A coupling means for interconnecting the several sections of a sectional pile structure which includes tubes of deformable material embedded in and opening through the adjacent ends of the pile sections, and elongated connectors also of deformable material having bifurcated end portions for reception in the respective tubes. Wedges operatively associated with these end portions engage abutment within the tubes to separate the furcations, forcing them outwardly into expanding engagement with the tube to locally expand the latter and thereby to provide an interlock between each tube and the connector. Concurrently with the local expansion of each tube in a given direction transversely to its length, there occurs a compensating contraction thereof in a direction transverse to its expansion whereby to relieve stress and to minimize the likelihood of splitting the tube, while at the same time, interlocking the tube and connector against relative angular movement.

12 Claims, 8 Drawing Figures
SECTIONAL PILE AND COUPLING MEANS

This invention relates to an improved coupling means and to the combination thereof with the interconnected pile sections of a sectional concrete pile or other structure.

In accordance with the invention, the coupling means comprise an elongated coupling tube of deformable material which is open at one end and has an abutment therein spaced from its open end. An elongated connector of deformable material has a bifurcated end portion received in the tube. A wedge operatively disposed between the funications of such end portion has a shank projecting longitudinally from between the funications, said shank being adapted for endwise engagement with, but disconnected from, the abutment and functioning to relatively spread the funications as the connector is forced into the tube to locally expand a portion of the tube in a first direction transversely to its length while contracting it in a direction normal to the first direction so as to interlock the tube and the connector against relative lengthwise and angular movement.

In accordance with a further feature of the invention, the free ends of the funications extend longitudinally toward the abutment beyond the maximum thickness portion of the wedge and are forced inwardly and rearwardly of the maximum thickness portion of the wedge and toward the shank by camming engagement with the relatively opposed convergent inner surface areas of the tube beyond the locus of maximum expansion of the latter.

In the preferred use of the coupling means of the invention, in combination with the pile sections of a sectional concrete pile, the tubes are firmly anchored against lengthwise displacement in their respective pile sections and each pile section is formed with an internal void around the respective tubes at locations to accommodate the local expansion of the tubes without damage to the surrounding pile structure. Such voids may conveniently be formed by wrapping or encircling each tube at the desired location with a compressible material which displaces the concrete as the latter is poured therearound during the casting of the concrete pile section.

In accordance with the preferred embodiment of the invention, the arrangement is such that the connectors with their associated wedges are loosely disposed in the coupling tubes of aligned pile sections as the latter are brought toward each other, the abutments within the tubes being brought into operative engagement with the wedges, while the adjacent ends of the pile sections are still spaced apart, so that the first few blows or impacts of the pile driver on the associated sections will then be transmitted through the said abutments to the wedges to firmly establish the coupling by expansion of the bifurcated ends of the connector and of the surrounding portions of the respective tubes into interlocking relation.

The positions of the several parts will preferably be so related that the adjoining ends of the pile sections will abut each other and terminate such expansion at the optimum stage thereof.

The preferred embodiment of the invention together with one minor modification thereof is illustrated in the accompanying drawings in which:

FIG. 1 is a perspective exploded view of the adjoining end portions of relatively aligned pile sections, together with the coupling means for interconnecting the same, the pile sections being relatively spaced apart prior to the establishment of the coupling or interconnection.

FIG. 2 is a cross-sectional view through the adjacent end portions of the pile sections showing the pile sections and their associated closely assembled relation with the pile sections still spaced apart and in readiness to be forced into endwise abutment, whereby to actuate the coupling means.

FIG. 3 is a view similar to FIG. 2, but with the pile sections in endwise abutment and the coupling means firmly engaged.

FIG. 4 is an enlarged detail view showing but a single coupling tube and its cooperating end portion of the connector rod and wedge in substantially the position they occupy in FIG. 2, prior to their actuation to interlock the coupling tube and connector to each other.

FIG. 5 is a view similar to FIG. 4, but showing the parts as they appear following establishment of the interconnection or coupling.

FIG. 6 is a section on the line 6--6 of FIG. 5; and,

FIG. 7 and 8 are views corresponding respectively to FIGS. 4 and 5, but showing a modified construction on the connector and its associated wedge.

