

[54] SLEEVED-PILE STRUCTURE

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61/53.7, 53.52; 52/170, 298

[56]

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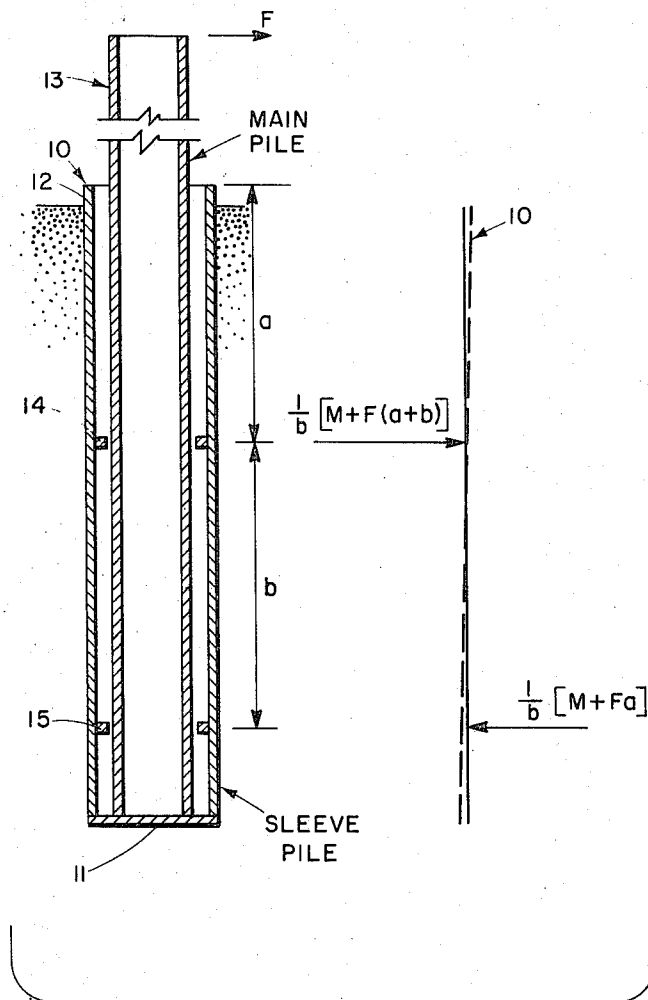
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[57]

ABSTRACT

A sleeved-pile structure is disclosed which improves the distribution of forces between an embedded pile and the adjacent soil region and, for example, permits pile lateral deflections which are predictable and unconstrained by soil strength limitations.

22 Claims, 6 Drawing Figures



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 a. DIRECT-EMBEDDED PILE
 b. PILE SLEEVE

