PATENT SPECIFICATION

Application Date: May 24, 1938. No. 15508/38. **515,120**

Complete Specification Left: Oct. 7, 1938.

Complete Specification Accepted: Nov. 27, 1939.

PROVISIONAL SPECIFICATION

Improved Method of and Means for Forming Concrete Piles

We, ALFRED HILEY, a British Subject, of Dalegarth, Valley Road, Rickmansworth, in the County of Hertford, and THE BRITISH STEEL PILING COMPANY LIMITED, of Thames House, Millbank, Westminster, S.W.1, in the County of London, a Company incorporated under the laws of Great Britain and Northern Ireland, do hereby declare the nature of this invention to be as follows:—

This invention relates to the formation of concrete piles *in situ* and particularly to an improved method and means for ramming the moist concrete forming the upper portion of the deposited column. The invention is especially intended to provide apparatus which obviates the employment of mechanical devices to plug the tube such as are described in the Specification of Letters Patent No. 197,430 which latter specification is mainly applicable to the construction of the lower portion of piles.

In the formation of concrete piles under soft and water logged ground conditions a piling tube, fitted with a shoe or otherwise sealed at its driving end, is driven into the ground until a firm resistance is met, after which the tube is supplied with a sufficient quantity of moist concrete in one or more charges to fill the hole up to capping level upon withdrawal of the tube. Should the tube be withdrawn until a very small quantity of concrete remains to be deposited, the pressure at the outlet of the tube is not sufficient to balance the pressure exerted by the soft ground surrounding the free concrete and naturally the ground tends to cave in. Where, however, an additional quantity of concrete has been added to the tube in an endeavour to overcome this difficulty it has been found that this expedient is open to the objection that owing to the high state of lubrication present in the concrete the surplus concrete does not apply any force beyond its mere deadweight and, further, it is expensive, when set hard, to remove down to the required cap level.

In the improved method for forming concrete piles *in situ* this difficulty is overcome according to the present invention by disposing a bulk or wad of granular material, such as sand having a predetermined moisture content, which has the property of bulking appreciably when the moisture content is increased to partially occupy the voids, upon the final charge of concrete material previously poured into the tube to compose the pile. Further, according to the invention the upwardly and downwardly striking hammer which gives the necessary vertical vibratory movements to the tubes when causing it to deposit and tamp the concrete within the firm lower strata, is so arranged that for the purpose of depositing the concrete in the softer upper ground upwardly striking impulses are given to the tube which is allowed to oscillate downwardly between each stroke by the action of gravity further assisted only by the cushioning steam force bringing the hammer to rest at the bottom of its downward stroke so that the sand plug takes its full friction and arching action, without these being diminished by any sudden jolt, to grip the tube with full effect. The result is that the concrete is forced to slump downwardly and spread away below the tamping end of the piling tube and thus ram the concrete into a size fully up to a definite and decided area. During the operation of forming the pile in the soft strata the vertical oscillating movements given to the tube are assisted by the spring suspension and ropes supporting the piling tube and which are hauled in by the winch as the tube ascends and whilst the pile is being built up. The sharp upward impulses given to the tube by the piling hammer are caused to act through the medium of the pair of extracting links, freeing thereby both the concrete and the sand plug which latter relaxes its pressure on the tube. Upon removal of pressure the sand plug is rendered less compact and tends to decrease in volume as the moisture content changes in relation to the voids allowing the plug to readily slip down the tube. On the ensuing downward natural oscillation the sand plug has an opposite action and resumes its substantially fixed stationary position within the tube and

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develops a pronounced ramming effect to spread out the concrete issuing below the end of the piling tube.

By applying the method described it has been found that in adverse ground conditions such as soft clay the diameter of the finished concrete column can be made appreciably larger than the diameter of the tube, and the pressure on the deposited layers is enough to cause the concrete to find its escape only by way of the surrounding outer walls of the tube and in fact extending some distance upwards along its length. Hitherto, concrete deposited in unfavourable ground conditions, the required diameter may not be attained which results in a column of less strength and resistance value than can now be obtainable where a sand plug or wad is used in accordance with the present invention. Sand which has been found particularly suitable in carrying the invention into effect contains air spaces or voids amounting to approximately one third of its volume. The volume of each cubic foot of sand, if inundated to completely fill the voids with water, remains substantially the same as when dry, but if the voids are only partially filled with moisture an appreciable increase of volume takes place reaching a maximum of about one and a third times the amount when dry. Under partially inundated conditions the voids become about half filled and additional moisture absorbed at this stage begins to produce the reverse effect until saturation is complete when if placed in a piling tube its action would correspond somewhat with that of a heavy fluid.