Referring now in detail to the accompanying drawings, the numerals 10--10 therein designate the adjacent end portions of concrete pile sections adapted for interconnection to form a sectional pile of substantially any desired length.

Each of the pile sections 10 here shown preferably has a uniform cross-sectional shape of equilateral triangular configuration having the corners or angles thereof truncated or bevelled as shown and having end faces 12--12 in planes normal to the length of the pile section.

Pretensioned reinforcing cables 14 are cast into the pile sections in parallel relation to each other, preferably adjacent the respective angles so that they themselves define the corners of an imaginary equilateral triangle having its sides uniformly spaced inwardly from the external side surfaces of the pile sections.

One or more elongated permanently deformable coupling tubes 16, preferably of a suitable metal such as steel, may be embedded in opposite ends of each section. It is desirable, though not essential, that such coupling tubes be initially of circular cross-section. The longitudinal axes of such tubes extend parallel to those of the pile sections and in the present instance are coincident therewith. Each of the coupling tubes 16 extends to and has an outer end co-terminus with the adjacent end face 12. At a location longitudinally spaced from its outer end, the tube is provided with a fixed abutment 18 which may comprise a flat anchor plate extending in a plane transversely to the length of the section and secured in flush abutting relation, as by welding, to the inner end of the inner end of the tube around the full circumference thereof to resist radial deformation of the tube as well as to close its inner end.

At a location adjacent the inner end of each coupling tube, the concrete material of the pile section is formed to define a void 20 around the tube to permit transverse or diametrical expansion of the tube without damage to the surrounding concrete material. In other words, the void defines a suitably located space into which the tube may readily be expanded without cracking or crumpling the surrounding concrete. Such a void may be defined by a wrapping 22 of readily compressible material such as foam plastic encircling the midportion of the tube as shown, so that when the concrete in plastic form is cast therearound in manufacture of the pile section, the wrapping results in the formation of a correspondingly shaped hollow or void in the concrete as the latter sets and cures.

The coupling tubes 16 constitute elements of a suitable coupling means by which a plurality of pile sections 10 may be interconnected in end to end abutting and aligned relation to form a sectional or composite pile consisting of any desired number of said sections. Preferably and, in accordance with conventional practice, there will be interposed between the abutting ends 12--12 of each pair of interconnected pile sections, a flat cushion or pad 23.

The coupling means for each interconnected pair of pile sections also includes an elongated connector or connector rod 24 of a deformable material of high-tensile strength such as steel having opposite bifurcated end portions freely receivable in the respective aligned coupling tubes 16 of the pile sections to be interconnected. Such bifurcated end portions of the coupling rod are adapted for expansion transversely to the length of the connector and its associated tubes.

To this end, the longitudinal slots 26 between the funications 27 at the respective ends of the connector rod are adapted for operative reception of and expansion by wedges 28. The wedges 28, respectively, have shanks or butt end portions 30 projecting longitudinally from between the funications 27 for
endwise thrusting engagement with the anchor plates or abutments 18 of the coupling tubes, thus to expand the connector rod bifurcated ends transversely into locking relation with their respective tubes as the pile sections are forced into endwise abutting engagement with each other.

Normally, before the coupling connectors 24 are assembled with the respective tubes 16 and expanded into locking engagement therewith, the wedges 28 will be operatively positioned and retained in the slots 26 of each coupling rod in position for actuation, preferably by means of a conventional tape or tensile means 32 encircling each slotted end portion with its associated wedge. It will be understood that the tensile means 32, through sufficiently strong to maintain the wedge and rod in properly associated relation, will have insufficient tensile-strength to interfere with expansion of the bifurcated ends of the coupling rod when the wedges are forced longitudinally into the slots during their use.