COMPARISON OF BEHAVIOR

$$\text{NOTE } T = \sqrt[5]{EI/n_h}$$

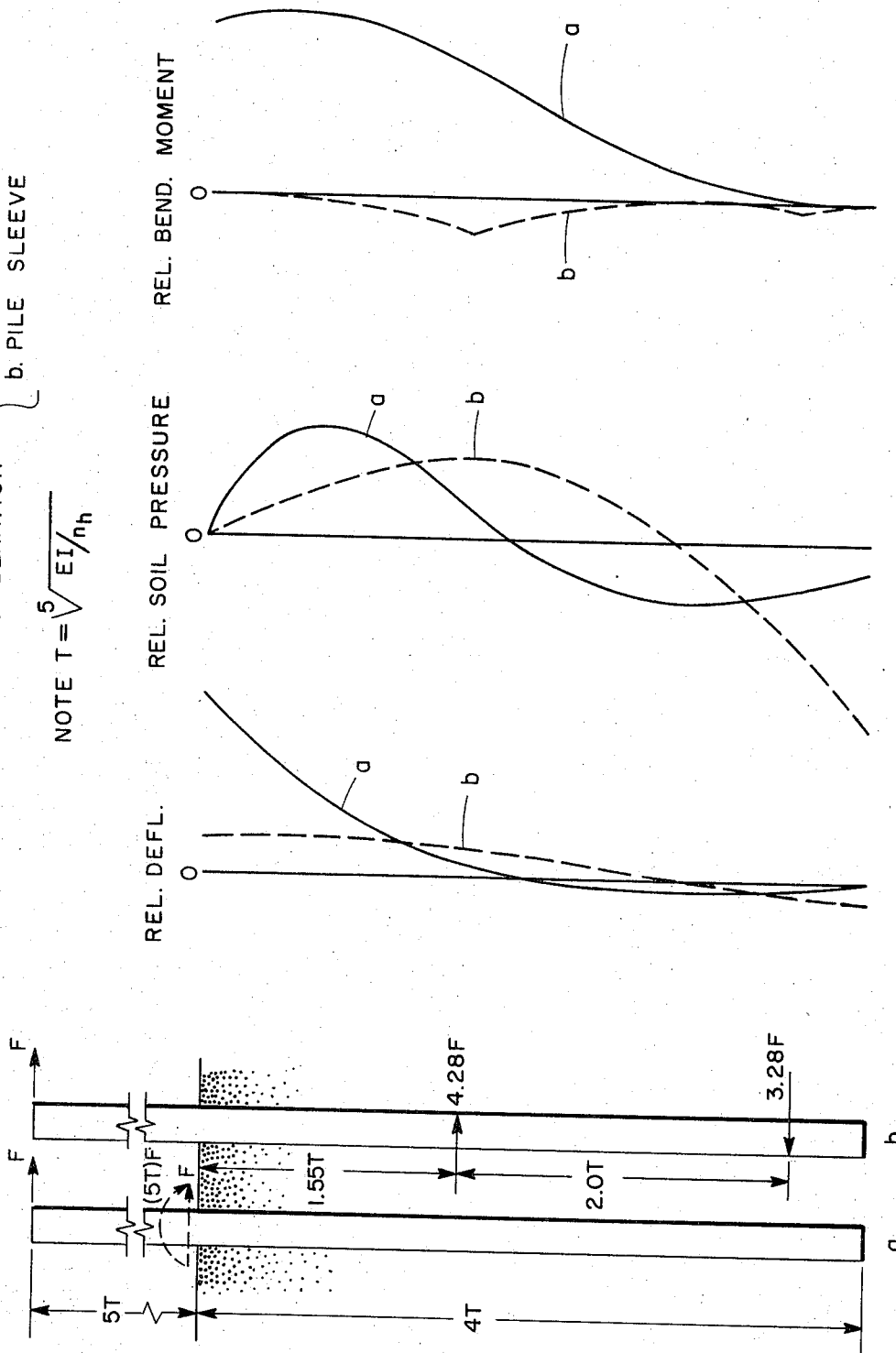


Fig. 3

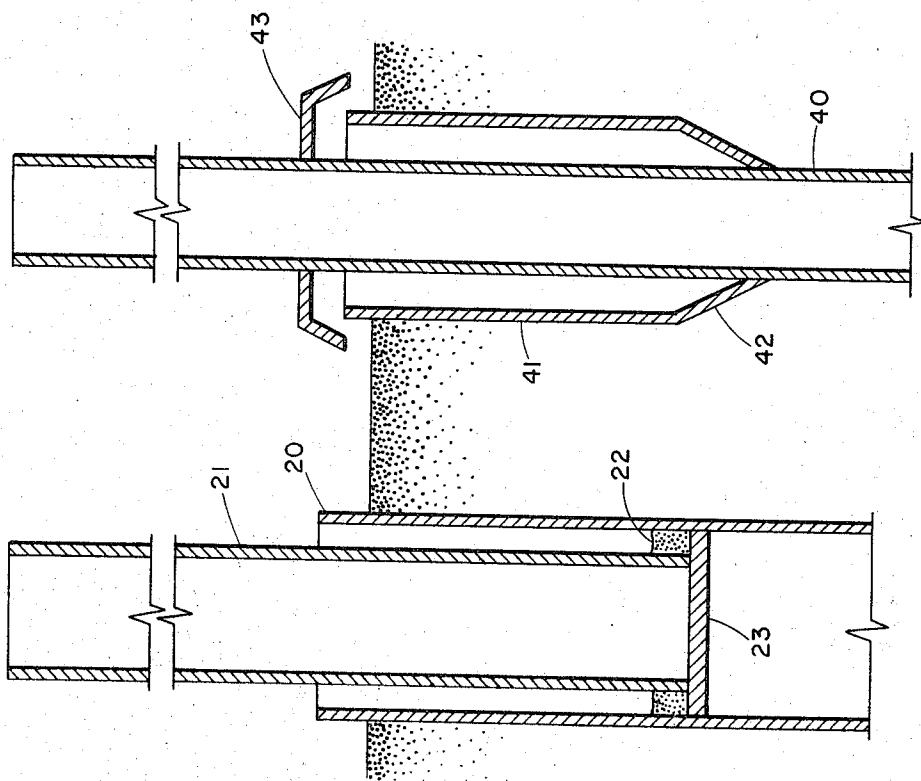


Fig. 4

Fig. 5

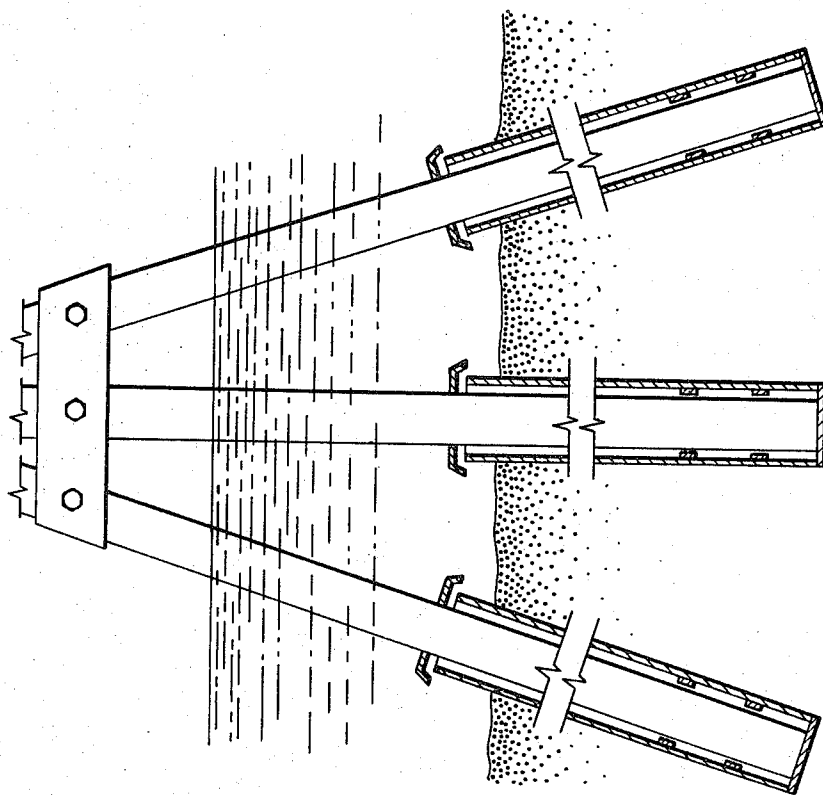


Fig. 6

SLEEVED-PILE STRUCTURE

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates generally to apparatus for and methods of controlling the distribution of forces between a pile and the adjacent soil region so as to improve this distribution in relation to soil strength, and so as to permit pile lateral deflections which are predictable and which are unconstrained by soil strength limitations.

Heretofore, in designing piles for lateral load, engineers have been severely constrained by the stress-strain-time characteristics of the soil and by the interaction between the pile and soil. Thus, for example, large diameter steel pipe piles with their superior elastic energy absorbing capability and terminal strength as compared to the strongest single timber pile have not been utilized to their fullest efficiency as single element dolphins or components of clustered dolphins primarily because the acceptable stress levels for piles in the case of repeated lateral loads must be limited to those levels that preclude or minimize accumulated soil strain and pile displacement.

It is, accordingly, a primary object of the present invention to provide a method for controlling the transfer of load and soil forces between a pile and the adjacent soil region.

It is another object of the present invention to provide a pile structure wherein the pile stress levels are not limited by the problem of accumulated strain in the near-surface soil region.

Another object of the present invention is to provide apparatus for increasing the pile stress levels which may be accepted repeatedly by a pile embedded in a region where soil resistance is low.

Another object of the present invention is to provide a sleeved-pile assembly that is interconnected at one or more discrete subsurface locations so as to restrict the transfer of load forces to these depths.

A still further object of the invention is to provide a sleeved-pile arrangement which prevents the application of undesirable soil forces to the pile.

A still further object of the present invention is to provide a technique for effectively coupling and decoupling piles from pre-selected soil regions.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings wherein:

FIG. 1 illustrates the behavior and response of a conventional pile embedded in a soil region and subjected to lateral loading;

FIG. 2 illustrates one simplified embodiment of the present invention under similar loading conditions;

FIG. 3 is a comparison of the behavior of a direct embedded pile and a pile-sleeve of the present invention;

FIG. 4 illustrates an alternative embodiment wherein the load transfer occurs at a single location;

FIG. 5 shows a modification of the invention where the sleeve terminates at an intermediate soil depth above the remote end of the embedded pile;

FIG. 6 illustrates a cluster of sleeved-piles connected in a dolphin arrangement.

