

Measurement of Piling and Embedded Retaining Wall Work

1. General

Bills of quantities for building and civil engineering works are normally prepared in conformity with a standard method of measurement approved for use with the relevant form of contract. Some of the provisions of these standard methods are not, however, considered to be well suited to the efficient and practical measurement of piling. Model Bills of Quantities which are shown elsewhere on this website set out principles which are commended to future revision committees of standard methods of measurement and to those responsible for measuring piling works.

The following paragraphs explain the intention of the suggested items included in the outline bills of quantities. There will need to be variations or additions to these items to meet particular circumstances, structures or sites.

Materials from which the piles are formed and the section characteristics of these piles should be stated in item descriptions. Section characteristics are

- (a) for steel piles, section reference or mass per metre and cross-sectional dimensions
- (b) for other than steel piles, cross-sectional dimensions or specified diameters.

It should be noted that the finished diameter of a properly constructed cast-in-place pile may be greater than but not less than the specified diameter due to the method of construction or the nature of the ground.

Piling work should always be billed as 'provisional' and measured and valued as executed since it is only in exceptional circumstances that piles will be installed to the precise depths shown on the drawings or as measured. Provision for contingencies should be made by providing provisional sums in the bill of quantities and not by increasing the quantities beyond those expected to relate to the work to be executed.

The quantities should be computed net from the drawings unless directed otherwise in the Contract. No allowance should be made in the measurement of a pile for an increase in the specified diameter, waste or cut-off level tolerances.

2. Preliminaries

The model provisions for incorporation into piling tenders, and the typical schedule of attendances and facilities which would commonly be provided by a Contractor to a piling contractor are shown elsewhere on this website.

Separate measurement items should be included for each required establishment on site, distinguishing between that for any preliminary piles and for the main piling works. Unless there is a particular requirement, the establishment of plant on site and its subsequent removal can be measured as one item.

Additional items for establishment within the site should be included when piling is to be installed in separate work areas which require the transfer of units of plant involving an expenditure of time and resources significantly greater than that required for moving from pile position to pile position within the same area. The separate areas should be defined on the drawings and in the Particular Specification or the bill of quantities.

The terms and conditions of the standard forms of contract set down the obligations of the Employer and the Contractor to each other in respect of the provision of insurances. Where the Contractor has to effect insurance cover, the

Employer's requirements must be set out in the contract documents. Should there be no direct obligations included in a contract for the Contractor to effect insurances to meet contractual liabilities, he is still obliged to obtain insurance cover to comply with statutory requirements, and it is advisable that he should take out appropriate insurance cover as a matter of commercial prudence.

In all standard forms of contract the responsibility for the accurate setting-out of the structure rests with the Contractor. If it is specified that the setting-out of the pile positions is the responsibility of a piling sub-contractor, the Contractor must provide and maintain permanent stations setting out the positions of the structural grid lines and temporary benchmarks, and be responsible for maintaining them until he has satisfied himself that the piles have been installed in the correct positions, or, if a pile is found to be incorrectly positioned, until the piling sub-contractor has been notified and given the opportunity to verify the alleged error.

Item descriptions in the bills of quantities should identify work which is affected by bodies of water (other than groundwater) such as rivers, streams, canals, lakes and tidal water. Item descriptions for work affected by tidal water should also distinguish between work affected at all times and work affected only at some states of the tide. Water surface levels adopted for the purpose of such distinctions should be stated in item descriptions.

3. Obstructions

The removal of overhead, surface and underground obstructions and the backfilling of the voids with suitable material, through which piles can be readily driven or bored and soundly constructed, will need to be carried out by the Contractor before piling work begins (see Attendances and Services). Where appropriate, backfilling is to be carried out in accordance with the working/piling platform design.

4. Working levels

The piling platform level is the level at which the piling rig stands to carry out the work. Where necessary the piling platform and access thereto will be suitably prepared to support adequately the piling plant and equipment and attendant transport.

Where piling has to be carried out from a fixed structure or staging, whether permanent or temporary, or where floating or temporary staging may be used at the Contractor's discretion, the bill of quantities should be drafted accordingly.

'Commencing surface' in relation to an item in a bill of quantities is the surface level at the pile position at the commencement of the boring or driving operation. Work from each commencing surface which differs from the piling platform level and where the Contractor may incur significant additional costs should be billed separately.