Sand, as used in accordance with the present invention, is preferably given a smaller percentage of moisture than that necessary to produce the maximum bulking of its volume so that when filled into a length of tube to the extent of several diameters and compressed by a piston-like action of concrete material below, the voids take up more moisture, whereby the natural tendency of the material to bulk continues its effect causing in the restricted bore a form of wedge action allowing considerable resistance from friction and arching to come into play when opposing a thrust from below.

The degree of resistance derived from the sand plug can be varied by using more or less material and the amount of water given to it.

For general requirements and for producing a well compacted pile of full diameter sand is used containing approximately 3% to 5% of moisture by weight, filling about one fourth of the void spaces. An amount of sand sufficient to occupy a length of some four to six diameters within the piling tube will in average conditions produce the necessary ramming effect upon the concrete below.

For piles which are to finish at some considerable depth below ground level the sand plug to produce a proportionate ramming effect may well occupy a length of piling tube which may exceed 6 diameters serving also to fill the pile hole conveniently to a height near to the ground level after completion of the tamping of the concrete.

Other ingredients of a non-cohesive nature may be added to the sand, for example cement, to allow the plug to harden somewhat if desired, as where placed at some appreciable distance below ground level for which a great resistance against outside pressure may be needed.

In order that the invention may be clearly understood reference is directed to the accompanying drawings wherein:—

Fig. 1 is a sectional elevation of a pile-driving apparatus constructed in accordance with the invention.

Fig. 2 is a view of a pile partly formed and with the pile forming tube partly withdrawn.

Fig. 3 shows diagrammatically a curve illustrating the difference in hardness of soil at various elevations.

Fig. 4 is a section of a pile formed in accordance with the invention and is a sectional view of a pile formed *in situ* in accordance with the invention and showing how the concrete has been consolidated and caused to extend in accordance with the hardness of the surrounding soil.

Fig. 5 illustrates a modified form of the method according to the invention giving an amplified degree of ramming.

Fig. 6 illustrates a device for filling the concrete and plug forming materials of suitable moisture contents into the pile driving tube.

Fig. 7 is a side elevation of a part of the pile-driving equipment adapted for extracting and depositing operations.

Fig. 8 is a plan view of the rubber distance piece.

Fig. 9 is sectional elevation of the bobbin for adjusting the action of the hammer to give upward and downward strokes and to give upward impulses only.

Fig. 10 illustrates diagrammatically the formation of the upper part of the pile having the non-integral sand plug above it.

Referring to the drawings, 1 is a tube which is filled, after driving to the required depth, with concrete and in a position ready to be oscillated by upward and downward blows of a hammer 2,

whilst being extracted for a distance equivalent to the depth of the lower firm ground 3 and convertible to give upward blows only during the final ascent through relatively soft ground 4. The elastic link gear 5 is suitably adjusted in length preferably by the introduction of the necessary thickness of a rubber packing 6 which is inserted above the bobbin which can also serve if screwed upwards sufficiently for the purpose of controlling the admission of steam through a valve 7 so that the tube can have modulated downward movement without being subjected to impact in the downward direction when afterwards employing a wad or plug of sand in accordance with the invention and which is placed on the concrete filled into the piling tube.

Fig. 2 shows the piling tube 1 extracted until its lower end 9 comes within the zone of the soft strata 4 an additional quantity or final charge of concrete 9 having been placed in the tube and covered with a suitable volume of damp sand 8, the concrete and sand having been placed down the tube by shoots 10 or 10*a* respectively adapted to discharge the material into the mouth of the tube. The extraction of the tube can now be resumed with the aid of the hammer suitably converted to deliver upward blows which causes the tube to oscillate in the spring suspension and together with the sand plug the effect is obtained of a wedged rammer locked within the tube during successive downward movement but free to slip relatively to the tube upon upward movement.

Fig. 3 shows a curve indicating the typical variation in ground resistance value at different depths in the ground. The soft upper strata being of the kind which can exert an adverse pressure effect on a pile.

Fig. 4 shows a pile completed and rammed out into full section, the sand used resting within the otherwise vacant hole with a small surplus possibly appearing at the top at ground level, the non-integral material above the pile being readily removable before the pile is capped.