Briefly, and in general terms, the above objects are accomplished by means of a sleeved-pile construction that includes a hollow structural element, termed the sleeve, and an internal load bearing structural element, termed the pile. The sleeve member of this assembly which is effectively closed off at or near its lower end, may be set in the soil by any suitable method including those utilized for the embodiment of conventional piles or caissons. It may be set in place by itself or, as will be seen hereinafter, when permanently connected to an internal pile set together with this pile as a unitary structure.

The pile and sleeve are interconnected for force transfer therebetween in either direction at one or more pre-selected discrete subsoil locations or zones along their common length. The selection of these transfer sites may be made either to achieve a desired distribution of soil pressure in response to forces and displacements applied to the pile or to prevent the application of undesired soil forces to the pile.

From a different point of view, the sleeved-pile construction of the present invention may be considered a solution or technique for selectively coupling and decoupling ground supported structures from favorable and unfavorable subsurface soil zones.

The contrasting performance of prior art pilings as compared with the present invention may perhaps best be appreciated by referring now to FIG. 1 of the drawings which shows a steel tubular pile embedded in an area where soil resistance is low. In this illustrative case, the pile is loaded by a lateral force F that is applied at the free end thereof. It is generally accepted that the embedded portion of such a laterally loaded pile, in the case of cohesionless soil, may be reasonably well represented by a beam on an elastic foundation where the foundation modulus, i.e., soil stiffness, increases linearly from zero at the surface of the soil. This increasing soil stiffness is plotted in FIG. 1. It will thus be recognized that the conventional beam is loaded in the most unfavorable manner possible, that is, with shear and moment applied at the end where soil stiffness is a minimum. Consequently, large deflections at the loading point are inevitable, and this situation is depicted in FIG. 1.

The above discussion explains why for laterally loaded piles it is commonly recommended that applied load magnitudes be limited to 25 to 35 percent of the ultimate single load capacity. This limitation is, therefore, a recognition of the fact that larger repeated loadings will produce accumulated deformations of the soil and accumulated lateral displacements of the pile. Thus, the maximum stress level for a dolphin pile often is established by the near-surface soil conditions and not by the pile's inherent bending strength.

If the embedded portion of the pile shown in FIG. 1 is placed inside a "pile sleeve" having a diameter larger than the pile, this sleeve rather than the pile becomes the beam on the elastic foundation. The loading now can be applied not at the weakly supported end but at pre-selected lower subsoil locations where the soil stiffness is large. This principle is illustrated in FIG. 2. Here, sleeve 10 is embedded in the soil in a manner which prevents any soil from occupying its interior space. Thus, for example, the sleeve may be closed off at its lower end by a suitable end plate 11. This plate may be permanently attached to the sleeve so as to form a unitary structure which may be embedded in

place by any pile driving method. The upper end of sleeve 10 extends a short distance above the soil surface. This is done as one simple way of preventing any surface soil from entering the top of the sleeve. This precaution is necessary since sleeve 10 should not contain any material which can act as a load transfer mechanism between sleeve 10 and main pile 13 disposed therein.

Depending upon the nature of the external load and the means used to transfer lateral forces between pile and sleeve, pile 13 may simply rest on lower plate 11. In this regard, plate 11 may be formed with an appropriate central recess or projection to accommodate the end of the pile and readily support it in a concentric manner. Also positioned within sleeve 10 is the force transfer means previously mentioned. In this showing, this means consists of two shear transmitting diaphragms 14 and 15 spaced apart a distance b with the upper diaphragm a distance a from the free end of the sleeve. These diaphragms which are ring-like members may be secured to the inner wall of sleeve 10 by any suitable process or they may be attached to pile 13. Alternatively, sleeve 10 may be formed with these diaphragms as integral reduced diameter portions thereof. The diaphragms, in this illustrative embodiment, are dimensioned such that a suitable clearance space exists between their inner rims and main pile 13. This clearance allows pile 13 to be introduced into sleeve 10 after the latter is in place. And it permits pile replacement. When the pile and sleeve are permanently interconnected, no such clearance is necessary.

When any lateral force is applied to main pile 13 at its free end, this force now will be coupled from the pile via the transmitting diaphragms to the sleeve at the depths corresponding to the position of these diaphragms. These diaphragms, it will thus be appreciated, because of subsurface locations direct the load forces into soil regions having a more favorable resistance than the near-surface soil region. The resultant deflection of the sleeve is depicted in FIG. 2, and it will be seen that its displacement is considerably less than the prior art pile arrangement depicted in FIG. 1. While sleeve 10 experiences only the limited deflection shown in FIG. 2, pile 13, on the other hand may freely deflect in response to the external load. This deflection will be predictable and unconstrained by the soil strength limitations.