On land the commencing surface will normally be the piling platform level; it can, however, be higher than the piling platform level when the pile is formed through a berm or the slope of an embankment, or lower when working adjacent to an excavation or cofferdam. In cases where the rig working level is above the commencing surface (e.g. in marine works from a staging or in a cofferdam with the rig at the top of the excavation), the bored or driven pile length which will be paid for should be measured from the bed level or the bottom of the excavation.

5. Measurement of lengths and depths

The concreted length of a cast-in-place pile is the length of the in-situ concrete measured from the specified cut-off level or the commencing surface, whichever is lower, to the specified toe level of the pile. Where pile cut-off levels are higher than the commencing surface, it may be necessary to extend the piles. The unconcreted length (empty bore/drive) between the specified cut-off and the commencing surface should be included in the item for total depth bored or driven. In this connection attention is directed to the provisions of the *Specification for piling and embedded retaining walls* for casting level tolerances in respect of cast-in-place piles.

The length of preformed concrete, timber or steel piles is the length stipulated or approved by the Engineer to be supplied, handled and pitched prior to driving. This length does not include unforeseen extensions. When driving to a set which is not achieved within the expected length, the Contractor should have the Engineer's written instruction before any pile is extended. The nature of preformed piles demands that the Contractor is instructed as to the length to be supplied to the pile position in sufficient time to enable the length to be cast or purchased.

Bored and driven depths should be measured from the commencing surface to the bottom of the casings of driving cast-in-place piles and to the toe level of other piles, with due adjustment for raking piles.

Separate items, similar to those for vertical piles, should be provided in a bill of quantities for raking piles, the amount of the rake being stated in the description. Measurement should be along the axes of the piles. In practice there is a limit to the amount of rake to which some types of pile can be installed.

6.Cast-in-place bored and driven piles

6.1 General

Driven permanently cased piles formed by driving a steel casing or concrete shell in one or more pieces which remain in place after driving and which are filled with concrete, are included in this section.

The following separate items are required in a bill of quantities for different work areas and commencing surfaces and for each pile diameter detailed on the drawings

- (a) the number of piles
- (b) the total depth of the bored or driven piles (the maximum anticipated length of the piles is to be stated)
- (c) the total concreted length of piles.

The maximum depth to be bored or driven will influence a contractor in his selection of the plant and equipment to be used and this in turn will affect the price offered. Plant and equipment do possess limitations in performance, so variation orders which increase the tendered maximum depth may produce a situation where the capacity of the plant and equipment upon which the contract is based may have to be increased, designs changed, or other piling systems substituted. To overstate the depth may produce an uneconomic tender due to the capacity of the plant offered being in excess of that which is required.

The forming of an enlarged base to a driven cast-in-place pile by driving out a concrete plug should be measured as an extra-over item. The diameter of the shaft should be given in the item description, but not the size of the enlarged base as this cannot be predetermined and is not subject to remeasurement.

6.2. Casings

Where permanent casings are specified as part of the piling works, these should be measured. The internal diameter and performance criteria for the casing should be contained in the item description. If anti-friction coating or other applied finishes are required on the outside surface, this requirement should be included in the item description.

Sufficient time must be allowed for permanent casings to be manufactured and delivered to site in time for the commencement of the piling work. As this material forms part of the permanent works, it is incumbent upon the Engineer to specify the length which has to be placed at a pile position.

Where temporary casings are left in as a result of unforeseen ground conditions and on the specific instructions of the Engineer, the additional costs incurred by the Contractor should be reimbursed.

6.3. Cutting-down of pile heads

The extent of cutting-down of the heads of cast-in-place piles will be governed by the depth of the specified cut-off level below the commencing surface, the standing water level if any, the length of the temporary casings required to support the sides of the bore, and whether or not concrete has been placed under fluid. An item for cutting down the heads of cast-in-place piles, disposal of the debris and preparation to receive the pile caps should be measured taking into account the cut-off level tolerances stated in the specification. It is normally economical for the Contractor to trim the piles and dispose of surplus lengths of piles.

6.4. Material for disposal

The volume of surplus excavated material for disposal should be calculated net from the specified cross-sectional area of the bored cast-in-place piles, or of the preboring for driven cast-in-place piles, and the bored lengths as measured in accordance with the Contract. The volume of enlarged bases to bored cast-in-place piles should be added. The actual volume as excavated can be greater due to the use of temporary casings and the nature of the ground.

A provisional item for excavating or re-excavating oversite to reduced level and disposal of the surplus material should be included in the appropriate bill of quantities to allow for possible additional excavation required due to any upward displacement of ground brought about by the driving of cast-in-place or preformed piles.

