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PILE JOINTS

This invention relates to joints for connecting pile sections together.

5 Piles are in common use as foundation members for supporting engineering structures such as buildings, bridges, viaducts, retaining walls and quay walls, and can be either cast-in-situ piles which are formed by first boring a hole of a required size and depth in the ground
10 and then filling the hole with concrete and steel reinforcements, or pre-formed piles which are constructed in advance and subsequently driven into the ground at a desired location using a suitable hammer. As regards pre-formed
15 piles, for practical reasons, the length of a pile which can be transported, handled at site and driven is limited. This limiting length is typically between 6 to 20 metres. Therefore, if the required total embedded length of a
20 driven pile is greater than this limiting length, as is often the case, it becomes necessary to utilise pile sections each of a length that can be conveniently handled, adding one or more further section(s) to a section or sections already driven
25 until the desired depth is reached. The most common method of lengthening a driven pile section is by providing a pile joint (also called

a splice), whereby the section already driven has a new pile section connected to it. In this way by providing one or more joint(s), a pile can be driven to great depths if required, for example, up to 50 metres.

Pile joints must satisfy technical requirements, one of which is strength. In considering the strength of a joint it is necessary to refer to the ultimate resistance of the joint when subjected to each of the following: (i) a compressive force acting along the longitudinal axis of the pile, (ii) a tensile force also acting along the longitudinal axis, and (iii) a bending moment acting in any plane passing through the longitudinal axis of the pile. Thus, in referring to the strength of a joint it is necessary to state whether one is referring to the compressive, tensile or bending strength. Ideally the compressive, tensile and bending strength of a pile joint should be at least the same as that of the pile shaft, which is that part of a pile outside the joint, so that the joint does not form a localised weak part of the pile taken as a whole. However, sometimes a less stringent requirement with respect to the strength of the pile joint is imposed in order to save cost at the expense of the standard of pile performance overall.

In United Kingdom Patent Specification No. 1 184 370 there is disclosed a pile joint in two halves each comprising a metal sleeve or collar surrounding a pile end section and a steel end plate welded to the sleeve. The end plate is also welded to the longitudinal reinforcement bars of the pile section. Each end plate is provided with holes spaced equidistantly apart, each of which opens into a cavity formed by a

1 pocket in the pile surface. Each pocket is lined by an
indentation in the sleeve (which indentation served as a
mould for the pocket during casting of the pile section),
or each pocket is at a cut-away portion of the sleeve
5 surface (at which portion a removable wooden block was
inserted during casting to form the recess). To secure
the two pile sections together bolts are passed through
aligned holes of the joint halves and made fast by nuts.
The wall of each pocket extends around the bolt therein
10 to the perimeter of the end plate such that each bolt is
inboard of the plane at right angles to the plate which
contains the junction of pocket wall and plate perimeter
on each side of the bolt. The base of each pocket is
thus rigidly supported, by the pile section, from
15 outboard of the bolt therein when the joint is acted upon
by a tensile force or bending moment. Thus, in its mode
of operation in resisting such a force or bending moment,
there is no significant cantilever action in the base
plate. The bolts are on substantially the same pitch
20 circle as the reinforcement bars.

According to one aspect of the present invention
there is provided a pile joint in two halves each
comprising an end plate and a reinforcement band fast
with the end plate; each joint half being for positioning
25 on a concrete pile section during casting of the section
at one end of the section such that the band serves as a
collar around the section whereby one such section can be
secured to another by positioning the two sections such
that bolts can be passed through aligned holes in the end
30 plates of two opposed joint halves and the joint made
fast by bolting together the two halves, the bands being
recessed to give access for inserting and tightening the
bolts; each bolt hole being in a cantilever portion of
its plate that protrudes from its pile section such that
35 this portion is unsupported by its pile section over its
radial extent from a location inboard of the bolt hole to
the outer periphery of the portion and each bolt hole