The wedges 28, connector rod 24 and coupling tubes 16, all are so related in their dimensions that after a connector rod with its wedges 28 operatively positioned therein, has been loosely placed in the aligned coupling tubes 16 of the still relatively spaced ends of pile sections 10 to about to be interconnected, and a sufficient endwise force is thereafter applied to bring the adjacent end faces 12-12 of these pile sections into abutting relation on opposite sides of the interposed cushion 23, such thrust will be transmitted through the anchor plates 18-18 or abutments at the closed ends of the tubes to the wedges 28. This, in turn, will cause the wedges 28 to fully expand to opposite bifurcated ends of the connector 24 to a transverse dimension appreciably greater than the internal diameter of the tube 16, and at a location within thevoid 20, whereby the tube, in turn, will be locally bulged or enlarged at 34 into said void. Thus, the expanded end of the connector rod will, in turn, have formed a locally enlarged interior portion of the tube in which it is firmly received and interlocked so that the connection rod and its associated coupling tubes provide a strong tensile connection between the pile sections.

Moreover, due to the abutting relationship of the adjacent end faces 12-12 of the interconnected pile sections, such sections will be able to withstand substantial bending stress at the interconnection thus formed.

It is of importance that the enlargement of the connector rod end and each tube 16 associated therewith, is in one diametrical direction only, and is accompanied by a compensating contraction of the tube transversely to its expansion whereby to relieve the stress on the tube. Thus, in general, the arrangement is such as to permit a maximum bulging or expansion of the tube for the purpose of forming an efficient interlock with the rod, while minimizing the danger of splitting the tube in this manner. Furthermore, in accordance with an important feature of the invention, the transverse or diametrical expansion of each tube 16 is controlled and limited by abutting engagement between the end faces 12-12 of the interconnected pile sections 10-10. The parts are preferably so proportioned that the abutment of these end faces 12-12 will occur and expansion of the tubes will cease when the tubes 16 have been expanded and interlocked with the ends of the coupling rod to form a coupling or connection of substantially maximum strength.

In the specific embodiment herein illustrated, it is of importance that in the fully assembled and interlocked relation of a pair of interconnected pile sections, the divergent or thickened butt end of each wedge is located substantially at 18, near the center of each bulged or expanded portion 34 of the tube and that the bifurcated ends 27 of the connector or connector-rod at such time will have moved over and substantially past such butt end have been cammed back inwardly into clamping relation about the butt end of the wedge by engage ment with the relatively opposed inner surface areas of the tubes. Instead the plate of either or abutment 18 therewithby to lock the wedge securely in its operative position so that the wedge cannot thereafter become lose and permit separation of the interconnected piles even though a tial tenstile stress is placed on them, as through withdrawal of piles. In this same connection, it is of importance that the shank 30 of each wedge is at times detached from the anchor plate or abutment substantially away therefrom with the connector in the event of such stress. In other words, such stress will not cause the wedge to be pulled free from wedging relation in the connector.

Otherwise stated, it will be apparent that each wedge has a shank 30 which is of relatively reduced thickness at its junc ture with the maximum first in the endwise portion of the wedge. In the fully expanded condition of the coupling tube 16, the said shoulder normally will be positioned medially of the length of the bulge or expanded portion at or near its maximum point of expansion so that after the expanded or divergent furcations 27-27 of the slotted ends of the connector move beyond the butt end of the wedge 28, they are bent back inwardly behind the said end by camming engagement with the inner surface areas 34 of said expanded portions which converge rear wardly away from the butt end of the wedge and toward the abutment or anchor plate 18.

In the use of the pile sections as above described, the first such pile section 10 will be substantially fully driven as by means of a conventional pile driver, following which a second pile section is coupled thereto and the so interconnected pile sections are again driven. It will be apparent that additional pile sections may be added as required in substantially any desired number to form a sectional or composite pile consisting of any desired number of such interconnected sections.

In order to interconnect a couple together the respective pile sections, it will be apparent, that after each pile section is driven to the desired extent, a connector 24 with the wedges 28 operatively positioned in the slots 20 of its bifurcated ends, is placed in the upwardly opening coupling tube 16 of the driven pile section, following which the pile section to be couple thereto is hoisted into aligned relation with the first pile (as shown in FIG. 1) and lowered until the upwardly project ing end of the connector 24 is received in the downwardly opening lower end of its coupling tube 16 with the wedge 28 thereof having its shank 30 abutting relation with the anchor plate or abutment 18 defining the closed end of said tube. At this time, the relationship of the parts will be substantially as shown in FIGS. 2 and 4. The second or added pile section may be manually angularly orientated about the connector at this time to have its triangular cross-section in vertical registry with that of the pile section therebelow, following which one or more blows of the pile driver on the upper end of the just added pile section and the ensuing thrusting force of the abutments or anchor plates 18 against the wedges 28 of the connector will expand the connector and the tube as the adjacent end faces 12 of the pile sections 10 are brought into abutting relation through the interposed cushion 23, the furcations at the free ends of the connector being simultaneously bent inwardly and clinched in the rear of the maximum thickness butt end of each wedge to prevent its accidental retraction. Upon completion of the coupling, the parts will be related in the manner shown in FIGS. 3 and 5.

