PART 3

Measurement Risk in Contract Control

Managing Measurement Risk in Building and Civil Engineering, First Edition. Peter Williams.

Chapter 10
Contract Control Strategies

As discussed in Chapter 4, many different types of pricing documents are employed in construction:

- Some are formal – issued by the employing authority.
- Some are informal – prepared internally by the contractor or subcontractor.
- Some become formal – when contractors and/or subcontractors issue their internal documents for tendering purposes and/or for incorporation as a contract document (e.g. a contractor's contract sum analysis or activity schedule).

Irrespective of the pricing document, or its formality or informality, and regardless of whether it is included in the contract documents, the pricing document forms the basis for contractor's/subcontractor's financial control of the project.

10.1 Financial control

Morris (1999), Burke (2013) and others consider that project management concerns the management of change.

Looking at the job of construction site managers, this is certainly true, as most of their time is consumed dealing with unforeseen events, unexpected design changes and incidents that arise 'out of the blue'.

The same could be said of the site quantity surveyor (QS), who has to deal with the financial consequences of what happens on-site. Added to this, upwards of 50% of site QS's time is spent preparing the monthly cost-value reconciliation, which compares actual cost and value with planned, and most of the remaining time is spent dealing with dayworks and claims and finding ways to make money out of loss-making activities.

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10.1.1 The role of measurement

Change has to be managed and this requires a strategy for control. Measurement is central to the financial management of construction projects and is integral to the role played by the pricing document in the contractor's financial control strategy. The pricing document:

- Establishes **the contractor's budget** for the contract.
- Forms the basis for **subcontract enquiries** and the subsequent **subcontract agreement**.
- Provides a means for making **main contract payment applications** to the employer.
- Provides a means for making **subcontract payment applications** to the main contractor.
- Establishes a starting point for **valuing variations** to the contract.
- Creates the basis for **the contractor's internal valuation** which, in turn, enables the contractor's monthly **cost-value reconciliation** to be prepared.
- Forms the basis of the contract **final account**.

Both the contractor's QS and that of the employer perform many measurement iterations during the course of a contract, even on lump sum contracts. The PQS is mostly involved with measuring and valuing variations to the contract and work in connection with the expenditure of provisional sums.

10.1.2 Measurement risk

Risk is the chance of something happening that will have an impact upon the outcomes of the contract. It cannot be completely eradicated, but it can be managed.

Measurement might be considered as comprising three parts:

1. Magnitude.
2. Dimensions (units).
3. Uncertainty[1].

The use of the word 'uncertainty' is interesting because it also introduces the notion of 'risk' simply because the two words are often considered synonymous. However, in a useful discussion, Ross and Williams (2013) suggest that 'uncertainty' has a separate and distinct meaning from 'risk'. They quote a number of authorities who concur in this view amongst whom is Winch (2010) who perhaps makes the clearest distinction:

- Uncertainty is *the absence of information required* for decision making.
- Risk is *the condition where information is still missing but a probability distribution can be assigned to the occurrence* of a particular event.

Transposing this logic into a measurement context would seem to suggest, therefore, that:

- Uncertainty arises in circumstances where there is insufficient information available to measure the work or object in question.
- Risk is where a judgement is needed to assess the likely consequences arising from the occurrence of a specific event or circumstance in relation to an item of work or object that can be measured.

Table 10.1 provides some examples of each.

Consideration of risk and uncertainty in measurement is not, however, confined to measurable items. The procurement and contractual arrangements for a project can also have a considerable impact on measurement issues, whether in relation to the main contract between employer and contractor or a subcontract, or sub-subcontract, further down the supply chain.

The measurement process doesn't end when the bill of quantities, or other pricing document, is completed, and a great deal of measurement goes on during the contract whilst work is progressing in order to:

Table 10.1 Measurement risk and uncertainty.

