

April 7, 1959

G. R. MOORE
RETAINING WALLS

2,880,588

Filed April 16, 1956

2 Sheets-Sheet 1

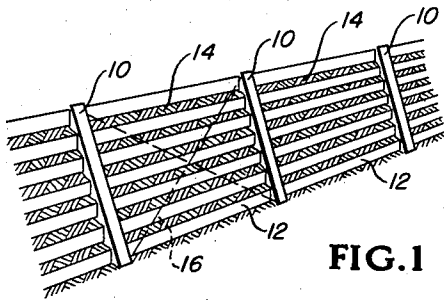


FIG. 1

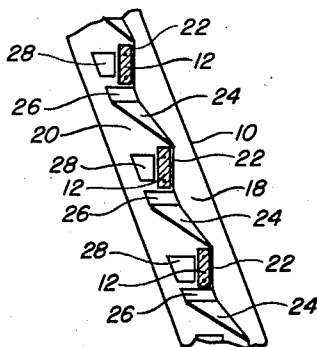


FIG. 2

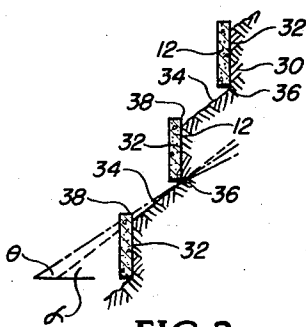


FIG. 3

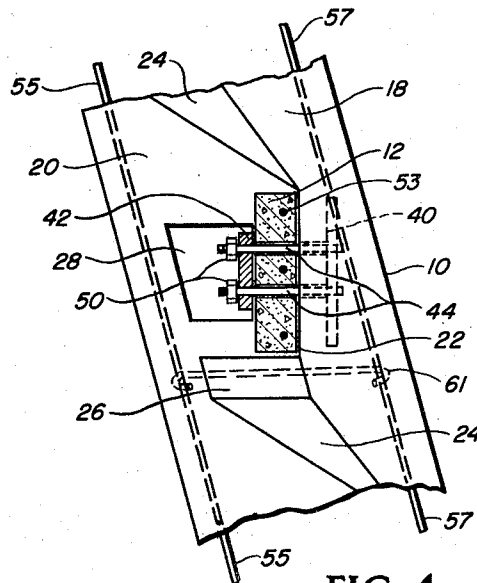


FIG. 4

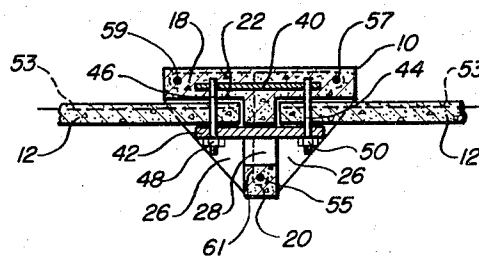


FIG. 5

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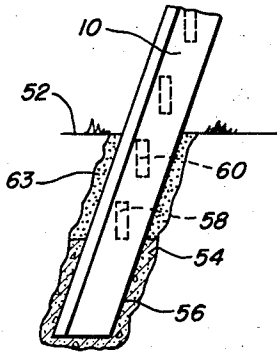