It would also be pointed out in connection with the showing of FIG. 2 that by having the lateral force transfer from pile to sleeve occur at points well below the ground surface, greatly reduced soil pressures occur in the region of soil weakness just below the ground surface. Maximum soil pressures on the sleeve will occur at greater depths where the soil is more resistant to such pressures. Also these soil pressure maxima will be less than the corresponding peak soil pressures on a similarly loaded unsleeved pile. At any given depth, moreover, the soil resistance will be greater for the sleeve than for the unsleeved pile because of the greater diameter of the sleeve. The sleeved-pile, therefore, can accept much greater lateral loads than the same pile without an accompanying sleeve, and in doing so, the sleeve will deflect much less than would the unsleeved pile. This is of particular importance when many load repetitions are required and when the load-deflection characteristics of the pile must be predictable and reproducible through many load cycles.

That the aforementioned benefits are realized from the pile-sleeve of the present invention may perhaps better be appreciated from an examination of FIG. 3 which is a comparison of the behavior of a direct embedded pile and a pile-sleeve. The overall length of the members, for this example, is $9T$ where

$$T = \sqrt[5]{EI/n_h}$$

and where EI is the flexural rigidity and n_h is the co-efficient of subgraded reaction. In the case of the pile-sleeve, the force transfer means in this showing are located $1.55T$ and $3.55T$ below the soil surface.

The arrangement shown in FIG. 2 may serve, by itself, as a single element dolphin structure without the need of complementary energy-absorbing fendering. High energy absorption is realized by using pile 13 in the bending mode. The bending stress levels may be a substantial fraction of the steel yield stress. The elastic energy absorbed is in proportion to the square of the stress intensity. The present invention permits the development of high stress levels, including the utilization of high-yield-strength steels, with the large associated lateral deflections, unconstrained by adverse soil behavior. While the embedded portion of pile 13 will be subjected to very large shear and large bending moment at the mud line, this shear and bending moment will be transmitted into the sleeved-pile well below this line.

Pile 13, in this particular application, may be a large diameter steel pipe, and if appropriate, it may be filled with sand or any other suitable material to increase its energy absorbing capacity. While steel pipe piles are particularly appropriate for dolphins, the piles can be, of course, steel pipes, concrete-filled steel pipes, structural steel pipes, reinforced concrete, prestressed concrete and other suitable constructions. It should also be appreciated that a cluster of these sleeved-piles may be assembled and interconnected in a dolphin arrangement as shown in FIG. 6. Because of the improved soil pressures realized by the sleeved-pile structure, the spacing between the individual piles of such a dolphin may be reduced. This reduction decreases the overall dimensions of the dolphin, and constitutes an important benefit of the present invention when utilized in this manner.

FIG. 4 shows an embodiment of the invention wherein sleeve 20 and pile 21 are permanently interconnected only at a single moment resisting joint 22. A suitable closure plate 23 may be secured to the remote end of pile 21 to prevent entry of soil into the annular space between this pile and sleeve 20. The moment transfer element 22 normally will fully seal the annular space between pile and sleeve. Since there is no need to prevent soil intrusion into the interior of the pile itself, the additional closure plate 23 may, if desired, be omitted. In this respect, there may be cases where it is advantageous to allow soil to come up inside the interior pile; i.e., to lessen the driving resistance.

FIG. 5 shows an alternative construction wherein sleeve 41 surrounds only an upper portion of the embedded pile 40. Sleeve 41 has its lower end portion tapered at 42 to facilitate the driving operation. This arrangement also constitutes a more economical use of material. Also, it would be pointed out, that the large diameter sleeve 41, the tapered portion 42 and that portion of the main pile 40 which is below the tapered section together function as a variable diameter sleeve.

Thus, this arrangement is functionally similar to that shown in FIG. 4. A cap 43, secured to pile 40, overhangs sleeve 41 to effectively close the opened end of this member.

The radial clearance between the pile and the sleeve, it will be appreciated, is governed by elastic distortions at the desired bending stress levels, by fabrication practices, and by the degree of out-of-round which may be expected to develop during the driving operation.

The pile and its associated sleeve may be permanently joined to each other by welding or by casting concrete in the annular space between them at pre-chosen zones along their common length. As mentioned hereinbefore, the pile may be embedded as a complete assembly or the sleeve may be embedded and the pile subsequently placed within it. In the latter case, the force transfer means should be designed to permit removal and replacement of a worn, corroded or otherwise damaged pile.