Measurement	
Risk	**Uncertainty**
• A measured item for a drain trench excavation, 3–4 m deep, where the contractor has to include for an earthwork support system in his price • Where an item is included in a bill of quantities for the construction of a structure which the contractor is required to design • A provisional quantity in a bill of quantities where the quantity stated is artificially inflated to provide a hidden contingency	• A provisional quantity in a bill of quantities where the amount of work in the item can only be estimated • A prime cost sum is included in a measured item of brickwork for facing bricks that the designer has yet to specify • The inclusion of a provisional sum in a bill of quantities where the item in question is known about, or anticipated, but cannot be quantified

- Measure the quantities of work done according to the type of contract being used.
- Deal with provisional quantities and provisional sums.
- Measure variations to the contract.
- Prepare the contractor's cost-value reconciliation.

10.2 Measuring the quantities of work done

Post-contract measurement is conducted by different people for different reasons during the currency of a construction contract.

The accuracy, reliability and contractual validity of such measurements can be extremely variable and much depends upon who is doing the measuring.

An experienced PQS is usually qualified and very able when it comes to measurement, but contractors' QSs come in all shapes and sizes and levels of competence in measurement, whether qualified, partially qualified or non-qualified. Some subcontractors are competent in measuring their particular trade, whilst others may have little or no QS background and may struggle with the finer points of methods of measurement and contract conditions.

Measurement may be undertaken:

- For or on behalf of the employer, usually in conjunction with the contractor, is a valid process under standard forms of contract, and the results of the measurement process will find their way into interim payments and into the final account.
- By the contractor, and submitted to the employer, may or may not be accepted and it is for the contract administrator to decide whether the measurements are valid or not.
- By subcontractors, and submitted to the contractor, may be accepted if they are capable of being accepted by the employer.
- By subcontractors, and submitted to the contractor, will be rejected if they are not capable of being accepted by the employer unless the terms of the subcontract are different to those of the main contract.

10.2.1 Admeasurement and remeasurement

'Admeasurement' is often taken as a synonym for 'remeasurement', but the words have different, if subtle, meanings. The term *remeasurement* is used in NRM2, Paragraph 3.3.8.2, whilst *admeasurement* is used in several places in CESMM4, but neither term is defined.

According to the Oxford Dictionary:

- **Admeasurement** is *the act of ascertaining and apportioning*.
- **Remeasurement** means to *measure again*.

In terms of construction, *admeasurement* originated from Clause 56 of the ICE Conditions of Contract (now ICC – Measurement Version), meaning to establish the difference between a final quantity and an original quantity of work, whether more or less. It is this difference that determines, for instance, whether or not any of the rates and prices in the contract bills are *rendered unreasonable or inapplicable in consequence of* the change in quantity.

Whilst the term 'admeasurement' is peculiar to the ICC – Measurement Version, other standard contracts use words and phrases that essentially mean the same thing. Therefore, in a measure and value contract, the admeasurement process will take place, if not in name, in order to identify differences in the estimated and final quantities of work for the purpose of arriving at a fair valuation of work done.

The dictionary definition of 'remeasurement' infers the measurement of something that has already been measured but is to be measured again. This process results in a fresh set of quantities that replace the original rather than establishing the difference between the two as in admeasurement.

Remeasurement is common in lump sum contracts where the basis for determining the final account is the omission of one item from the contract sum and the substitution of another should a change or variation have occurred.

Consider a bill of quantities item for *mass concrete in foundations* in a lump sum contract, where the original quantity is measured as 93 m^3. Under the JCT 2011 contract, a change in this quantity would be a variation. If the final quantity is measured as 136 m^3, the original item would be omitted from the contract sum and a new item, with the same description but a remeasured quantity of 136 m^3, would replace it. This adjustment would be made in the 'variation account' of the final account as illustrated in Table 10.2.

Table 10.2 Remeasurement.

