

CHAPTER SEVEN

Specification of Piling

EXTENSIVE use is made of piles in civil engineering work, often for the purpose of transmitting heavy loads down to a firm stratum at a considerable depth below ground level. Sheet piling is used extensively to hold back water or loose soil and to form the walls of wharves, jetties, etc.

There are three main classes of piling: timber, reinforced concrete and steel sheet. Reinforced concrete piles can be cast or formed in situ, and there is a wide variety of proprietary in situ concrete piling systems. In one method a steel lining tube is sunk by a mechanical auger until a satisfactory bearing stratum is reached, concrete is forced into an enlarged base, steel reinforcement with helical binding is lowered down the temporary lining tube and further concrete is placed and rammed as the lining tube is withdrawn. Another method makes use of compacted gravel in place of concrete and the interstices in the gravel are subsequently filled with cement grout injected under pressure.

Different methods can be employed for excavating the soil from the pile holes, such as the use of cutters or shells inside lining tubes. Yet another system entails the driving of a conical cast iron shoe at the base of a steel tube; the steel tube may be left in position or withdrawn according to circumstances. In both cases steel reinforcement and concrete will be placed in the void. Another system uses a revolving screw pile shoe to bore through the various strata.

When specifying contractor-designed concrete piles it is usual to state the superimposed load to be carried by each pile, the method of disposal of any surplus spoil, any restrictions regarding the type of pile or method of driving and the finished levels of tops of piles in relation to ground level.

CIVIL ENGINEERING SPECIFICATION

With piles other than contractor-designed, it is advisable to set out the specification requirements in a logical sequence to assist the Contractor in reading the document and to reduce the risk of omission of essential details. As with the work previously described, it is good practice to insert materials clauses for each class of piling followed by workmanship and other requirements.

The following lists of items give a typical range of clauses covering each of the three main classes of piling.

CONCRETE PILES (CAST)

- (1) Concrete
- (2) Reinforcement
- (3) Shoes
- (4) Casting
- (5) Curing, stripping and stacking
- (6) Ready-made piles
- (7) Trial piles
- (8) Handling
- (9) Pitching and driving
- (10) Lengthening piles

Alternatively, concrete piles may be formed in situ, when they are likely to be constructed under a proprietary system. When engineer-designed, it is usual to specify the dimensions of piles, class of concrete and type and size of reinforcement. In addition, clauses normally will be included relating to compaction of concrete and cover to reinforcing bars, and the Contractor is usually required to keep a record of the construction of each pile and to test certain piles.

TIMBER PILES

- (1) Timber
- (2) Piles
- (3) Creosoting or tarring
- (4) Shoes and rings
- (5) Pitching and driving
- (6) Cutting off heads of piles

SPECIFICATION OF PILING

STEEL SHEET PILING

- (1) Steel sheet piles
- (2) Driving
- (3) Damaged piles
- (4) Cutting piles
- (5) Drilling piles

A selection of typical specification clauses for piling follow:

TYPICAL SPECIFICATION CLAUSES	EXPLANATORY NOTES
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CONCRETE PILES (CAST)

Concrete

Concrete shall be mixed in the proportions of 50 kg (112 lb) of Portland cement to 0.13 m³ (4½ ft³) of aggregate with a maximum size of 20 mm (¾ in.). Minimum compressive strengths 28 days after mixing shall be 39 MN/m² (5600 lbf/in.²) on a preliminary test and 29 MN/m² (4200 lbf/in.²) on a works test.

The cement and aggregate shall comply with the requirements under 'Concrete Work' (see Chapter 5).

Mix and strength requirements should be given, but the Contractor can be referred to previous clauses for materials, and for gauging and mixing requirements as necessary. In some cases rapid-hardening cement may be specified. Alternatively, the compressive strengths might be expressed in N/mm.²

Reinforcement

Reinforcement shall consist of 30 mm (1¼ in.) diameter mild steel bars and 6 mm (¼ in.) diameter binding links to B.S. 785, bent and fixed as shown on the Drawings. Main reinforcing bars shall be supplied in one complete length as far as possible; where this is impracticable, separate lengths shall be satisfactorily spliced or butt welded. Steel skeletons or cages shall be fabricated before being placed in the moulds.