Fig. 5 shows a pile of plain concrete during the final stage of deposition wherein the sand plug is contained in a sack or bag to allow the use for gaining pronounced terminal effect in the consolidating step of a drop weight, if such should be required for furnishing an extra ramming effect towards the completion of the pile or to form the head of extra size in lieu of capping.

Fig. 6 shows one form of vertical shoot 10, having hinged doors 11 which are opened by a rope 12 as required directly down the mouth of the piling. Supports 13 attached to the shoot 10 to allow the same to be set at an inclined position to the ground to enable sand to be easily shovelled in from a heap. An elevating rope 14, looped around a pair of oppositely disposed hooks 15 is employed to raise the shoot.

Fig. 7 shows the elastic link 5 of the automatic gear of the pile hammer wherein the shock absorber cords can take a sufficient pull to actuate the lever and are then extended without much further effort till the hammer has ended its downward travel and a rubber U-shaped distance packing 6 (Fig. 8) is inserted below a lug 17 on the hammer or the bobbin made long enough can be screwed up the rod to change the time of steam admission to the extent necessary to change the action of the hammer.

Dated this 24th day of May, 1938.

MEWBURN, ELLIS & CO.,
70 & 72, Chancery Lane, London, W.C.2,
Chartered Patent Agents.

COMPLETE SPECIFICATION

Improved Method of and Means for Forming Concrete Piles

We, ALFRED HILEY, a British Subject, of Dalegarth, Valley Road, Rickmansworth, in the County of Hertford, and THE BRITISH STEEL PILING COMPANY LIMITED, of Thames House, Millbank, Westminster, S.W.1, in the County of London, a Company incorporated under the laws of Great Britain and Northern Ireland, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the formation of concrete piles *in situ* and particularly to an improved method and means for ramming the moist concrete forming the upper portion of the deposited column.

In the formation of concrete piles under soft and water logged ground conditions a piling tube, fitted with a shoe or otherwise sealed at its driving end, is driven into the ground until a firm resistance is met, after which the tube is supplied with a sufficient quantity of moist concrete in one or more charges to fill the

hole up to capping level upon withdrawal of the tube. Should the tube be withdrawn until a very small quantity of concrete remains to be deposited, the pressure at the outlet of the tube is not sufficient to balance the pressure exerted by the soft ground surrounding the free concrete and naturally the ground tends to cave in. Where, however, an additional quantity of concrete has been added to the tube in an endeavour to overcome this difficulty it has been found that this expedient is open to the objection that owing to the high state of lubrication present in the concrete the surplus concrete does not apply any force beyond its mere deadweight and, further, it is expensive, when set hard, to remove down to the required cap level.

In the improved method for forming concrete piles *in situ* this difficulty is overcome according to the present invention by disposing a bulk or wad of granular material, such as sand, upon the charge of concrete material previously poured into the tube to form the pile, the said granular material having or being then given a suitable moisture content to engender the property of bulking and thereafter vibrating said tube to deposit and tamp the concrete. Further, according to the invention the upwardly and downwardly striking hammer which gives the necessary vertical vibratory movements to the tubes when causing it to deposit and tamp the concrete within the firm lower strata, is so arranged that for the purpose of depositing the concrete in the softer upper ground upwardly striking impulses are given to the tube which is allowed to oscillate downwardly between each stroke by the action of gravity further assisted only by the cushioning steam force bringing the hammer to rest at the bottom of its downward stroke so that the sand plug takes its full friction and arching action, without these being diminished by any sudden jolt, to grip the tube with full effect. The result is that the concrete is forced to slump downwardly and spread away below the tamping end of the piling tube and thus ram the concrete into a size fully up to a definite and decided area. During the operation of forming the pile in the soft strata the vertical oscillating movements given to the tube are assisted by the spring suspension and ropes supporting the piling tube and which are hauled in by the winch as the tube ascends and whilst the pile is being built up. The sharp upward impulses given to the tube by the piling hammer are caused to act through the medium of the pair of extracting links, freeing thereby both the concrete and the sand plug which latter relaxes its pressure on the tube. Upon removal of pressure the sand plug is rendered less compact and tends to decrease in volume as the moisture content changes in relation to the voids allowing the plug to readily slip down the tube. On the ensuing downward natural oscillation the sand plug has an opposite action and resumes its substantially fixed stationary position within the tube and develops a pronounced ramming effect to spread out the concrete issuing below the end of the piling tube.