Omit				Add			
	'In-situ' concrete works				**'In-situ' concrete works**		
	Plain in-situ concrete				Plain in-situ concrete		
A	Mass concrete; Class C20; Any thickness; In trench filling; Poured on or against earth or unblinded hardcore	93	m3	A	Mass concrete; Class C20; Any thickness; In trench filling; Poured on or against earth or unblinded hardcore	136	m3

The same item in a measure and value contract would be dealt with differently as measure and value contracts do not have a contract sum. Consequently, any difference in the original quantities would be admeasured (i.e. adjusted ±) to reflect the final quantities of work carried out, and the bill of quantities would be altered accordingly.

The extent to which work executed is remeasured or admeasured depends on the type of contract.

10.2.2 Lump sum contracts

Lump sum contracts are based on the concept of a fixed and agreed price to do a job which establishes the contract sum agreed by the parties (e.g. employer–main contractor and main contractor–subcontractor). The contract sum in a lump sum contract may only be adjusted if the contract terms contain express provisions to do so.

Under the JCT SBC/Q 2011, for instance, the contract sum may only be adjusted for specified reasons:

- Variations issued by the architect/contract administrator.
- Adjustment of provisional sums.
- Adjustment of approximate quantities.
- Payments for direct loss and expense.
- Insurance payments.

Consequently, the quantities given in a lump sum contract are, to all intents and purposes, fixed, agreed and not subject to adjustment unless there is a legitimate reason why the works should be remeasured.

Subcontractors, particularly, often fail to understand this concept. Sometimes, this stems from ignorance of contract law, sometimes from lack of information from the main contractor and sometimes because they instinctively remeasure the work they have done in the belief that this is the means whereby maximum payment can be guaranteed.

Additionally, subcontractors are often unaware that they are signed up to a lump sum contract despite the main contract being a measure and value contract and vice versa. There is no question that main contractors can often make extra margin in such circumstances by either:

- Profiting from an under-measured bill of approximate quantities whilst at the same time subcontracting the works as a series of lump sums.
- Tying subcontractors to a measure and value arrangement whilst the main contract is a lump sum contract with a generously measured bill of quantities or in the belief that it will be possible to 'pull the wool over the eyes' of the subcontractors when it comes to admeasuring their work.

10.2.3 Measure and value contracts

Under measure and value contracts, there is no contract sum at the outset. The only thing fixed and agreed by the parties beforehand are the rates and prices that will apply to the contract, and it is these rates and prices that will be used in order to value the work carried out by the contractor (or subcontractor).

The prices will consist of the contractor's preliminaries, including any fixed or time-related charges or method-related charges, and the rates will be for individual items of measured work such as earthworks, concrete work, wall and floor finishes, drainage etc.

Measure and value contracts are often classified as 'remeasurement' contracts, but this is not strictly correct. They are really 'admeasurement' contracts because the difference between the original quantities and the final quantities is what determines the final payment and whether any change is needed in the rates and prices to reflect the consequences of the change in quantities. In practice, both terms are used interchangeably.

Measure and value contracts arise out of uncertainty:

- With the scope of works required.
- With the design or parts of the design.

There is an element of risk for the contractor (or subcontractor) with measure and value contracts in that the eventual admeasure may equally be less than envisaged as more, and as such, the risk is that margin may be lost as well as turnover. Ross and Williams (2013) illustrate this point with a worked example which shows that a 10% reduction in measured quantities could lead to a 24% loss of profit on the contract.

With a measure and value contract, the original pricing document may be a bill of approximate quantities or possibly a schedule without quantities. In both cases, the work carried out will be

measured according to the rules of measurement stated in the contract documents, and the value of this work will be established by applying the agreed rates and prices to the quantities.

The JCT SBC/AQ 2011 is an example of a measure and value contract whereby the contractor's rates and prices are used in the first instance to establish a tender total (i.e. *not* a contract sum) and, thence, following admeasurement of the completed work, to determine an ascertained final sum which is the amount to be paid by the employer to the contractor.