FIG. 7

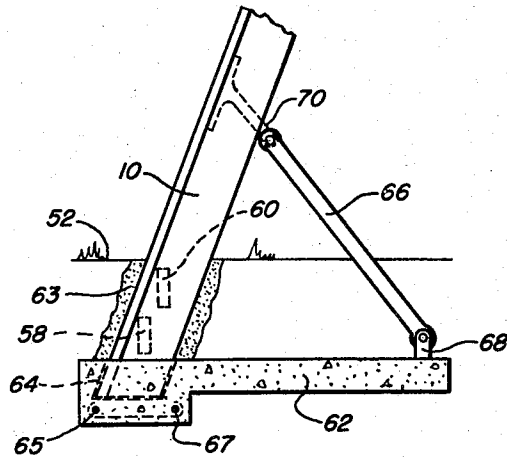


FIG. 8

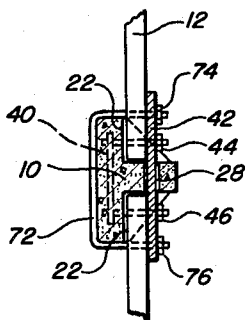


FIG. 9

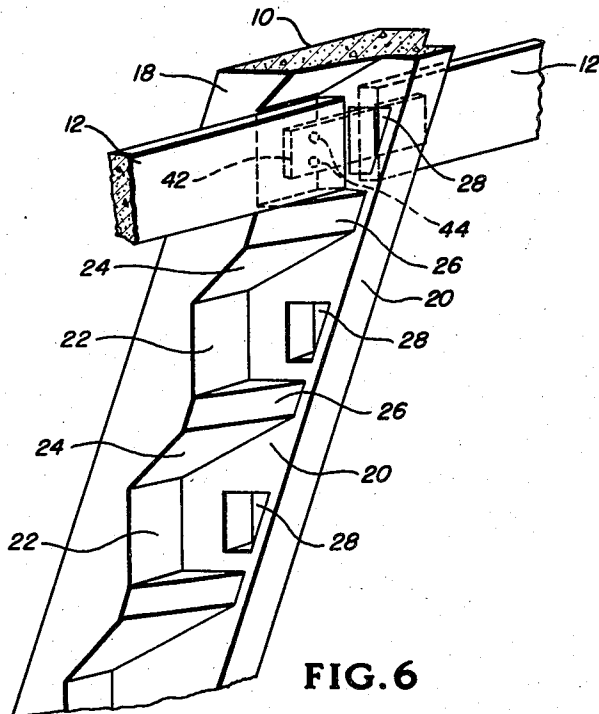


FIG. 6

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2,880,588

RETAINING WALLS

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11 Claims. (Cl. 61—39)

This invention relates to earth retaining walls and relates in particular to a retaining wall erected of precast concrete elements, preferably prestressed with steel wires in tension, which may be installed with a minimum of excavation and back fill, and which overcomes most of the disadvantages characteristic of earth retaining walls of the prior art.

Previously many forms of earth retaining walls suitable for prefabrication of structural elements and field erection have been suggested. Conventionally these walls comprise a plurality of parallel earth supporting elements or front stretchers disposed horizontally one upon the other with the retained earth behind them. These front stretchers are held in place usually by a plurality of parallel header elements extending from the front stretchers back into the retained earth, where nearly always a second series of back stretchers buried in the earth fixed the back ends of the headers. The stretchers and headers were frequently of very complex structural design, this being required so that the front and back ends of the headers could be locked into position between the adjacent front and back stretchers. The front stretchers lying in immediate contact with one another did not provide for ready discharge of seepage and special stretcher elements with weep holes were required in addition to the special front and back stretchers.

Characteristic of most all prior art retaining walls is the very disadvantageous requirement of extensive preliminary excavation or subsequent back filling, or both. This was ordinarily required in order to locate the back stretchers, if used, or to install the headers in place extending back into the earth. If the wall had to be located at or near the face of an existing bank which required support, then excavation to a depth equal to the header length was necessary. After installation of the wall, back filling with a large volume of earth equal to the excavation was required around the headers and behind the front stretchers. If the wall could be located in front of the existing bank a distance equal to the header length, no local excavation was needed, but the necessity of back-filling means that an excavation was required somewhere to obtain the back fill.

The present invention is accordingly directed to an improved earth retaining wall composed of prefabricated concrete stretcher and T-post elements, adapted to easy field erection, and which avoids all of the aforementioned disadvantages. It eliminates the conventional headers and back stretchers and requires an absolute minimum of excavation and backfilling. The elements are exceedingly simple in structure, adapted to prefabrication at a single centrally-located point and simple field erection, and only two different kinds of elements are needed. No special provision of weep holes is required for seepage to prevent buildup of unwanted hydrostatic pressure behind the wall and yet the front appearance of the wall is architecturally pleasing. In addition, no extensive foundation is required to support the wall.