By applying the method described it has been found that in adverse ground conditions such as soft clay the diameter of the finished concrete column can be made appreciably larger than the diameter of the tube, and the pressure on the deposited layers is enough to cause the concrete to find its escape only by way of the surrounding outer walls of the tube and in fact extending some distance upwards along its length. However, when concrete has been deposited in unfavourable ground conditions, the required diameter has not always been attained which results in a column of less strength and resistance value than can now be obtainable where a sand plug or wad is used in accordance with the present invention. Sand which has been found particularly suitable in carrying the invention into effect contains air spaces or voids amounting to approximately one third of its volume. The volume of each cubic foot of sand, if inundated to completely fill the voids with water, remains substantially the same as when dry, but if the voids are only partially filled with moisture an appreciable increase of volume takes place reaching a maximum of about one and a third times the amount when dry. Under partially inundated conditions the voids become about half filled and additional moisture absorbed at this stage begins to produce the reverse effect until saturation is complete when, if placed in a piling tube, its action would correspond somewhat with that of a heavy fluid.

Sand, as used in accordance with the present invention, is preferably given a smaller percentage of moisture than that necessary to produce the maximum bulking of its volume so that when filled into a length of tube to the extent of several diameters and compressed by a piston-like action of concrete material below, the voids take up more moisture, whereby the natural tendency of the material to bulk continues its effect causing in the restricted bore a form of wedge action allowing considerable resistance from

friction and arching to come into play when opposing a thrust from below.

The degree of resistance derived from the sand plug can be varied by using more or less material and the amount of water given to it.

For general requirements and for producing a well compacted pile of full diameter sand is used containing approximately 3% to 5% of moisture by weight, filling about one fourth of the void spaces. An amount of sand sufficient to occupy a length of some four to six diameters within the piling tube will in average conditions produce the necessary ramming effect upon the concrete below.

For piles which are to finish at some considerable depth below ground level the sand plug to produce a proportionate ramming effect may well occupy a length of piling tube which may exceed 6 diameters serving also to fill the pile hole conveniently to a height near to the ground level after completion of the tamping of the concrete.

Other ingredients of a non-cohesive nature may be added to the sand, for example, cement, to allow the plug to harden somewhat if desired, as where placed at some appreciable distance below ground level for which a great resistance against outside pressure may be needed.

In order that the invention may be clearly understood reference is directed to the drawing filed with the Provisional Specification and to the accompanying drawings, wherein:—

Fig. 1 is a sectional elevation of a pile driving apparatus constructed in accordance with the invention.

Fig. 2 is a view of a pile partly formed and with the pile forming tube partly withdrawn.

Fig. 3 shows diagrammatically a curve illustrating the difference in hardness of soil at various elevations.

Fig. 4 is a sectional view of a pile formed *in situ* in accordance with the invention and showing how the concrete has been consolidated and caused to extend in accordance with the hardness of the surrounding soil.

Fig. 5 illustrates a modified form of the method according to the invention giving an amplified degree of ramming.

Fig. 6 illustrates a device for filling the concrete and plug forming materials of suitable moisture contents into the pile driving tube.

Fig. 7 illustrates diagrammatically the formation of the upper part of the pile having the non-integral sand plug above it.

Fig. 8 illustrates diagrammatically a stage in the construction of a concrete pile, and

Fig. 9 is a further stage in such a construction.

Referring to the drawings, 1 is a tube which is filled, after driving to the required depth, with concrete and in a position ready to be oscillated by upward and downward blows of a hammer 2, whilst being extracted for a distance equivalent to the depth of the lower firm ground 3 and convertible to give upward blows only during the final ascent through relatively soft ground 4.

Fig. 2 shows the piling tube 1 extracted until its lower end 9 comes within the zone of the soft strata 4 an additional quantity or final charge of concrete 9 having been placed in the tube and covered with a suitable volume of damp sand 8, the concrete and sand having been placed down the tube by skips 10 or 10*a* respectively adapted to discharge the material into the mouth of the tube. The extraction of the tube can now be resumed with the aid of the hammer suitably converted to deliver upward blows which causes the tube to oscillate in the spring suspension and together with the sand plug the effect is obtained of a wedged rammer locked within the tube during successive downward movement but free to slip relatively to the tube upon upward movement.

Fig. 3 shows a curve indicating the typical variation in ground resistance value at different depths in the ground. The soft upper strata being of the kind which can exert an adverse pressure effect on a pile.

Fig. 4 shows a pile completed and rammed out into full section, the sand used resting within the otherwise vacant hole with a small surplus possibly appearing at the top at ground level, the non-integral material above the pile being readily removable before the pile is capped.