The coupling thus formed will obviously be one of extremely high tensile strength permitting retraction or withdrawal from the ground of the interconnected pile sections and capable of strongly resisting any relative bending or misalignment between adjacent pile sections at their coupling point.

In the modified form of the invention illustrated in FIGS. 7 and 8, the construction and arrangement of the individual pile sections 10-10 and their associated coupling tubes 16 and abutments or anchor plates 18 is identical with the arrangement illustrated and described in connection with the preferred embodiment. Here, however, the connector 24 is in the form of a hollow rod or pipe of a suitable deformable metal of high tensile strength, such as steel, having its opposite ends slotted and bifurcated substantially as in the preferred embodiment so as to be transversely expandable in substantially the same manner as in the preceding embodiment.
In this form of the invention, each of the wedges 28' associated with the opposite bifurcated ends of the connector, may comprise semi-cylindrical portions or halves 29 of a cylindrical rod interconnected in forwardly converging relation and welded together at their forward convergent end, the shank 30' of the wedge being received between and welded to the rear end or ends of said portions, which ends define forwardly facing shoulders behind which the furcations of the connector may be clined or bent inwardly toward each other in substantially the same manner as in the preferred embodiment.

It will be apparent here that the semi-cylindrical wedge portions 29 to 29, having their cylindrical faces of substantially smaller diameter than the interior of the connector and the associated coupling tube, will transversely expand or enlarge the connector and coupling tube in one diametrical plane while causing a compensating contraction of the coupling tube in a diametrical plane normal thereto so that the tube is deformed into a substantially elliptical or oval cross-sectional shape.

In both embodiments of the invention it will be apparent that such non-circular deformation of the interlocking portions of the connector and the associated coupling tubes will result in a non-rotatable or coupling between the interconnected pile sections to thus maintain the pile sections in their positions of relative angular orientation about the aligned axis of their respective coupling tubes.

In the embodiments of the invention above described, the opposite ends of the connector have cooperated with separate coupling tubes to establish identical connections or connections. However, it will be apparent that the invention may comprise, but a single tube cooperating with one bifurcated end only of a connector, stud or the like, to firmly anchor the latter in position, as in the case of a conventional expansion bolt.

In this application there is shown and described the preferred embodiment of the invention together with a modification of certain parts thereof, simply by way of illustration of the best mode contemplated for practicing the invention. However, it is recognized that the invention is capable of other modifications and variations within the scope of the appended claims, and, therefore, the foregoing description and drawings are to be regarded as merely illustrative in nature and not as restrictive.

Having thus described my invention, I claim:

1. Coupling means comprising an elongated coupling tube of deformable material open at one end and having an abutment fixed therein in spaced relation to said open end; an elongated connector of deformable material having a bifurcated end portion received in said tube; a wedge having a portion of maximum thickness in a direction transverse to the length of said rod, said portion being positioned between and spaced inwardly from the free ends of the furcations of said bifurcated end portion and said wedge having a shank of less than said maximum thickness projecting longitudinally from between said furcations into engagement with said abutment; said wedge having operative surfaces converging from said maximum thickness portion towards said open end of the tube and in operative wedging engagement with said respective furcations for relatively spreading said furcations in said direction responsive to longitudinal movement of said connector towards said abutment; said tube having a portion internally thereof enlarged in said transverse direction and snugly receiving said spread apart furcations, and further portions internally thereof of lesser dimensions in said direction than said enlarged portion and on opposite longitudinal sides of said enlarged portion for preventing relative longitudinal movement between said connector and said tube.