General requirements with regard to the nature and method of fixing steel reinforcement should be given. Note the requirements relating to fabrication of steel cages and the use of forks or stretchers.

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Pressed steel forks or stretchers, machine moulded and true to length, shall be fixed in the positions indicated on the Drawings, to keep the binding links taut.

Shoes

Chilled hardened cast iron shoes with mild steel straps, weighing 25 kg (56 lb) each, as supplied by Messrs X or other equal and approved, shall be provided, shall be accurately fitted to the piles and tied to the pile reinforcement.

The type and weight of shoe should be stated, together with fixing requirements.

Casting

Concrete piles shall be cast in wrought timber or other approved moulds on a substantial horizontal platform capable of carrying the weight of the piles without appreciable deflection. The concreting of each pile shall be completed in one continuous operation free from interruptions of any kind.

All arrises of piles shall be chamfered and holes for lifting tackle shall be formed through piles in the positions shown on the Drawings.

General requirements are given as to moulds and casting platforms. Timber, steel or composite moulds would normally be permissible. It is essential that each pile should be cast in a single operation. Note the requirement as to chamfered arrises.

Curing, stripping and stacking

Piles made with ordinary Portland cement shall be kept moist for a minimum period of 14 days after casting. Side forms may be stripped 1 day and bottom forms 10 days after casting, provided the piles are kept supported on level blocks spaced not more than 2 m (6 ft) apart.

It is essential that piles should be properly cured and that forms are not stripped prematurely. Piles must not be driven before they have matured sufficiently. The periods quoted can be reduced where rapid-hardening

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Piles may be lifted 21 days after casting and moved to a suitable stacking site, but they shall not be driven until at least 6 weeks after casting. Each pile shall be suitably marked with the date of casting and the stacks so arranged as to permit the use of piles in correct age order.

Ready-made piles

The Contractor may use ready-made piles with the approval of the Engineer. The Contractor shall provide details of the manufacturer and the piles to be supplied, which shall be produced strictly in accordance with the requirements of the previous clauses. Care shall be taken to prevent damage to the piles in transit.

Trial piles

The Contractor shall, as soon as practicable after the acceptance of his tender, cast, drive and test trial piles made with an approved rapid-hardening cement, either singly or in groups in permanent positions as directed by the Engineer. The trial piles shall be manufactured in conformity with the requirements of the relevant clauses in the specification.

Handling

Piles shall be carefully handled and lifted and shall not be jolted or stacked in a manner which will subject them to bending. No pile shall be lifted other than by slinging from the lifting holes.

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and other special types of cement are used.

The use of ready-made piles will often result in the earlier supply of piles, but care is needed to prevent damage to piles in transit. The Engineer will have right of access to the supplier's casting yard.

It is customary for the Contractor to be required to cast, drive and test a number of trial piles on the site with a view to determining the probable lengths of the piles generally.

The lifting holes are usually formed at the quarter points in the pile. Alternatively, cast iron pipes may be cast into the piles for lifting purposes.

Pitching and driving

Piles shall be pitched accurately in the required positions and shall be driven to the lines shown on the Drawings. Any piles which are out of alignment or verticality shall be withdrawn and re-pitched.

Single acting rams or drop hammers weighing not less than 3000 kg (3 tons) and giving 40 blows per minute with a drop of 1 m (3 ft) shall be used for driving piles. Driving shall continue until the piles penetrate to a minimum depth of 7.5 m (25 ft) below dredged level or until a set of 25 mm (1 in.) has been obtained for the last 10 blows of the monkey with the specified drop.

Raking piles shall be driven accurately to the rake shown on the Drawings. The pile frame shall be fitted with leads capable of adjustment to the required angle and extension leads shall be used where necessary.

Piling frames must be capable of driving piles below the level of the base of the frame. The Engineer or his representative shall be present when each pile is driven to its final set. Suitable helmets shall be fitted to the heads of piles to prevent damage during driving.

The Contractor shall supply the Engineer with a report containing a complete record of the results of the driving of each pile.

After piles have been driven to the required set and to the satisfaction of the Engineer, the concrete shall be cut away from the head of each pile for a distance of 600 mm (2 ft) and the main reinforcing bars bent as necessary for connection to intersecting members.