7. Special requirements for cast-in-place bored piles

The forming of an enlarged base to a bored cast-in-place pile by underreaming is measured as extra over to the shaft. The diameter of the shaft and the diameter of the enlarged base should be given in the item description. An item should be included in the bill of quantities to cover the provision of the additional equipment and attendance necessary for the inspection of the pile bores and underreams.

If a pile is to be founded on or in rock, the nature and properties of the founding stratum must be defined in the description and, in the case of bored cast-in-place piles, the amount of penetration should be stated and included in the depth of boring.

As boulders and discontinuous rock inclusions occurring in a shaft cannot be measured with any degree of precision, the payment for penetrating such strata should be treated as an obstruction and paid for on an hourly basis. The type of plant and the method to be utilized for the removal of the obstruction should be stated.

Where concrete is specified to be placed under water or a bentonite suspension as the prescribed method of construction, reference must be made in the bill to this additional work. However, it need not be a separate item but can be included in the item description for the concreted length of pile. The length measured for this work should be the full length of the concreted pile, even if the bore is only partly filled with fluid.

An item for placing concrete by means of a tremie should not be included in a bill of quantities as a contingency item or just to obtain a rate for the work, as additional plant, equipment and labour would be required, the concrete would need to be enriched and the rate of production would be reduced.

When bored cast-in-place piles are installed through water or a bentonite suspension, the Contractor needs to take this into account when disposing of the arisings from the bore, as they will be wet, or contaminated by the bentonite suspension.

Provision will be required on site for the disposal of water arising from the bores as it is displaced by the concrete. The disposal of bentonite suspension should be described in the item for boring.

8. Measurement of reinforcement in cast-in-place piles

A bill of quantities should describe the kind and quality of the steel and the section of the bars if other than plain circular in cross-section. Each bar diameter should be given separately and a distinction should be made between straight bars, lateral ties and helical reinforcement. The rate for reinforcement should include steel in laps, tying wire and additional steel for handling purposes to the extent required for the work detailed in the tender drawings. It should also include spacers, which need to be specified as to size, quality and frequency unless these requirements are left to the discretion of the (piling) contractor. The projecting reinforcement required for building into the pile cap should be included in the measurement.

Reinforcement in raking piles should be billed separately from that in vertical piles.

An alternative to measuring reinforcement separately which may be adopted for piles of diameter up to 600 mm is to describe the reinforcement required in the item for the concreted length of pile. This method is appropriate to small-diameter piles which are specified to be reinforced for their full length since the cost of the reinforcement is not a significant item when compared against the total cost of the pile.

9. Precast concrete, timber and steel piles

9.1. General

The following separate items are required in a bill of quantities for different work areas and commencing surfaces and for each cross-section or mass per metre detailed on the drawings

- (a) the number of piles
- (b) the length of each pile and the number to be supplied
- (c) the total depth driven (the maximum anticipated depth of the piles should be stated).

If slip coating or other applied finishes are required to be applied to the surface to reduce downdrag or to protect the pile, this requirement should be included as a separate item description for the length of piles required.

9.2. Length of pile supplied

The actual supply length of a preformed pile will affect the unit rate, as the most economic casting lengths of precast concrete piles will incorporate standard lengths of steel as offered by the manufacturers.

Where there is a requirement for long single-length precast concrete piles, normally in excess of 13 m long, prestressed concrete piles will often be specified.

Steel piling is supplied by manufacturers in lengths under 3 m, 3 m to under 5 m, 5 m to 14 m, over 14 m to 24 m, over 24 m to 30 m, and over 30 m, the purchase price per tonne being governed by the purchased length.

9.3. Pile extensions

Pile extensions should not be included in the measurement of the main piling but billed as separate items of work. There are three items required to describe the work to an extension: a numbered item, a pile unit length item and a depth driven item. Contractors do not have a uniform approach to the pricing of their fixed costs for extensions, as the nature of these costs permits them to be allocated either against the numbered item or within the billed unit length. These two items should not be subject to variation once instructed, as is the case with the driving item. The numbered item should include for preparing the head to receive the extension, handling and pitching and making good applied coatings or finishes; additionally, in the case of a steel pile, the welding on of the extension.

Steel piles can be extended by welding on a length that has been cut from a pile which has not been driven to its full supply length. Degaussing is seldom necessary and should not be regarded as included but should be measured as a provisional extra-over item. Cut-off lengths from precast concrete piles cannot be reused.