There may be a presumption that a measure and value contract will be admeasured on the basis of a physical on-site measure of the completed work. This may be far from the case because:

- The original drawings upon which the approximate quantities were based may have been less inaccurate or uncertain than at first envisaged.
- Revised drawings may have been prepared during the course of the contract which may be much more representative of what was actually constructed.
- 'As-built' drawings may have been prepared which exactly depict what was constructed.

On a measure and value contract, it is usual practice to admeasure from the drawings, and it is only where these are uncertain or inaccurate that actual site measurements are taken. Subcontractors often have difficulties with this in the mistaken belief that nothing can be more accurate than measuring that which is actually built. This is not the case, and site measures are notoriously inaccurate because of:

- The natural tendency to 'over-measure' (in order to make more money).
- Failure to follow precisely the standard method of measurement.
- Failure to measure 'net' as depicted on the drawings or in standard construction details.
- The idea that 'pinching' a few metres here and there will not be noticed.

Subcontractors are often at a distinct disadvantage when it comes to admeasures because:

- Subcontract enquiries rarely contain full and complete information.
- Very often, the work gets underway and the subcontractor has little or no drawn information to work from.
- Main contractors are frequently reluctant to provide subcontractors with full or up-to-date drawings from which to measure.
- Main contractors invariably fail to pass on contract administrator's instructions so that subcontractors find difficulty in distinguishing variations from measured work.
- At final account stage, subcontractors either have out-of-date drawings or no drawings at all.

As a consequence, subcontractors regularly have to resort to the time and expense of a physical measure which (i) will undoubtedly be far less reliable than measuring from drawings and (ii) is more than likely to be disputed by the main contractor.

10.2.4 Cost reimbursement contracts

By their very nature, there is no remeasurement/admeasurement involved with cost reimbursement contracts.

The idea with this sort of contract is that the contractor is paid on the basis of the actual cost of carrying out the work – that is, the cost of labour, materials, plant and subcontractors to which is added a pre-agreed percentage, or sometimes a fixed fee, to cover preliminaries, overheads and profit.

Paradoxically, there is often a cost reimbursable element to both lump sum and measure and value contracts in the form of **daywork**. This is a means of valuing work done on the basis of the time spent and the materials and plant used together with a percentage addition to cover oncosts, overheads and profit.

Where payment is made on the basis of time spent, it could be argued that the very act of recording the time expended by various classes of labour, and types of plant and equipment, is a form of measurement with the unit of measurement being **the hour**.

10.3 Provisional quantities and provisional sums

Provisional sums are to be distinguished from provisional quantities because they each arise, and are dealt with, differently both contractually and in terms of measurement. The measurement of these items is conducted by, or on behalf of, the contract administrator.

Provisional quantities arise in lump sum contracts. They are the estimated quantities of items of work to be carried out by the contractor where accurate quantities cannot be measured. Provisional quantities do not arise in measure and value contracts because all the quantities in such contracts are estimated.

In SMM7, work that can be described in accordance with the rules of measurement but cannot be measured accurately is to be identified as *approximate* (General Rule10.1). The same rule applies in Paragraph 3.3.8.1 of NRM2, but such quantities are to be identified as *provisional*. This gives rise to a measured item as illustrated in Table 10.3.

Table 10.3 Provisional quantity.

	Excavating and filling		
	Excavations		
	Excavation		
A	Bulk excavation; Not exceeding 2m deep [Provisional]	12500	m3

It will be noted from Table 10.3 that the provisional quantity (12 500 m^3) is a 'round' figure. This should put the contractor 'on warning' of the approximate nature of the quantities even if the word 'provisional' doesn't! The large quantity billed may indicate the possibility of a hidden contingency.

Care should be exercised with approximate/provisional quantities because a lump sum contract, by definition of its nature, requires a mechanism for adjusting any quantities in the contract bills, whether provisional or not.