It is usual to indicate in the specification the type of piling plant to be used and the method of determining the lengths of piles. Other common requirements cover the use of helmets, stripping of heads of piles and supply of records covering pile-driving operations.

On occasions the lengths of piles are determined by reference to test piles driven in advance of the main piles. The Engineer will then decide on the lengths to which the remainder of the piles are to be constructed and may vary the type and weight of hammer to be used.

The weights of hammers vary between 2000 and 4000 kg (2 and 4 tons) and the drop or free fall of the hammer is often 1 m (3 ft or 3 ft 6 in.).

The Contractor's report normally gives details of pile reference and location, and shortening or lengthening details, depth of penetration, set and safe load.

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Where piles extend for more than 600 mm (2 ft) above the required level, the surplus length shall be cut off and removed unless the Engineer directs otherwise. The Contractor's billed rates shall include for stripping heads and cutting off surplus lengths of piles.

Lengthening of piles

Where piles require to be lengthened, the reinforcing bars shall be stripped of concrete for a minimum distance of 600 mm (2 ft). The old concrete must be adequately roughened and rinsed with clean water prior to the application of a neat cement slurry and a 5 mm ($\frac{1}{4}$ in.) thick layer of cement mortar of the same proportions as that contained in the concrete mix.

The additional reinforcement shall be spliced or butt-welded to the exposed reinforcing bars, as directed by the Engineer. The new concrete shall be of the same mix as the original concrete and shall be adequately compacted between suitable moulds. The Engineer may permit the use of rapid-hardening Portland cement or high alumina cement in the new concrete where desirable.

The specification requirements aim at securing a satisfactory connection between the new and the old concrete and reinforcement respectively. It is customary to use butt joints for this purpose. The use of rapid-hardening or high alumina cement may be permitted to speed up the work.

TIMBER PILES

Timber

Timber for piles shall be greenheart of good quality, straight, sound, sawn square, well seasoned and free from rot, worm, beetle, injuries, shakes, large and decayed knots or other defects and shall conform to B.S. 1860, Part I.

It is good policy to begin with a clause covering timber requirements to ensure the use of timber of adequate strength and durability. Note the reference to B.S. 1860

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dealing with the measurement of characteristics affecting the strength of structural softwood.

Piles

Piles shall be at least 300 mm × 300 mm (12 in. × 12 in.) and shall be properly pointed and shod, and be provided with rings at their heads. Piles are to be driven at least 3 m (10 ft) into the river bed.

A common size for timber piles is 300 mm × 300 mm (12 in. × 12 in.). Average lengths are sometimes included in the specification particulars.

Creosoting

Creosoting of timber piles shall be carried out in accordance with the requirements of B.S. 913 (full cell process) and the creosote shall comply with B.S. 144. The timber shall be worked, incised 20 mm ($\frac{3}{4}$ in.) deep and have clean surfaces and a moisture content not exceeding 25 per cent prior to pressure creosoting. All later cuts shall receive two brush coats of creosote prior to the fixing of the timber in its final position.

It is essential to list preparation work on the timber prior to creosoting and to detail the method of creosoting. Note the use of British Standards to ensure a good standard with a minimum of description.

Tarring

All connecting surfaces of timbers, scarf joints and cut ends shall receive two coats of hot coal tar complying with B.S. 3051 before the timbers are fixed. After completion the whole of the timberwork shall be painted with two coats of hot coal tar.

The application of coal tar is an alternative to creosote. The Contractor is referred to a British Standard for the detailed requirements.

Shoes and rings

The points of all timber piles shall be protected with cast iron shoes weighing

Timber piles need protection by metalwork at both

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not less than 12.5 kg (28 lb) each, securely fixed to the timber with wrought iron straps. The heads of timber piles shall be protected with tightly fitting mild steel or wrought iron rings, 75 mm (3 in.) wide \times 20 mm ($\frac{3}{4}$ in.) thick.

Pitching and driving

Timber piles shall be accurately pitched in the required positions and driven to the lines and levels shown on the Drawings or as directed by the Engineer. The driving hammer shall weigh not less than 2000 kg (2 tons), shall not drop a greater distance than 2 m (6 ft), and shall be guided by leads to ensure that the piles are driven in correct alignment and to the required batter.

