outer flanges of adjacent piles, at least some of said piles being driven into the ground to a depth greater than the proposed depth of the excavation to enable them to withstand substantial lateral forces from said wall; excavating within said peripheral area to expose portions of said piles facing the area to be excavated including at least a portion of one outer longitudinal flange of each; and attaching generally horizontally extending sheeting members to said piles by securing flange-fastener means to an angularly misaligned flange, placing sheeting fastener means against a portion of the outer longitudinal flange of each of said sheeting members, inserting between both said fastener means a link at an angle to at least one of said fastener means which is complementary to said angle of misalignment, securing said link to both fastener means, and placing said link under tension so that said sheeting members when thus attached to said piles comprise a line of sheeting of which the outer surface lies entirely within said excavation to form a retaining wall outwardly of said piles.

2. The method of constructing a retaining wall for deep excavations in which sheeting members are attached to the longitudinal flanges of flanged piles by means of slotted clips in which the width of the slot is greater than the thickness of the flange and which employs sheeting retention plates and linking bolts for connecting said plates to said clips, comprising the following steps: piling driving a plurality of said piles vertically into the ground about the periphery of an area to be excavated, whereby a substantial proportion of said piles are positioned with their outer longitudinal flanges angularly misaligned relative to the predetermined line of the retaining wall, at least some of said piles being driven into the ground a distance greater than the proposed depth of the excavation to withstand substantial lateral forces from said wall; excavating within said periphery to expose portions of said piles facing the area to be excavated including at least one longitudinal flange of each, attaching generally horizontal sheeting members to said piles by making an assembly of two of said sheeting members disposed horizontally edgewise one above the other, placing one of said clips so that its slot receives an angularly misaligned flange, placing one of said plates against the outside faces of said sheeting members, and positioning a linking bolt between the adjacent edges of said sheeting members, said linking bolt being secured to said piles to form a retaining wall within said excavation outwardly of said piles.

3. The method of constructing a retaining wall for deep excavations in earth which contains obstructions, comprising the following steps: piling driving a plurality of flanged piles vertically into the earth about the periphery of an area to be excavated, whereby at least one of said piles becomes rotated so that it is positioned with its outer longitudinal flange angularly misaligned relative to the predetermined line of the retaining wall adjacent thereto; driving said piles into the ground to a depth required to withstand substantial lateral forces from said wall after excavation to a certain depth has been completed, except for at least one pile which is driven to refusal against an obstruction at a depth less than said required depth; excavating within said periphery to expose at least one flange of each pile contiguous to the area to be excavated; attaching generally horizontal sheeting members to said piles by securing flange fastener means to an angularly misaligned flange, placing sheeting fastener means against the outside face of a sheeting member, inserting between both said fastener means a link at an angle to at least one of said means which is complementary to said angle of misalignment, securing said link to both fastener means, and placing said link under tension; said sheeting members when thus attached to said piles forming a line of sheeting which lies within said excavation to form a retaining wall outwardly of said piles; continuing the excavating to said obstruction; removing said obstruction;
disengaging the flange fastener means from the pile which was driven to refusal; driving said last-named pile to a greater depth; resecuring said last-named flange fastener means to a flange of the pile from which it was removed, and re-applying tension to the link attached to said last-named flange fastener means whereby to re-attach the sheeting members to said last-named pile.

4. The method of constructing a retaining wall for deep excavations comprising the following steps: piledriving a plurality of flanged piles vertically into the ground about the periphery of an area to be excavated with at least one of said piles positioned with its outer longitudinal flange angularly misaligned relative to the outer flanges of adjacent piles, at least some of said piles being driven into the ground to a depth greater than the proposed depth of the excavation to enable them to withstand substantial lateral forces from said wall; excavating within said periphery to expose portions of said piles facing the area to be excavated including at least a portion of one outer longitudinal flange of each; and attaching generally horizontally extending sheeting members to said piles by: securing flange fastener means to the flange of an angularly misaligned pile, placing sheeting fastener means against the outside face of a sheeting member, inserting between and securing to both said fastener means a tension link at an angle to at least one of said fastener means which is complementary to the angle of misalignment, and placing said link under tension tending to draw said sheeting member toward said misaligned pile, whereby all said sheeting members when thus attached to said piles comprise a line of sheeting of which the outer surface lies entirely within the excavation to form a retaining wall outwardly of said piles.

5. The method of constructing a retaining wall for deep excavations comprising the following steps: piledriving a plurality of flanged piles vertically into the ground about the periphery of an area to be excavated with at least one of said piles positioned with its outer longitudinal flanges angularly and spatially misaligned relative to the flanges of adjacent piles, at least some of said piles being driven into the ground to a depth greater than the proposed depth of the excavation to enable them to withstand substantial lateral forces from said wall; excavating within said periphery to expose portions of said piles facing the area to be excavated including at least a portion of one outer longitudinal flange of each; and attaching generally horizontal extending sheeting members to said piles by: securing flange-fastener means to flanges of angularly and spatially misaligned piles, placing sheeting fastener means against the outside face of the sheeting members, inserting between and securing to both said fastener means a tension link of a length adapted to compensate for the spatial misalignment of each pile, said tension link being at an angle to each of said fastener means of which the sum is complementary to the angle of misalignment of the respective pile, and placing said links under tension tending to draw said sheeting members toward the misaligned piles, whereby all said sheeting members when thus attached to said piles comprise a line of sheeting of which the outer surface lies entirely within the excavation to form a retaining wall spaced outwardly from said piles.

6. The method of constructing a retaining wall for deep excavations comprising the following steps: piledriving a plurality of flanged piles vertically into the ground about the periphery of an area to be excavated with at least one of said piles positioned with its outer longitudinal flanges angularly misaligned relative to the outer flanges of adjacent piles, at least some of said piles being driven into the ground to a depth greater than the proposed depth of the excavation to withstand substantial lateral forces from said wall; excavating within said periphery to expose the outer longitudinal flanges of piles facing the area to be excavated; and attaching generally horizontally extending sheeting members to the flanges of said piles, including the flanges of said misaligned piles, by securing a plurality of fastener means respectively at one end each to a plurality of the outer longitudinal flanges of said piles, thereafter placing sheeting fastener means against the outside face of at least one sheeting member; and moving said respective fastener means relative to one another to support said sheeting member from said outer longitudinal flanges, said sheeting members when thus supported from said piles forming a retaining wall outwardly of said piles and entirely within said excavation.

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