1 being offset radially outwards of a corresponding dowel
that is fast with the end plate and extends therefrom to
the same side as the reinforcement band for embedment in
the concrete of the pile section whereby tensile loads
5 and bending moments applied at the joint are resisted by
cantilever action at the end plates. In this joint the
tensile and bending strength of the joint is developed
through cantilever action of the end plates, giving high
resistance in tension and bending. This cantilever
10 action can take place because each end plate portion in
which there is a bolt hole is unsupported by its pile
section over its radial extent from inboard of the bolt
hole. If required the strength of the joint in
compression, tension and bending can be made at least
15 equal to that of the pile shaft merely by adjusting the
thickness of the end plate, the size of the dowels, and
the size of the bolts. The joint can be constructed at
moderate cost since the design of the joint is simple and
it can be constructed without the use of very
20 sophisticated or elaborate machinery other than that
normally available in a small workshop. The provision of
extra reinforcement in the form of the dowels and the
confining effect of the reinforcing band surrounding the
pile sections serve to prevent cracking of the concrete
25 during pile driving. Because of the simplicity of the
joint, joining of the two halves together to form the
complete joint can be executed in minimal time as it
involves mainly centering a new pile section over a
driven section and tightening a few bolts. As the joint
30 is completed on site without involving any site welding,
there is no need to provide welding equipment or the
services of a welder at the site of pile driving. By
making the two halves of the joint at least substantially
identical, any possibly of an error in matching the two
35 halves of the joint is avoided.

According to another aspect of the present
invention, there is provided a pile joint half,

01 comprising an end plate, a reinforcement band fast with
the end plate and extending therefrom to one side of the
plate, elongate reinforcing parts extending from said one
side and distributed around the end plate, and a
05 plurality of fastening means with which said end plate is
provided and which are also distributed around said plate
for employment in fastening said half to another such
pile joint half to form a joint; the first-mentioned said
half being for occupying a position at one end of a
10 concrete pile section during casting of a concrete body
of said section such that said band serves as a collar
around said body and said parts serve as internal
reinforcements of said body, said band including portions
which are set back from the periphery of said end plate
15 in the respective regions of said fastening means to give
access for employing said fastening means, so that each
fastening means is in a portion of said plate which
protrudes from the band such that this portion is
unsupported over its radial extent from a location
20 inboard of the fastening means to the outer periphery of
this portion, each fastening means being offset radially
outwards of a corresponding said reinforcing part,
whereby, in said joint, tensile loads and bending moments
applied at said joint are resisted by cantilever action
25 at the end plates of the joint, said fastening means
comprising holes.

According to a further aspect of the present
invention, there is provided a concrete pile section,
comprising an elongate concrete body and two pile joint
30 halves at respective ends of said body, each pile joint
half comprising an end plate, a reinforcement band fast
with the end plate and extending therefrom to one side of
the plate, elongate reinforcing parts extending from said
one side and distributed around the end plate, and a
35 plurality of fastening means with which said end plate is
provided and which are also distributed around said plate
for employment in fastening said half to another such

01 pile joint half to form a joint; each said band serving
as a collar around said body, the elongate reinforcing
parts serving as internal reinforcements of said body,
each band including portions which are set back from the
05 periphery of its end plate in the respective regions of
its fastening means to give access for employing said
fastening means, so that each fastening means is in a
portion of its plate which protrudes from its band such
that this portion is unsupported over its radial extent
10 from a location inboard of the fastening means to the
outer periphery of this portion, each fastening means
being offset radially outwards of a corresponding said
reinforcing part, whereby, in its joint, tensile loads
and bending moments applied at its joint are resisted by
15 cantilever action at the end plates of its joint, said
fastening means comprising holes.

According to a yet further aspect of the present
invention, there is provided in combination, first and
second concrete pile sections each comprising an elongate
20 concrete body and a pile joint half at one end of the
body, each pile joint half comprising an end plate, a
reinforcement band fast with the end plate and extending
therefrom to one side of the plate, and elongate
reinforcing parts extending from said one side and
25 distributed around the end plate, and a plurality of
fastening means by which the end plates are fastened
together to form a joint and which are also distributed
around their plates; each band serving as a collar around
its concrete body and the elongate reinforcing parts
30 serving as internal reinforcements of their body, each
band including portions which are set back from the
periphery of its end plate in the respective regions of
said fastening means to give access for employing said
fastening means, so that each fastening means is in a
35 cantilever portion of said plate which protrudes from the
band from a location inboard of the fastening means, each
fastening means being offset radially outwards of

01 corresponding elongate reinforcing parts of the
respective halves, whereby, in said joint, tensile loads
and bending moments applied at said joint are resisted by
cantilever action at the end plates, said fastening means
05 comprising bolts and holes.