It is therefore a primary object of the present inven-

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tion to provide an improved retaining wall for earth embankments and the like.

It is an additional object to provide an improved earth retaining wall of simple design utilizing the most advanced techniques of soil and concrete engineering which permits a substantial improvement and economic savings in manufacture and installation over prior designs.

A more particular object is to provide an improved retaining wall constructed of prefabricated concrete elements which are preferably prestressed to resist the intended loading.

The appearance of the retaining wall according to this invention and the detail of the structure of the elements and the inter-connection thereof will be more clearly understood by reference to the accompanying drawing in which:

Figure 1 is a front perspective view of a section of a completed wall showing the T-posts and plank stretchers and preliminary tensioning rods used in one or more bays during erection to lend stability,

Figure 2 is a side view of the T-post showing the ends of the stretchers, the stretcher supports, and the web apertures,

Figure 3 is a schematic view of the end of the stretchers showing their spaced apart and stepped back disposition in relation to the angle of repose of the earth being retained,

Figure 4 is a detail side view of the T-post showing the manner of securing the stretchers thereto,

Figure 5 is a view at right angles to Figure 4,

Figure 6 is an isometric view of the rear of a T-post showing the configuration of the stretchers, tie plates, web apertures, etc.,

Figure 7 is a side view illustrating the foundation for T-posts for smaller retaining walls including auger hole, sub-grade planks, grout, etc.,

Figure 8 is a side view illustrating the foundation for the T-posts for higher retaining walls including sub-grade planks, T-footing with backstay, and an indentation for the T-post, and

Figure 9 is a cross section view of the T-post showing another manner for securing plank ends especially where used below grade to resist overturning.

Referring now more particularly to Figure 1, a fragmentary perspective front view of the completed structure is shown. The T-posts 10 incline from the vertical back toward the embankment to be supported. The T-post 10 incline from the vertical can vary from 5° to about 35°; however, normally it is approximately 18°. The horizontal stretchers 12 extend between adjacent T-posts and are spaced apart from one another leaving open spaces 14. Here is exposed the earth at its normal angle of repose as illustrated in greater detail below. These openings afford space for planting decorative and earth retaining plants, now shown, and also provide for any seepage of moisture from any point behind the wall. Thus any seepage water need not run clear to the foot of the wall to the usual weep holes, thus preventing excessive hydrostatic pressures developing behind the retaining wall. Also illustrated are temporary cross braces 16, shown in broken lines, extending from the top of one T-post to the bottom of the adjacent post. These braces are steel cables, wires, or flat steel straps located in one or two bays in the full length of the retaining wall to provide rigidity during the assembly of the wall. After the stretchers 12 are all secured to the T-posts, the cross braces may be removed and the minimal volume of backfill then is placed. If desired, they may be left in place for added strength.

In Figure 2 a fragmentary side elevation view in partial cross section is shown of the T-posts. A clearer view of the configuration of the rear part of the T-post is

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shown in Figure 6, and reference to it at this point is suggested. The T-post 10 is shown with its front flange 18 and back web 20. The front surface of flange 18 is flat, but its rear surface is faceted and consists of a series of alternate angularly disposed flat bearing surfaces 22 and connecting surfaces 24 disposed on each side of triangular stretcher supports 26. Neither of these surfaces 22 or 24 is parallel to the front surface of the flange, but bearing surfaces 22 against which the stretchers 12 bear is inclined thereto at the same angle as the intended slope of the T-posts and the wall. In other words, bearing surface 22 is inclined with respect to the flange so as to be vertical when the T-post 10 is installed. Connecting or transition surface 24 is inclined at an angle which is determined by the intended slope of the T-posts, the vertical extent and spacing of the stretchers 12, and the shape of stretcher supports 26. These supports are triangular-shaped surfaces extending between each side of web 20 and the rear surface of the flange 18. The weight of stretchers 12 is transmitted to the T-posts through these supports. A series of openings 28 is provided through the web 20 immediately above the stretcher supports 26 and at a distance back of the bearing surface 22 equal to the thickness of stretchers 12. As is noted in Figure 2, the stretchers are held with their front and back surfaces in vertical planes and are spaced apart from one another, the embankment bearing against their rear surfaces.