An alternative method of measurement for the numbered item and supply length is to bill extensions as a numbered item stating the length required to be

supplied and including all the labour and other items associated with an extension.

9.4. Applied finishes

If an anti-friction coating or other applied finish is required on the outside surface, this requirement should be included in the item description.

9.5. Cutting-down of pile heads

The extent of the cutting-down of the heads of preformed piles will be the length of the pile from the specified cut-off level to the head of the supply length; this item should include for exposing the steel reinforcement at the pile cut-off level and disposal of the debris. In respect of steel piles, the ownership of the cut-off lengths and responsibility for their disposal should be stated. Should the Contractor supply a preformed pile of a greater length than that specified or ordered by the Engineer, this extra length remains the property of the Contractor.

9.6. Rock shoes

Where precast concrete and steel piles are required to be fitted with rock shoes, the type and weight should be specified.

9.7. Preboring

Where it is a requirement to prebore for a preformed pile, the Engineer should specify the method, and if this results in a void between the sides of the excavation and the pile, an item should be provided for infilling with approved material.

10. Jointed precast concrete segmental piles

10.1. General

The following separate items are required in a bill of quantities for different work areas and commencing surfaces and each cross-section detailed on the drawings

- (a) the number of piles
- (b) the length of each pile toe unit and the number to be supplied
- (c) the length of each extension unit and the number to be supplied
- (d) the number of pairs of mechanical joints to be supplied
- (e) the total depth to be driven.

If slip coating or other applied finishes are required to be applied to the surface to reduce downdrag or to protect the pile, this requirement should be included as a separate item description for the length of piles required.

10.2. Length of pile

The maximum length of the pile which can be transported by road as a normal load is 13 m. In the case of precast jointed concrete piles, lengths in excess of 13 m are normally catered for by the addition of mechanically jointed extension units.

10.3. Pile extensions

Should the Engineer require provision for an extension to a length of jointed precast concrete segmental pile, instructions prior to casting must be given for a mechanical joint to be fitted to the head of the pile toe unit. To cater for this possibility, it is prudent to include an item in the bill of quantities.

Where there is a requirement to extend a segmental pile which has been supplied without a mechanical joint, a solution should be adopted to suit the loading of the pile. Examples may include pile-trimming to expose reinforcement, with in-situ extension, and epoxy resin or similar jointing to attach a further precast pile segment. An item for this work should be included in the bill of quantities.

11. Preliminary piles

Preliminary piles installed and tested before the start of the main works should be measured in a separate bill of quantities or be the subject of a separate contract. Their installation should be measured in accordance with the appropriate method of measurement for the type of pile, and separate items should be measured for each specified loading and type of test. The specification should state whether preliminary piles are to

remain as constructed, or the tops are to be cut off, or if they are to be incorporated into the Works or to be withdrawn.

12. Tests on working piles

Separate items should be provided in the bill of quantities for each specified loading. The item description should include all preparatory work such as site surfacing, bringing the pile head to the commencing surface level, preparing the head of the test pile and all work required in connection with the form of anchorage used including, where applicable, the supply of kentledge.

13. Plant standing during tests

If plant is required to stand between tests on preliminary piles and the start of the main piling contract work, during tests on working piles or while soil samples are taken, payment should be subject to the rules applying to daywork or on the basis of an itemized delay rate.

14. Samples and in-situ tests

Separate items should be provided in the bill of quantities for each form of sampling and testing operations; for example, sampling and testing undisturbed soil samples, penetration tests, manufacture and testing of concrete cubes, integrity-testing and dynamic load testing.

15. Removal of artificial and natural obstructions

The removal of natural obstructions such as boulders and discontinuous rock inclusions and unquantifiable artificial obstructions occurring within the shaft of a pile should be allowed for by provisional items in the bill of quantities, the Contractor being reimbursed for overcoming such obstructions.

Payments should be subject to the rules applying to daywork and should be paid extra over the measured work for the piles involved.

16. Payment on daywork basis

Provision should be made in an appendix to the bill of quantities for the Contractor to define the equipment on which his tender is based, together with the hourly rates for each plant and gang.

17. Observations and records

Pile records are important, as the information they contain will be used for the purpose of measurement of the Works and the preparation of as-made records of the Works.

Although every effort has been made to check the accuracy of the information and validity of the guidance given in this publication, the Federation of Piling Specialists do not accept any responsibility for mis-statements contained herein or misunderstanding arising herefrom.