Any piles driven out of line, broken, split or otherwise damaged are to be withdrawn and replaced where necessary. Maximum permissible deviations shall be 50 mm (2 in.) for alignment and 2 per cent for verticality.

Cutting off pile heads

After timber piles have been driven to the required set and to the satisfaction of the Engineer, the heads shall be cut off square at the levels shown on the Drawings or as directed by the Engineer. When estimating the lengths of timber piles the Contractor shall make allowance for the removal of damaged timber in pile heads.

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ends. Sufficient information should be given to avoid any doubt as to the Engineer's requirements.

The depth of penetration of the piles may be determined in various ways, including the attainment of a certain set when the length of pile is not readily determinable. The weight of the driving hammer may be varied to suit the particular strata encountered.

Timber piles to wharves and jetties are often driven to a batter of about 1 in 24.

Even although rings are provided, timber in the heads of piles becomes compressed and splits from the impact of the driving hammer. It must then be removed.

STEEL SHEET PILING

Steel sheet piles

Steel sheet piling shall be Messrs X No. 3 section, weighing 57 kg (41.35 lb/ft) or other equal and approved, and it shall conform with the requirements of B.S. 15: Mild Steel for General Structural Purposes. The piles shall be free of pronounced warp, have properly formed interlocks and be free from cracks at folds. The piling shall be coated with an acid-resisting tar based paint before delivery to site.

The Contractor shall provide all special closer piles and shall allow for thoroughly greasing the locks of piles before pitching.

Driving

The Contractor shall provide all necessary frames, leaders, etc., needed for driving the steel sheet piling. A suitable helmet shall be provided to prevent damage to the head of the pile when driving. The piles shall be guided and held in position by adequate temporary walings and struts and all precautions shall be taken to ensure that the piles are driven in correct alignment. The Contractor shall submit to the Engineer or his representative for approval the method he proposes to use for the driving of piles.

The sheet piles shall be driven accurately and truly vertical to the lines and levels shown on the Drawings or as directed by the Engineer. Any creep occurring shall be eliminated in a manner approved by the Engineer.

The Engineer may specify a particular make and type of pile or specify that the piles shall be of approved type, giving greater flexibility to the Contractor.

The Contractor is required to provide all plant, equipment and labour necessary to drive the steel sheet piling satisfactorily in the required positions and to the appropriate depths.

The piles may be driven singly or in pairs and they must be properly interlocked throughout the whole of the driving period. It is good practice to specify the action to be taken when obstructions are encountered or when piles are driven below the required level.

Where the steel sheet piling is to be tied back to

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Where the driving of any pile or pair of piles meets obstruction or resistance, it shall be discontinued and the driving of other piles commenced and/or continued until the final level is reached. The Contractor shall return to the piles meeting obstruction or resistance and recommence driving until the final level is reached or, on the instructions of the Engineer, the affected piles are cut off at a suitable level.

Any piles driven deeper than the required level shall be withdrawn to the correct level. Existing piles on the site of the new work shall be withdrawn completely and re-driven in new positions as shown on the Drawings.

Damaged or misplaced piles

Any piles which are driven out of alignment or twisted, broken, bent or otherwise damaged in driving shall be withdrawn and replaced, at the Contractor's expense, with other piles which are properly driven to the satisfaction of the Engineer's representative.

Cutting piles

The Contractor will not be permitted to cut steel sheet piling, except where shown on the Drawings or as ordered by the Engineer. Any cutting shall be performed with an approved type of oxy-acetylene burning plant.

Drilling piles

The Contractor shall drill the steel sheet piling as necessary and shall fix steel channel waling and tie rods as shown on the Drawings.

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concrete, one method is to weld mild steel tangs, about 15 mm × 50 mm × 375 mm ($\frac{1}{2}$ in. × 2 in. × 15 in.) girth, to the back of the sheeting. One end of each tang will probably be split and fishtailed.

This clause provides for the removal of unsatisfactory piles and their replacement with sound, properly driven piles.

Cutting of steel sheet piling is generally restricted as to extent and method.

This is a reminder to the Contractor that his piling price must include for the additional labours involved.