In Figure 3 is shown a semi-schematic side view of the stretchers 12, supported as above described in their spaced-apart, stepped-back positions. The embankment being retained is indicated generally at 30 resting against rear surfaces 32 of the stretchers 12, and forming the front exposed earth surfaces 34 extending from lower rear edge 36 of each stretcher angularly downward to the rear surface 32 of the next lower stretcher at the normal angle of repose α . This angle is either known or readily determinable for all loose solid materials for which such retaining walls are used. It varies from a minimum of about 24° for muck to about 45° for coarse sand. A value of about 33° is typical of sandy loam. The angle θ which a line drawn through lower rear edge 36 of one stretcher and through upper rear edge 38 of the next lower stretcher makes with the horizontal is always less in this retaining wall than the normal angle of repose α for the material retained. This ensures that the retained earth will never spill over the top edges of any of the stretchers. The angle θ of course is determined by the design of the T-post, mainly its slope and vertical spacing of stretcher supports 26 as is obvious from an inspection of Figure 2.

Figures 4 and 5 are views of the T-post 10 taken at right angles to each other and in partial cross section illustrating one satisfactory manner of securing the ends of the stretchers 12 thereto. Previously described elements are here indicated by the same numbers. Figures 4 and 5 will be described together.

The adjacent ends of stretchers 12 rest upon supports 26 between rear bearing surface 24 and web opening 28. An anchor 40, embedded in the T-post flange 18 during its fabrication, is disposed in the flange adjacent rear bearing surface 22. A tie plate 42 extends through web opening 28 against the rear surfaces of the ends of the adjacent stretchers 12. Through corresponding holes in the ends of anchor 40, stretchers 12, and tie plate 42, are extended anchor bolts 44 and 46 tightened by nuts 48 and 50. This structure ties the stretchers 12 and T-posts 10 into a single rigid unit.

The stretchers 12 are preferably precast concrete planks which should be reinforced with steel, and which are preferably prestressed by any known applicable method. The lower stretchers are increased in thickness in direct proportion to the soil loading from the retained earth, which in turn is proportional to the soil depth above each plank. Reinforcing or prestressing wires 53 are

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indicated in Figures 4 and 5 and disposed nearer the front surface of stretcher 12 than the rear surface. They are placed in tension when the load is applied, and are preferably prestressed. Because the wires are off center and in tension, the plank is deflected at its center back against the earth to be retained so that its front fibers are in compression and its back fibers are slightly in tension. With applied load, these prestresses tend to be relieved, the initial deflection is neutralized, while the concrete compressive stress in the back face of the plank increases. With a slightly greater or full design load, the normal outward deflection of the stretchers occurs and the normal fiber stresses of compression in the back fibers and a slight tension in the front fibers exist.

The T-post 10 is precast concrete which should be reinforced with steel and preferably prestressed by any known applicable method. Reinforcing or prestressing wires 55 are indicated in Figures 4 and 5. Since the web is in tension and the flange in compression when this post is loaded, the web is provided with one or more steel reinforcing rods running through it. A more preferable modification is a T-post whose web is prestressed by means of at least one high strength alloy steel reinforcing wire anchored in and extending longitudinally through the web, which wire is pretensioned prior to casting the concrete beam. This places the web of the finished beam under a precompression when unloaded and forces the T-post to deflect slightly at its top back toward the earth before the earth load is applied to it through the plank stretchers. With applied earth load, the T-post straightens relieving the concrete precompression in the web and increasing concrete compression in the flange. Additional stabilizing reinforcing steel or prestressing wires 57 and 59 may be required by design considerations. Prestressing wires 55, 57, and 59 are tied together with steel reinforcing stirrups 61 located in the web.