For many installations, a principle function of piles is to transfer vertical load from a superstructure into the soil below. In some such installations, it is desired to provide lateral flexibility in the foundation, either to accommodate non-load displacements of the superstructure which may be caused by its internal strains, or to improve the dynamic response of the structure to earthquake motions. Conventional piles do not provide this lateral flexibility because the soil resists lateral displacement of the pile. By providing the pile with a sleeve proportioned to provide adequate annular clearance between the pile and sleeve over the proper vertical depth below the ground surface, the pile may bend unconstrained by the soil. The pile can be designed for the proper combination of flexural rigidity and sleeved length to provide the lateral flexibility required. Typically, this flexibility results in very small lateral forces; indeed, the flexibility is provided for the purpose of minimizing such forces. However, whatever the magnitude of the transverse forces in the pile, they may be easily transferred to the sleeve at one or more points well below the ground surface.

The sleeve pile concept of the present invention encompasses arrangements for which there are no structural connections between pile and sleeve. The pile may pass through the sleeve transferring all of its axial and transverse forces directly to the soil or to an underlying stratum or rock or other firm bearing material below the sleeve. In this usage, the primary function of the sleeve is to hold the soil apart from the pile while permitting the pile to bend unconstrained by the soil resistance. This permits the designer to provide a predictable degree of lateral flexibility unimpeded by restraining soil pressures on the pile.

Some piles whose primary function is to transfer vertical force from the structure above into the ground below must pass through soil strata which tend to apply "negative skin friction" loading to the pile, i.e., a downward loading in addition to the downward load applied at the pile top. By utilizing the sleeve of the present invention over a portion of the pile length and by thus holding the soil apart from the pile, such as shown in FIG. 5, this undesirable negative skin effect may be eliminated. In such an application, any structural connection between pile and sleeve would serve only to laterally stabilize the pile, and these details would be such as to allow relative axial displacement of sleeve and pile.

In those situations and applications where force transfer means is present between the sleeve and pile, the embedded sleeve should behave as a "long pile." What constitutes a long pile is well known in the art. In cohesionless soil, for example, an embedded length which is at least three or four times the quantity $\sqrt[5]{EI/n_h}$ is generally considered sufficient for purposes of this definition.

For other soils the proportions required to assure "long pile" behavior are defined in a different manner than for piles in cohesionless soil, but the long pile behavior concept is well understood in the art. The invention here disclosed is not limited to cohesionless soils but is applicable to a wide range of soils and soil conditions.

For a discussion of the behavior of long and short piles, see the article entitled "Lateral Resistance of Piles in Cohesionless Soils" by Bengt B. Broms, which appeared in the May 1964, Journal of the Soil Mechanics and Foundations Division, Proceedings of the American Society of Civil Engineers, and especially pages 124, 125 and 128 thereof. Reference may also be had to pages 8-115 to 8-119 of the "Handbook of Ocean and Underwater Engineering" by Myers, Holm and McAllister, published by McGraw-Hill Book Company, 1969, for additional information on long piles. A long pile may also be defined as a pile of such embedded length that when subjected to a lateral loading applied above the ground surface, any increase in its length produces no significant change in the distribution of lateral soil pressure.

It should be recognized that fundamental to the sleeved-pile concept is the prevention of force transfer between pile and sleeve throughout their common length except at such connection points as are purposely chosen. For this reason, the annular space between pile and sleeve may contain water or other liquid but must be essentially free of any material which can transmit lateral forces from pile to soil or in the reverse direction, at unwanted elevations. Normally, as mentioned hereinbefore, a welded or concrete seal at the appropriate location will prevent any intrusion of soil into the annular space during embedment.

Intrusion of soil at the upper end of the sleeve, as mentioned hereinbefore, may easily be prevented by extending the sleeve a small distance above the ground surface. In an underwater location, this can be accomplished, as shown in FIG. 5, by a cap fastened to the pile and overhanging the sleeve with sufficient clearance to permit the desired relative displacements. Alternatively, a very flexible seal may be connected between pile and sleeve at the top of the sleeve.

In its broad concept, the sleeved-pile assembly is independent of any means such as jetting which may be employed to facilitate its embedment in the soil. Likewise, the combination may make use of any common structural materials, concrete, timber, metals alone or in combination. The sleeve may be of different geometrical cross-sections such as circular or polygonal or a multiplicity of sleeves in the form of single or multiple cells may be used which have uniform or varying dimensions along its length. By the same token, no limitation is placed on the geometrical cross-section of the pile and this structural member may be solid or made up of a plurality of thin elements.