For a better understanding of the invention and to
show how the same may be carried into effect, reference
will now be made, by way of example, to the accompanying
drawings, in which:-

10 Figure 1 is a side view of a pre-formed pile
section, provided with a joint half at each end;

Figures 2 and 3 are, respectively, sectional views
taken on line II-II and either of lines III-III in Figure
1 (or line III-III in Figure 4 or in Figure 6);

15 Figure 4 is a sectional view taken on line IV-IV
in Figure 3;

Figure 5 is a sectional view taken on line V-V in
Figure 4 (or Figure 6); and

Figure 6 is a side view of a pile joint.

20 The pile section 1 of Figure 1 is a reinforced
concrete pre-formed section having a generally triangular
cross-section. The joint halves 2 at each end of the
section 1 are at least substantially identical.
Referring to Figure 2, throughout the length of the pile
25 sections there run three longitudinal reinforcing bars 3
which are tied to triangular stirrups 4 spaced at
selected intervals along the pile shaft.

Turning to Figures 3 to 5, each joint half 2
consists of a steel end plate 8, a reinforcing

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steel band 6 upstanding from the plate 8 and three steel dowels 5. Each dowel 5 is adjacent a corresponding reinforcing bar 3 and is secured thereto by tying with fine metal wires (not shown). The configuration of the end plate 8 is identical to the cross-section of the major part of the length of the pile and this plate is provided with three bolt holes 7 for receiving bolts for bolting the two joint halves together to form a complete pile joint. The steel band 6, which is connected to the end plate 8 by welding 11, serves as a collar that completely surrounds the periphery of the pile over a short distance. At the part surrounded by the band 6 the pile has a different cross-section, as compared with the major part of the pile mentioned above, because, in order to provide a void 9 for inserting and tightening each bolt, a part of the steel band 6 is recessed over each bolt hole 7 as best seen in Figure 4. As can be seen from Figures 3 and 4, each bolt hole 7 is in a portion of its plate 8 that protrudes from the steel band 6 and hence from the part of the pile surrounded by the band 6, such that this portion has no support from the band 6 or the pile over its radial extent from the band 6, which is inboard of the hole 7, to the outer periphery of the portion.

In order to provide for structural continuity between the joint and the pile shaft, the three short dowels 5 are welded at 10 (or alternatively threaded on) to the end plate 8. As shown in Figures 4 and 5, structural continuity between the joint half 2 and the pile shaft is completed by positioning each dowel 5 so as to overlap a corresponding longitudinal reinforcing bar 3.

Figure 6 shows how two joint halves are secured together to make good the joint by means of three bolts 12, and it will be noted from Figures 3 to 6 that each bolt 12 is offset radially outwards of its corresponding dowel 5.

In manufacture each pile section is cast in an appropriate length of approximately 6 to 12 metres depending on the overall size of pile required and the ease of storage, transport and handling. This manufacture may be carried out at a central factory whereafter the sections are transported to the pile driving site, or alternatively the pile sections may be manufactured at the site. Each section is cast complete with two at least substantially identical joint halves, one at each end, as illustrated in Figure 1.

After the concrete in a pile section has gained sufficient strength, the section is driven into the ground at the required location using a suitable hammer and a pile driving frame. It is to be noted that the provision of extra reinforcement in the form of the dowels and the confining effect of the reinforcing steel band surrounding the pile, serves to prevent cracking of the concrete during driving. Driving is continued until the desired set (i.e. penetration per blow) or the prescribed total embedded depth is reached. If, after a given section is driven into the ground until the last 0.5 metre or so is still protruding, neither of these two criteria is met, it is necessary to lengthen the pile and continue driving. Lengthening is achieved by lifting a new pile section, aligning it carefully and placing it gently on top of the driven pile section such that all the bolt holes of the top half match the holes of the lower joint half, inserting the bolts and tightening them.