The outward deflection of the stretchers and the T-posts provides an additional advantage. During the normal backfilling of a retaining wall, certain passive earth pressures in excess of the designed active earth pressures are imposed on the back of the wall. The outward deflection of the stretchers and T-posts of ± 0.1 inch will remove the excessive earth pressures without the outward tipping of the retaining wall. Relief of such pressure on the wall of this invention forms no void behind it since the planks and T-posts are elastic and move back with the loss of earth load.

Such prestressing of the T-posts and plank stretchers in the retaining wall of this invention very substantially reduces the required size of the structural elements used in this wall to support a given load. Careful balancing of the prestressing forces and the load may be utilized to give an undeflected though loaded system of elements.

In Figure 6 is shown a rear semi-isometric view of the T-post and stretcher construction. The actual configuration of the web and stretcher supports is more clearly shown. Again, previously described elements are similarly designated, and a reference to the above description of Figure 2 is made.

In Figure 7 is shown a simplified side elevation view of the T-post and the manner of securing it in the ground for retaining walls not exceeding approximately 10 feet in height. As shown, T-post 10 inclines back at an angle against the embankment, not shown, and extends below ground level 52, to a designed depth in a bore hole 54. The lower end of the T-post 10 is placed in a post hole 54 drilled or dug into the earth. A trench, not shown, is dug between adjacent T-posts and the required one or more sub-grade stretchers 58 and 60 are installed. The hole around the T-post is filled with grout 56 up to the bottom of the lowest stretcher 58. The remaining part of the post hole 54 and the trench are carefully backfilled at 63 to grade 52.

In Figure 8 is shown a simplified side elevation view of the T-post and the manner of securing it in the ground

for retaining walls 8.0 feet to 30.0 feet high. As shown, T-post 10 inclines back at an angle against the embankment, not shown, and extends below ground level 52. The lower end of the T-post is placed in opening 64 in the upper surface of T-footing 62. As in Figure 7, one or more sub-level stretchers such as 58 and 60 are disposed between adjacent T-posts in a trench in this modification also in order to resist further the overturning moment of the supported embankment, and to resist forward sliding of the entire wall. The trench is then back-filled at 63. These sub-grade stretchers should be reversed front for back relative to the above-grade stretchers so that the steel reinforcing or prestressing elements are nearest the rear surface. Underground footing elements 62 are disposed below grade 52, run back into the embankment a short distance behind the T-post only, and are provided with an upward opening 64 in the front adapted to receive the lower end of a T-post. They are also precast concrete members, reinforced and prestressed if desired by means of wires 65 and 67. Backstay 66 is used in this modification and is anchored at 68 in the rear end of the T-footing element 62 and at 70 located about two-fifths of the T-post height from its lower end.

Either one or the other of the base anchoring structures shown in Figures 7 and 8 may be employed depending on the particular load conditions met in any given installation.

Referring finally to Figure 9, a modified end attachment for securing ends of sub-grade stretchers 12 to the T-posts 10 is shown. Tie plate 42 again extends through web opening, anchor 40 and anchor bolts 44 and 46 are also used as in Figure 4. A U-bolt or strap 72 extends across the front face of T-post flange 18 around the flange sides, and through the ends of tie plate 42 to nuts 74 and 76. This is a stronger attachment and is particularly well adapted to secure the ends of sub-grade stretchers 58 and 60 shown in Figures 7 and 8, from being forced away from the bearing surface 22 of the T-post 10 due to overturning or sliding earth forces against the sub-grade stretchers.