Fig. 5 shows a pile of plain concrete during the final stage of deposition wherein part of the sand plug is contained in a sack or bag to obtain a better effect in the consolidating step by the drop weight, if such should be required for furnishing an extra ramming effect towards the completion of the pile or to form the head of extra size in lieu of capping.

Fig. 6 shows one form of vertical shoot 10 which constitutes a measure for determining the correct quantity of sand to use. The shoot 10 has hinged doors 11 which are opened by a rope 12 as required directly down the mouth of the piling. Supports 13 attached to the shoot 10 allow the same to be set at an inclined position to the ground to enable sand to be easily shovelled in from a heap. An elevating

rope 14, looped around a pair of oppositely disposed hooks 15 is employed to raise the shoot.

Referring to Figs. 8 and 9 of the drawing there is illustrated diagrammatically the formation of a concrete pile under conditions where it is required or found desirable to expand the foot of a pile when being formed in soft ground at a low level. When the concrete has been deposited at a considerable depth down the hole formed by the tube 1, the latter, together with a sand plug, may be driven down again through the deposited materials to displace these for the purpose of forming the pile with an enlarged base which may be necessary where weak ground conditions prevail at the lowest depth which can be reached by the tube. The process of redriving would be performed with the end of the tube 1 closed against ingress of materials in accordance with specifications Nos. 385,647 or 197,430. The use of the sand plug when depositing the concrete materials at a low position on the ground enables these to be packed down in the low ground where intended.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A method of forming concrete piles *in situ* consisting in disposing a wad of granular material such as sand upon the charge of concrete material deposited in the pile driving tube which is to form the pile, said granular material having or being then given a suitable moisture content to engender the property of bulking and thereafter vibrating said tube to deposit and tamp the concrete.

2. A method of forming concrete piles as claimed in claim 1 wherein a reciprocatory movement is given to the tube by upwardly striking impulses and by the action of gravity.

3. A method of forming a concrete pile comprising the following steps:

(a) driving a pile forming tube fitted with a shoe and otherwise sealed at the lower end to the required depth;

(b) filling said tube with a suitable quantity of concrete to form the pile;

(c) depositing a wad of sand upon the aforesaid concrete;

(d) withdrawing said tube whilst positively oscillating the same in an upward and downward direction or in an upward direction only, during the concrete depositing step.

4. Apparatus for carrying into effect the method of pile formation as claimed in claim 1 or claim 2, comprising driving and withdrawal apparatus for inserting and withdrawing a pile forming tube, including means for oscillating said tube during the withdrawal step, means for introducing charges of concrete to the pile forming tube, means for introducing a charge of sand to form a wad on the previously deposited concrete, the said wad having a tamping effect upon the said column of concrete during the downward movement of the pile forming tube which latter slips over the said wad of sand during the upward oscillatory movement of said pile forming tube whereupon the concrete is expelled from the tube for the purpose specified as the pile forming tube is being withdrawn.

5. The improved method of forming concrete piles substantially as described.

6. The improved apparatus when used for forming concrete piles substantially as described with reference to the accompanying drawings.

Dated this 7th day of October, 1938.

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Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

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2. A method of forming concrete piles as claimed in claim 1 wherein a reciprocatory movement is given to the tube by upwardly striking impulses and by the action of gravity.

3. A method of forming a concrete pile comprising the following steps:

(a) driving a pile forming tube fitted with a shoe and otherwise sealed at the lower end to the required depth;

(b) filling said tube with a suitable quantity of concrete to form the pile;

(c) depositing a wad of sand upon the aforesaid concrete;

(d) withdrawing said tube whilst positively oscillating the same in an upward and downward direction or in an upward direction only, during the concrete depositing step.

4. Apparatus for carrying into effect the method of pile formation as claimed in claim 1 or claim 2, comprising driving and withdrawal apparatus for inserting and withdrawing a pile forming tube, including means for oscillating said tube during the withdrawal step, means for introducing charges of concrete to the pile forming tube, means for introducing a charge of sand to form a wad on the previously deposited concrete, the said wad having a tamping effect upon the said column of concrete during the downward movement of the pile forming tube which latter slips over the said wad of sand during the upward oscillatory movement of said pile forming tube whereupon the concrete is expelled from the tube for the purpose specified as the pile forming tube is being withdrawn.

5. The improved method of forming concrete piles substantially as described.

6. The improved apparatus when used for forming concrete piles substantially as described with reference to the accompanying drawings.

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