Where SMM7 and NRM2 are used in conjunction with the JCT 2011 SBC/Q contract, this is taken care of in Clause 5.1.1 which defines changes in quantity as a variation to the contract and confers legitimate powers to deal with them on the contract administrator.

Should it not be possible to create an approximate/provisional quantity, SMM7 (General Rule 10.2) and NRM2 (Paragraph 2.9.1.1) provide that a provisional sum be given as 'defined' or 'undefined' work.

An issue for contractors is that approximate/provisional quantities are not distinguished from other quantities in JCT 2011, and the contract administrator can vary such items with seeming impunity. However, JCT 2011 does redress the balance somewhat via the valuation of variations Clause 5.6.2, which states that a fair allowance shall be made to the rates and prices where the change in quantity is significant.

The word 'significant' is not defined in the contract, but Paragraph 3.3.8.2 of NRM2 does introduce the idea of a threshold of change (the 20% rule) despite it being of questionable contractual merit.

Provisional sums are described, but not measured, in the bill of quantities and represent a sum of money to be expended, as required, by the contract administrator. If, in the fullness of time, the work described is not required, the provisional sum(s) will be omitted from the contract sum calculation at the final account stage.

Provisional sums are to be identified as 'defined' or 'undefined' work pursuant to NRM2 Paragraph 2.9.1.1, depending upon the level of detail available at the time the bill of quantities is prepared. In CESMM4, there is only one classification – provisional sum for defined work.

In the event that a particular provisional sum is expended, the employer's QS, or equivalent, will normally measure the work involved. This does not constitute a remeasure or admeasure because no quantified allowance has been made in the bill of quantities.

Such work is treated as a variation to the contract, under both the JCT 2011 and ICC – Measurement Version forms of contract, unless the work is to be carried out by a nominated subcontractor under the ICC form. The work is, therefore, measured in accordance with the rules of measurement applicable to the contract and dealt with in the provisional and prime cost sum part of the final account as shown in Table 10.4.

Table 10.4 Dealing with provisional sums in the final account.

Provisional sum in BQ						Measurement of work in connection with Provisional sum in final account			
Omit						**Add**			
Ref	Item	Quantity	Unit	Rate	£ p				
	Provisional Sums					**General joinery**			
	Allow the Provisional Sum of £3 000 for sundry joinery work in Workroom A. (Undefined work)				3 000 00	Unframed isolated trims,skirtings and sundry items			
						Skirtings.			
						A Softwood; 169 mm x 20 mm; Torus; Fixed to blockwork	69	m	
						Architraves and the like			
						B Softwood; 56mm x 17 mm; Torus; Fixed to blockwork	33	m	
						Window boards			
						C Softwood; 219 mm x 33 mm; Rebated and rounded one edge; Fixed to blockwork	9	m	
						Pinboards			
						D 1200 mm x 1200 mm x 12 mm; Unframed; Fire-retardant felt; Burgundy; Fixed with 4 nr brass plates to blockwork	3	nr	

10.4 Measuring variations to the contract

Where empowered to do so, contract administrators may issue variation instructions where changes to the design are needed or where additional or less work than envisaged is required. Under some forms of contract (e.g. JCT 2011), changes in quantity qualify as a variation, whilst in others (ICC – Measurement Version), they don't. Changes to the Works Information under the ECC are 'compensation events'.

On occasion, certifiers will pay the contractor 'on account' for variations whilst awaiting appropriate written instructions from the architect or engineer (often one and the same person!), but strictly speaking, no payment should be made until the variation has been measured and valued in accordance with the contract conditions.

The measurement of variations follows the rules of measurement in the contract and normally involves deleting one BQ item and substituting it with another in the 'variation account' part of the final account for a lump sum contract. Work may equally be omitted altogether, changed in quantity or quality or simply changed.