As an example of the application of this invention to the retaining of an embankment, the following data are given: The embankment to be supported consisted of sandy loam having a normal angle of repose of about 33°, and was to be supported to a height of 10.0 feet with level backfill and no surcharge loading. The T-posts were precast and prestressed concrete, 19.0 feet in length, and had a 16.0 inch deep web. The flange width was 12.0 inches. The T-posts were grouted into auger holes 18 inches in diameter and bored 8.0 feet into the ground at an 18° angle, the slope of the posts, and were spaced on 10.0 foot centers. The stretchers were also precast, prestressed concrete 9.70 feet long, 12 inches wide and varied from 2.25 to 3.5 inches thick. Two prestressing wires centered 6.0 inches apart were used in the stretchers and wire 0.75 to 1.0 inch from the front face. The structure successfully supported the embankment, and due to the prestressing the stretchers required were only 2.25 (at the top) to 3.5 (at the bottom) inches thick, compared to a required thickness of 4.0 to 8.0 inches for ordinary concrete. No hydrostatic pressure buildup behind the wall occurred. No sliding, or overturning moments were measurable.

A particular embodiment of the present invention has been herein described and illustrated in considerable detail by way of illustration. It should be understood that various other modifications and adaptations thereof may be made by those skilled in this particular art without departing from the spirit and scope of the present invention as defined by the following claims.

I claim:

1. An improved retaining wall which comprises at least two posts of generally T-shaped cross section having a perforated web and extending upwardly from below

grade and at an incline back toward the mass retained, a plurality of parallel, spaced-apart substantially horizontal shelves disposed along said T-post on either side of said web and extending from each side of said web to the back surface of said flange, a plurality of parallel stretchers supported on their ends at said shelves in a stepped back relation to each other and extending substantially horizontal between said T-posts, said stretchers being spaced apart from one another sufficiently to provide an open retaining wall face, but not sufficiently to permit the mass retained to spill out therebetween, and securing means extended through each of said perforations in said web securing the end of said stretchers to the back surface of the flange of said T-post.

2. A retaining wall according to claim 1 wherein said stretchers are plank-shaped and are disposed along said T-post against the embankment in a stepped-back spaced-apart relation to each other so that a line drawn through the wall grazing the rear lower edge of one stretcher and the rear upper edge of the next lower stretcher makes an angle θ with the horizontal which is less than the normal angle of repose α of the material retained.

3. A retaining wall according to claim 1 wherein said securing means comprises a flat plate which overlaps the back sides of adjacent ends of the longitudinally aligned stretchers, an anchor embedded in the flange of said T-post adjacent said perforation, and at least two bolts extending from said flat plate through openings in the end of said stretchers into said anchor.

4. A retaining wall according to claim 1 in combination with at least one sub-grade stretcher extending between adjacent T-posts entirely below ground level and parallel to the above-grade stretchers to resist any sliding and overturning forces.

5. An improved prefabricated field erected retaining wall for embankments of earth and the like which comprises a plurality of parallel T-posts disposed flange forward and web back sloping upwardly and back against the embankment, said web being provided with a plurality of spaced openings along its length, a plurality of flat triangular-shaped support shelves precast in said T-post and extending from each side of said web between adjacent openings to the rear surface of said flange providing a substantially horizontal upper surface on each shelf, a plurality of precast concrete stretchers extending substantially horizontally between adjacent T-posts and supported at their ends on corresponding support shelves, said stretchers being supported with a vertical front surface one above the other in a spaced-apart stepped-back parallel relation along the T-posts to provide an open retaining wall face through which seeping water may flow and so that earth in the embankment retained rests against the rear vertical surfaces of each stretcher and spills forward and downward from below the lower edge of one stretcher at the angle of repose against the rear surface of the next lower stretcher along a line below the upper edge thereof, and connecting means extending through each of said spaced web openings and overlapping the ends of the adjacent stretchers to secure them to the said T-post.

6. A retaining wall according to claim 5 wherein said T-posts are extended downwardly in post holes along the bottom of said embankment, in combination with a mass of concrete poured into each hole around the foot of each post.

7. A retaining wall according to claim 5 in combination with a concrete T-footing disposed at the lower end of each of said T-posts with its cross arm parallel to and below said stretchers and its body portion running back into the embankment, said T-post resting in an opening in the upper surface of said T-footing at the juncture of said cross arm and said body portion thereof, a backstay extending upwardly at an angle from the rear end of said body portion to the web of said T-post, in combination with at least one sub-grade stretcher disposed in

a trench between said T-posts parallel to the above-grade stretchers to provide a firm foundation for said wall.