2. Coupling means as defined in claim 1, wherein said coupling tube has relatively opposed inner surface areas of said expanded portion converging toward said abutment;

the free ends of said furcations extending longitudinally beyond said maximum thickness portion of the wedge converging therefrom toward said shank, being maintained in said converging relation by snug engagement with the said relatively opposed inner surface areas of the tube.

3. Coupling means as defined in claim 1, including a compressible material encircling said coupling tube in longitudinal registry with said maximum thickness portion.

4. Coupling means as defined in claim 1, including means encircling said tube around and in longitudinal registry with said maximum thickness portion to define a void around said tube when said tube is embedded in concrete.

5. A sectional concrete pile comprising a pair of interconnected concrete pile sections in aligned relation in endwise abutment, said pile sections having abutting end faces in planes normal to the length normal thereof; elongated deformable metal tubes embedded in the abutting ends of the respective pile sections in longitudinal alignment therewith and with each other, said tubes being closed at the relatively remote ends; an elongated deformable metal connector having it opposite end portions disposed within the respective tubes, said end portions being formed with longitudinal slots; wedges having portions of maximum thickness operatively disposed in the respective slots and having portions of less thickness be projected longitudinally from the ends of said connector into abutting engagement with said closed end of the respective tubes, said wedges expanding said connector end portions and said tubes transversely to their lengths at locations spaced from the opposite ends of each tube; each pile section being formed with an internal void around its said tube at a location transversely aligned with said maximum thickness portion of a said wedge to accommodate such expansion of the tube.

6. A sectional concrete pile as defined in claim 5 in which said tubes are of normally circular cross-section.

7. A sectional concrete pile as defined in claim 5, including flat anchor plates embedded in said concrete pile sections in planes transverse to the length thereof and in abutting relation to the remote ends of said tubes to close the latter.

8. A sectional concrete pile as defined in claim 7, in which the relatively remote ends of said tubes are firmly secured to the respective said anchor plates around the full circumference of each tube end to resist outward deformation of said ends.

9. A sectional concrete pile as defined in claim 5, wherein said tubes are of normally circular cross-section and are contorted in directions normal to their expansion to relieve the stress on said tubes arising from such expansion.

10. An elongated concrete pile section and means for coupling same in aligned abutting relation to other similar pile sections, to form a composite sectional pile, said pile section having opposite end faces in planes normal to its length; a deformable metal tube embedded in each end portion of said pile section parallel to the length thereof and with the outer ends of said tubes opening outwardly through the respective end faces of the pile section, said tubes having abutments therein spaced from their outer ends; an elongated deformable metal connector adapted for locking reception of its opposite end portions in the adjacent tubes of interconnected pile sections, the opposite end portions of said connector being formed with longitudinal slots; wedges having maximum thickness portions operatively disposed in the respective slots and having reduced thickness shank portions projecting longitudinally therefrom for engagement with said abutments; said assembled connector and wedge being so proportioned that when positioned with the opposite ends thereof in the relatively adjacent aligned tubes of relatively aligned pile sections to be interconnected, and said sections are relatively moved toward endwise abutment with each other, said wedges engage said abutments while the pile sections are substantially spaced from each other, and are urged into said slots by said abutments during movement of said pile sections into endwise abutment, to expand such slotted ends of the connector and the said tubes, at locations spaced from the said abutments,
and to interlock said connector against withdrawal from said tubes, said concrete pile being formed with a void around each said tube at a location transversely aligned with said maximum thickness portion of each wedge in position to accommodate said expansion of the tube.

11. An elongated concrete pile section and coupling means for same as defined in claim 10, wherein said metal tubes and said connector are of circular cross-section whereby each said wedge acts through said connector to diametrically expand its associated tube in a first direction while simultaneously con-tracting said tube in a direction normal to said first direction whereby to relieve the stress on said tube.

12. An elongated concrete pile section and coupling means therefore, as defined in claim 11, wherein said abutments comprise flat anchor plates embedded in said pile section in planes normal to the length thereof, said anchor plates abutting and firmly secured to the inner ends of the respective tubes to close the latter and to prevent radial deformation thereof.

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