Variations are usually measured from revised drawings but, where necessary, can be made on-site. In this event, the contractor normally has a right to be present when the measurements are taken. This acts as a check on what the PQS is measuring, which is not needed if measuring from drawings, as the contractor will have a copy.

Attention should be paid to the distinction between remeasurement/admeasurement and the measurement and valuation of variations.

If measured work in the bill of quantities is omitted or changed in some way, it is normally within the power of the contract administrator to value this as a variation, and this power

extends, where appropriate, to the power to decide the appropriateness of BQ rates and prices if considered necessary.

If this process indicates that the BQ rates should be revisited in the circumstances, then method-related charges will be subject to scrutiny and adjustment, if the contract administrator thinks fit, in order that a fair valuation is determined.

The form of contract must be carefully examined, however, because different standard forms define variations in different ways. In some contracts, a change in quantity is a variation but not in others.

10.5 Preparing the contractor's cost-value reconciliation

The biggest monthly task for the contractor's QS is to accurately measure the work carried out on-site (the internal valuation) so that this can be compared with the valuation of work in progress determined for interim payment purposes (the external valuation).

The **external valuation**, whether conducted by the PQS or by the contractor, is a 'theoretical' measure of work done simply because of the way that the valuation is carried out.

Ross and Williams (2013) suggest that, most commonly, external valuations are based on **inspection**, which is a judgement of the percentage of work completed to date. The external valuation is prone to inaccuracy because the work may well be over- or under-measured due to the lack of precision in establishing the amount of work completed.

This contrasts with the contractor's **internal valuation**, which is a measured valuation that accurately establishes how much work has really been done.

The internal valuation needs to be accurate because it is compared with actual cost in order to establish the profitability, or otherwise, of the contract. The purpose of the exercise is to determine the real value of work in progress, and profit or loss, so that this can be reported to management for control purposes and for inclusion in the quarterly, six-monthly and annual accounts of the company. The cost-value reconciliation process is examined in detail by Ross and Williams (2013).

The accuracy of the internal valuation depends on how able the site QS is at measurement and upon the reliability of site records, diaries, daywork and time sheets and measurements taken by non-QS personnel.

10.6 Physical measurement

The physical measurement of construction work on-site is arguably the most difficult task facing the QS, measurement engineer, site engineer or subcontractor. Physical measurement poses a number of problems for the measurer, and the eventual output from the site measurement process can often provide a fruitful area for argument and dispute. Site measurement may be required for a number of reasons, but it frequently lacks the precision of measurement from paper drawings or computer-generated drawings and models – hence the arguments!

Another problem is that the QS frequently has to rely upon measurement data prepared by others. For example, a foreman or ganger might record the dimensions of a soft spot which is then filled with stone or concrete, or a subcontractor might remeasure some extra work that has been carried out. At some stage, the site QS will receive a copy of this information, but there may be problems:

- The measurements taken may have been exaggerated (with the best of intentions!) but are nevertheless inaccurate.
- The dimensions may not have been agreed or verified by the employer's representative (which a QS would normally do as a matter of course).
- The work may have been recorded as daywork with no dimensions taken.
- Records of the materials used may not have been kept.

Where a site engineer takes a grid of levels during earthworks operations, this information will be passed over to the QS at some stage. On the face of it, this sounds fine but the QS might have preferred three grids of levels: one favourable to the contractor for presentation to the employer, another favourable to the contractor and less favourable for the earthworks subcontractor and a final accurate set for internal costing or CVR purposes. This may sound like questionable practice or 'cooking the books', but it is simply a matter of making money by placing the levelling staff in high spots or low spots as appropriate.

It is always a good idea for the QS to ask site staff to take digital photographs of work that they have measured and to make sure that there is an object in the photo that will give an idea of scale – a measuring tape or levelling staff could be used, for instance. This is easier said than done because site staff are normally under pressure and may not have the time for QS 'niceties'.