The structural connections utilized for the transfer of forces between pile and sleeve depends upon the par-

ticular pile loading encountered and the desired behavior sought. The connection may be designed to transfer axial force components, transverse force components, moment components about the pile axis, moment components about transverse axis singly or in combination. For example, axial force components may be transferred by simply attaching a collar to the pile and having it rest on the upper ring diaphragm shown in FIG. 2.

What is claimed is:

1. A structural assembly comprising in combination
 - a pile;
 - a sleeve surrounding a longitudinal portion of said pile;
 - force transfer means interconnecting said sleeve internally to said pile at one or more selected locations along their common length; and
 - means for preventing soil from entering the interior space between said pile and sleeve above said force transfer means and occupying this space when said pile and sleeve are embedded in a soil region.
2. A structural arrangement comprising in combination
 - a pile;
 - a sleeve surrounding a longitudinal length of said pile;
 - force transfer means interconnecting said pile and sleeve at only pre-selected space locations; and
 - sealing means for closing the interior space between said pile and sleeve at a pre-selected lower sleeve location and preventing soil from occupying this space when said pile and sleeve are driven as a unitary structure into a soil region.
3. A structure comprising
 - a pile;
 - a sleeve disposed about a longitudinal portion of said pile; and
 - means interconnecting said pile and sleeve and sealing the space therebetween at a lower location along their common length such that when said pile and sleeve are driven into the soil as a unitary structure the sealing between said pile and sleeve prevents soil from entering the space within said sleeve that is above said lower location, said means interconnecting said pile and sleeve comprising the only force transfer means between said pile and sleeve.
4. In an arrangement as defined in claim 3 an additional force transfer means between said pile and sleeve at a location within said sleeve that is above said lower location.
5. A dolphin comprising
 - a sleeve closed off at one end thereof and embedded in the seafloor such that said closed end is at a sub-coil location;
 - a pile positioned within said sleeve with one end thereof supported by said closed end and the other end extending into the fluid medium;
 - means for transferring forces directed against said other end of said pile to said sleeve at one or more discrete pre-selected locations which occur at sub-soil positions along the length of said sleeve where the soil resistance is large compared to that at the near soil surface region.

6. A method for minimizing soil displacement caused by the repeated application of lateral loads to a pile embedded in said soil comprising

embedding a sleeve member which has a diameter greater than said pile in said soil region in a manner which provides a space between said pile and sleeve that is free of any force transferring material; and

interconnecting said pile and sleeve so as to permit force transfer therebetween at pre-selected locations which are remote from the soil surface so that load forces are coupled via this interconnection to the sleeve at depths where soil resistance is relatively large.

7. A cluster dolphin comprising in combination a plurality of pipe piles embedded in the ocean floor in a pre-selected pattern, the upper end of each pile extending above the ocean surface;

a sleeve surrounding a longitudinal portion of each pile,

each sleeve being embedded in the ocean floor such that a soil-free annular space exists between each sleeve and its associated pile along a common length portion thereof and such that the upper end of each sleeve extends above the ocean floor;

force transfer means interconnecting each sleeve and its associated pile at pre-selected locations beneath the ocean floor; and

means for interconnecting the upper ends of the piles to form a cluster dolphin.

8. A structure comprising, in combination

a sleeve closed off at its lower end;

a pile disposed within said sleeve with one end thereof resting on said closed off end,

said pile having a length greater than that of said sleeve; and

means located between said pile and said sleeve at one or more pre-selected positions along their common length which are between the upper and lower ends of said sleeve for transferring lateral forces from said pile to said sleeve only at these positions.

9. In an arrangement as defined in claim 8 wherein the length of said sleeve and its flexural rigidity is such that when said sleeve is embedded into the soil, it behaves as a long pile.

10. A unitary structure comprising, in combination a pile; and

a sleeve having a diameter greater than the size of said pile and a length less than that of said pile,

said sleeve being disposed about said pile and having only its lower end connected to said pile such that when said pile and connected sleeve are driven as a unitary structure into the soil, the soil is prevented from entering upwardly into the interior space that exists between said pile and said sleeve, this soil-free space permitting said pile, when it is subjected to a lateral load, to experience deflections unconstrained by the soil conditions around said sleeve.

11. In an arrangement as defined in claim 10 wherein the length of said sleeve and its flexural rigidity is such that when said sleeve is embedded into the soil, it behaves as a long pile.