8. A retaining wall according to claim 5 wherein the flange of said T-post is provided with a flat front surface and a faceted rear surface; said rear surface consisting of a vertical flat bearing surface disposed at right angles to and extending upwardly from each of said support shelves and inclined with respect to said front surface at an angle equal to that of said T-post from the vertical and against which the ends of said stretchers are forced by the pressure of said embankment, and an angular transition surface extending from the outer edge of said triangular support shelf to the upper edge of the next lower flat bearing surface.

9. A precast concrete field assembled retaining wall for earth embankments and the like which comprises a plurality of parallel T-posts disposed flange forward and web back sloping upwardly and angularly back against the embankment, at least one pretensioned prestressing wire extending longitudinally through the web of said T-post to give the top of said post an unloaded deflection back toward said embankment counter to that of the intended embankment load, the T-post web being provided with a plurality of openings therethrough spaced along its length, a plurality of triangular-shaped substantially horizontal support shelves along the length of said T-post and each shelf extending from each side of said web between each of said openings to the rear surface of said flange, a plurality of precast concrete stretchers extending substantially horizontally between adjacent T-posts and supported at their ends on corresponding support shelves, at least one pretensioned prestressing rod extending through each of said stretchers nearer the front surface so as to give the center part of said stretchers an unloaded deflection back toward said embankment counter to that of the intended embankment load, said stretchers being supported with an open vertical front surface one above the other in a spaced-apart stepped-back parallel relation along the T-posts providing an open front face through which seepage can flow and so that earth in the embankment retained rests

against the rear vertical surfaces of each stretcher and spills forward and downward from below the lower edge of one stretcher at the angle of repose against the rear surface of the next lower stretcher along a line below the upper edge thereof, and connecting means extending through each of said spaced web openings and overlapping the ends of the adjacent stretchers to secure them to the said T-post.

10. A retaining wall according to claim 9 wherein said stretchers are of rectangular cross section and elongated in the shape of a plank.

11. A retaining wall according to claim 9 wherein the flange of said T-post is provided with a flat front surface and a faceted rear surface; said rear surface consisting of a flat vertical bearing surface disposed at right angles to and extending upwardly from each of said support shelves and inclined with respect to said front surface at an angle equal to that of said T-post from the vertical and against which the ends of said stretchers are forced by the pressure of said embankment, and an angular transition surface extending from the outer edge of said triangular support shelf to the upper edge of the next lower flat bearing surface.

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UNITED STATES PATENT OFFICE
Certificate of Correction

Patent No. 2,880,588

April 7, 1959

George R. Moore

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, after line 11, insert the three following paragraphs which were inadvertently omitted:

It is a specific object of this invention to provide a prefabricated concrete retaining wall suitable for field erection from simple individual elements which eliminates up to about 95% of the preliminary excavation or backfill, or both, previously required.

Other objects and advantages of this present invention will become apparent to those skilled in this particular art as the description and illustration thereof proceed.

Briefly the present invention comprises a retaining wall suitable for supporting earth embankments and which consists of a plurality of posts sloping upwardly and back along the bank to be supported and supporting therebetween a plurality of horizontal and parallel plank stretchers spaced apart from one another. A space is provided between the stretchers through which seepage may escape from behind the wall. The passage of earth between the plank stretchers is prevented by making the spacing between adjacent planks relative to the back slope of the wall such that a line drawn through the wall and grazing the rear lower edge of one plank and the rear upper edge of the next lower plank makes an angle with the horizontal which is less than the normal angle of repose of the earth to be retained. This permits the earth to spill out from below the lower edge of one plank against the back surface of the next lower plank some distance below the upper edge of the latter. This permits escape of seepage between the stretchers without disturbance of the soil, as well as planting of the exposed soil with decorative plants to stabilize it.

Signed and sealed this 11th day of August 1959.

[SEAL]

Attest:
KARL H. AXLINE,
Attesting Officer.

ROBERT C. WATSON,
Commissioner of Patents.