Although the pile specifically described is of substantially triangular transverse cross-section, joints as described can be utilised

with precast reinforced concrete piles,
prestressed or otherwise, of other shapes in
transverse cross-section,
e.g. square or hexagonal shape. No matter what
5 the shape may be, the basic principle of
operation of the joint remains the same, i.e.
it is a bolted pile joint which depends on
cantilever action of the end plate to develop
its resistance to tensile load and bending
10 moment. However, the configuration and dimensions
of the joint in plane should be at least
substantially identical to that of the transverse
cross-section of the pile shaft. Moreover,
both the number of bolts and the number of
15 dowels per joint should be at least equal to
the number of corners in the transverse cross-
section (plus additional dowels if necessary
to give one per reinforcing bar). Thus for
a triangular, square or hexagonal cross-section,
20 both the number of bolts and the number of dowels
will be three, four or six respectively (plus
additional dowels if necessary).

Joints as described herein are applicable
to precast reinforced concrete piles whose safe
25 loads are in the low to medium range, i.e.
between 15 to 100 tons.

It will be appreciated that the joint herein
described is such that:-

- 30 the cost of the joint is low;
- the procedure involved in lengthening
the pile at the site using the joint
is simple, thus minimising the possibility
or errors;
- the jointing procedure is quick, thus
35 minimising idle time of driving machine
and crew;
- the jointing procedure involves a minimum

of extra equipment and trained personnel both in executing the joint at the construction site and in testing the quality of site workmanship, as compared, for example, with a joint requiring site welding; the joint is able to resist, without being damaged, the high impact stresses during pile driving using a hammer of appropriate weight and height of drop.

The above-listed features are obtained by having the two halves of the joint, which are identical, joined together by means of bolts, the joint being such that a short length of each joined pile section, which short length also forms part of one half of the completed joint, is completely surrounded by a reinforcing steel band; and by providing the short steel reinforcing dowels which are either welded or threaded onto the end plates and which give structural continuity between the pile and the joint. With this pile joint any tensile force or bending moment applied to the pile will be transmitted across the joint in the following sequence. When a tensile force is applied, the effect is to create a tensile force in each of the three longitudinal reinforcing bars. Similarly, if a bending moment is applied to the pile, one or two (but not three) of the reinforcing bars will be subjected to tensile force(s). The tensile force in any longitudinal reinforcing bar is first transferred to the corresponding dowel which in turn exerts a pull on the end plate. As this end plate is bolted to the end plate of the opposed joint half and the bolts are offset from the dowels and in plate portions that are unsupported radially outwardly of locations inboard

of the bolts, this pull is by means of
cantilever action and creates a tensile force
in the corresponding bolt which, together
with the other bolts, joins the two halves
5 of the joint together. As has been made clear
above, the cantilever action of the end plate
arises from the application of the force
in the bolt onto that part of the end plate
which protrudes into each of the three void
10 spaces; the protruding part of the end plate
forming a cantilever. In this way the tensile
force or bending moment is transmitted across
to the other half of the joint in which half
the sequence of transfer of force is reversed, i.e
15 from bolt to plate, plate to dowel and
finally to the corresponding longitudinal reinforcing
bar. The strength of the joint in tension or
bending can be increased or decreased merely by
altering the thickness of the end plates, the
20 size of the bolts and the size of the dowels.

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1 CLAIMS:

1. A pile joint in two halves each comprising an end plate and a reinforcement band fast with the end plate and extending therefrom to one side of the plate; each
5 joint half being for positioning on a concrete pile section during casting of the section at one end of the section such that the band serves as a collar around the section whereby one such section can be secured to another by positioning the two sections such that bolts
10 can be passed through aligned holes in the end plates of two opposed joint halves and the joint made fast by bolting together the two halves, the bands being recessed to give access for inserting and tightening the bolts; each bolt hole being in a cantilever portion of its plate
15 that protrudes from its pile section such that this portion is unsupported by its pile section over its radial extent from a location inboard of the bolt hole to the outer periphery of the portion and each bolt hole being offset radially outwards of a corresponding dowel
20 that is fast with the end plate and extends therefrom to the same side as the reinforcement band for embedment in the concrete of the pile section whereby tensile loads and bending moments applied at the joint are resisted by cantilever action at the end plates.
- 25 2. A pile joint as claimed in claim 1, wherein each dowel of each joint half is positioned to overlap a corresponding longitudinal reinforcing bar of the concrete pile section on which the joint half is positioned.
- 30 3. A pile joint as claimed in claim 1 or 2, wherein the two halves of the joint are substantially identical.
4. A pile joint substantially as hereinbefore described with reference to the accompany drawings.
5. A pile joint half, comprising an end plate, a
35 reinforcement band fast with the end plate and extending therefrom to one side of the plate, elongate reinforcing parts extending from said one side and distributed around



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01 the end plate, and a plurality of fastening means with
which said end plate is provided and which are also
distributed around said plate for employment in fastening
said half to another such pile joint half to form a
05 joint; the first-mentioned said half being for occupying
a position at one end of a concrete pile section during
casting of a concrete body of said section such that said
band serves as a collar around said body and said parts
serve as internal reinforcements of said body, said band
10 including portions which are set back from the periphery
of said end plate in the respective regions of said
fastening means to give access for employing said
fastening means, so that each fastening means is in a
portion of said plate which protrudes from the band such
15 that this portion is unsupported over its radial extent
from a location inboard of the fastening means to the
outer periphery of this portion, each fastening means
being offset radially outwards of a corresponding said
reinforcing part, whereby, in said joint, tensile loads
20 and bending moments applied at said joint are resisted by
cantilever action at the end plates of the joint, said
fastening means comprising holes.

6. A pile joint half, substantially as hereinbefore
described with reference to the accompanying drawings.

25 7. A concrete pile section, comprising an elongate
concrete body and two pile joint halves at respective
ends of said body, each pile joint half comprising an end
plate, a reinforcement band fast with the end plate and
extending therefrom to one side of the plate, elongate
30 reinforcing parts extending from said one side and
distributed around the end plate, and a plurality of
fastening means with which said end plate is provided and
which are also distributed around said plate for
employment in fastening said half to another such pile
35 joint half to form a joint; each said band serving as a
collar around said body, the elongate reinforcing parts
serving as internal reinforcements of said body, each



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01 band including portions which are set back from the
periphery of its end plate in the respective regions of
its fastening means to give access for employing said
fastening means, so that each fastening means is in a
05 portion of its plate which protrudes from its band such
that this portion is unsupported over its radial extent
from a location inboard of the fastening means to the
outer periphery of this portion, each fastening means
being offset radially outwards of a corresponding said
10 reinforcing part, whereby, in its joint, tensile loads
and bending moments applied at its joint are resisted by
cantilever action at the end plates of its joint, said
fastening means comprising holes.

8. A concrete pile section, substantially as
15 hereinbefore described with reference to the accompanying
drawings.

9. In combination, first and second concrete pile
sections each comprising an elongate concrete body and a
pile joint half at one end of the body, each pile joint
20 half comprising an end plate, a reinforcement band fast
with the end plate and extending therefrom to one side of
the plate, and elongate reinforcing parts extending from
said one side and distributed around the end plate, and a
plurality of fastening means by which the end plates are
25 fastened together to form a joint and which are also
distributed around their plates; each band serving as a
collar around its concrete body and the elongate
reinforcing parts serving as internal reinforcements of
their body, each band including portions which are set
30 back from the periphery of its end plate in the
respective regions of said fastening means to give access
for employing said fastening means, so that each
fastening means is in a cantilever portion of said plate
which protrudes from the band from a location inboard of
35 the fastening means, each fastening means being offset
radially outwards of corresponding elongate reinforcing
parts of the respective halves, whereby, in said joint,

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01 tensile loads and bending moments applied at said joint
are resisted by cantilever action at the end plates, said
fastening means comprising bolts and holes.

10. A combination of two concrete pile sections,
05 substantially as hereinbefore described with reference to
Fig. 6 of the accompanying drawings.

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