12. Apparatus for improving the vertical distribution of lateral soil pressures caused by the lateral loading of a pile set in soil comprising

a sleeve surrounding a longitudinal portion of said pile are embedded in the soil so as to provide around this portion of the pile a soil-free space that extends downwardly from the surface of the soil to the lower end of said sleeve,
the length of said sleeve and its flexural rigidity being such that the embedded sleeve behaves as a long pile; and

means for transferring lateral load forces from said pile to said sleeve only at one or more locations which are below the soil surface.

13. A unitary structural assembly comprising, in combination

a pile;

a sleeve positioned about a longitudinal length of said pile; and

means interconnecting the lower end of said sleeve and said pile and closing off the space therebetween whereby whenever said pile and connected sleeve are set in the soil with the top of said sleeve at or above the soil surface, a soil-free space exists around said pile from the soil surface down to said connecting means,

said connecting means also serving to transfer lateral load forces applied to said pile to said sleeve at the lower end thereof,

the length of said sleeve and its flexural rigidity being such that when said sleeve is set in the soil, it behaves as a long pile.

14. In an arrangement as defined in claim 13,

means in addition to said connecting means for also transferring lateral forces applied to said pile to said sleeve at one or more other locations which are between said soil surface and said connecting means.

15. A unitary structure comprising

a pile having a circular cross section;

a sleeve having a diameter greater than that of said pile and having a lower end portion tapered down to an opening the size of said pile;

said sleeve being disposed about a longitudinal portion of said pile with the lower end of said tapered portion being connected to said pile so as to make a unitary structure of said sleeve and pile,

the length of said sleeve and its flexural rigidity being selected with respect to the co-efficient of subgrade reaction of the soil in which said structure is being driven that when substantially the complete length of said sleeve is embedded in the soil, the sleeve behaves as a long pile.

16. A structure comprising, in combination a sleeve closed off at its lower end,

said sleeve having a length and a flexural rigidity such that when it is embedded in a soil region with its upper end slightly above the soil surface, it behaves as a long pile;

a pile of uniform size disposed within said sleeve with one end thereof resting on said closed off end, said pile having a length greater than that of said sleeve; and

forced transfer means located between said pile and said sleeve at one or more pre-selected locations

which are between the upper and lower ends of said sleeve.

17. In an arrangement as defined in claim 16 wherein said forced transfer means is such that relative axial displacement can occur between said pile and sleeve whereby said pile may be freely introduced or removed from said sleeve.

18. In combination,

a pile having a length thereof set in the soil;

a sleeve having a diameter greater than the size of said pile set in the soil so as to surround a longitudinal portion of said pile which is below the soil surface,

the lower end of said sleeve terminating in a reduced diameter portion which closes the space between said sleeve and said pile,

the upper end of said sleeve being located such that soil from the surface cannot enter the upper end of said sleeve and occupy the interior space between said pile and sleeve,

the reduced diameter portion of said sleeve also preventing soil from entering this interior space through the lower end of said sleeve;

the soil-free space, thus, existing around said longitudinal portion of said pile permitting said pile to deflect in response to loads applied thereto without being constrained by the soil conditions existing around said sleeve.

19. In an arrangement as defined in claim 18 wherein said reduced diameter portion of said sleeve acts to transfer lateral load forces applied to said pile at a location above the soil surface of said sleeve at a depth corresponding to the location of said reduced diameter portion.

20. In an arrangement as defined in claim 18,

means positioned within the soil-free interior space between said pile and sleeve for also transferring said load forces to said sleeve at one or more positions which are below the surface of the soil.

21. A structure comprising in combination

a pile;

a sleeve having a diameter greater than the size of said pile surrounding a longitudinal portion of said pile;

means securing the lower end of said sleeve to said pile and closing off the space therebetween,

said means permitting said pile and sleeve to be driven as a unitary structure into the soil and preventing soil from entering the interior space between said pile and sleeve during the driving operation whereby a soil free space exists around said longitudinal portion of said pile when the upper end of said sleeve is located above the soil surface,

said means also serving to transfer lateral load forces from said pile to said sleeve at said lower end;

the embedded length of said sleeve, its flexural rigidity and the stiffness of the soil in which said pile and sleeve are set being such that said sleeve behaves as a long pile; and

means for also transferring lateral load forces from said pile to said sleeve at a location which is between the upper and lower ends of said sleeve and below said soil surfaces.

22. In a structure as defined in claim 21 wherein said sleeve has a lower portion that is tapered down to the size of said pile.

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