Measurement data prepared by non-QSs may also suffer from deficiencies vis-à-vis the standard method of measurement:

- Measurable items may be missed.
- Claims opportunities may be overlooked.
- The dimensions taken may be inaccurate.
- Dimensions may be written down in a way that is difficult to follow (remembering that QSs have their own conventions for setting down dimensions and side casts).

There may be a number of reasons why it is necessary to measure construction work physically on-site:

- The quantities given in the bills of quantities are approximate, and no 'as-built' drawings have been prepared from which to measure the completed work.
- There is no grid of levels for the site, or the levels given on the drawings are either insufficiently detailed for accurate measurement or have been proved to be inaccurate when checked physically.
- The bills of quantities provided – either by the employer to the main contractor or by the main contractor to a subcontractor – are inaccurate because either the quantities are incorrect or the standard method of measurement has not been followed, or there is a conflict with the drawings and/or specification or for any combination of such reasons.
- The contract may be such that no quantities were provided at the outset, there are few if any drawings and the work must necessarily be measured from the finished items of work (a typical circumstance in refurbishment, repair and maintenance work).
- Instructions for variations to the contract may have been issued by the contract administrator, but no revised drawing has been issued to reflect the work involved (irrespective of whether the variation is an omission or an addition to the contract).
- Circumstances may have arisen on-site where unplanned or unexpected work has been carried out that needs to be measured and recorded before the work is covered over or excavations are backfilled and the data is lost.
- A subcontractor may have carried out additional work on the basis of a verbal instruction and has not been issued with any drawings representing the work involved.
- A subcontractor may have been requested by the main contractor to return to site in order to rectify completed work that has been damaged by another subcontractor, and there is no alternative but to physically measure the remedial work needed.

For these, and perhaps many other, reasons, physical measurement on-site may be necessary, but there are traps for the unwary, and it is vital to understand the contractual arrangements for the project in question before jumping to the conclusion that work done should necessarily be remeasured.

Site measurements are often taken when one trade has finished its work but the following trade has yet to commence or is only at a preliminary stage.

For instance, plastering to block walls may have been completed, but skirting boards and suspended ceilings have yet to be done. For practical reasons, the plastering will normally extend behind where the skirting is to go and beyond the finished level of the suspended ceiling, and it is, therefore, tempting to measure the plastering that has actually been applied to the walls. This is to forget the concept that:

a) Standard methods of measurement prescribe that measurements shall be net.
b) The tops of skirting boards and the finished line of suspended ceilings denote a **payment line** for measurement of the plastering work.

10.6.1 Conducting a site measure

Site measures are often undertaken by QSs working alone and with no one available to hold 'the other end of the tape'.

At one time, this posed a problem and most QSs will be familiar with the difficulty of finding a convenient point for 'hooking' the end of the tape to in order to take a measurement. Invariably, the tape will fall off at the last minute, and the QS is then obliged to trudge back through the mud and start again – frustrating, time-consuming and tiring work!

Measuring floor to ceiling heights, other than in domestic-scale buildings, is also problematic when working alone, particularly when the scaffolding has been dismantled or if there are dormer-style roof lights or atria to measure.

The advent of a modern generation of measuring devices has helped to solve such problems and make site measuring much quicker and more accurate. With some devices, measurement data can be downloaded directly to a PC or laptop and thence into a spreadsheet or measurement software package.

Basic QS equipment for site measures includes a retractable tape, long tape, measuring staff and dimension book.

10.6.2 Site measurement of specialist work

Some types of construction work cannot be measured on-site in conventional ways due to the nature of the work concerned. Piling work, embedded retaining walls and the like cannot be physically measured in the same way as 'normal' construction work. Imagine, for example, the problem of physically measuring the depth of a rotary bored pile 300 mm in diameter. A small person dangling on a rope would not be allowed for health and safety reasons!

An additional difficulty is the contract administration procedures and protocols required to agree such measurements with the main contractor and with the employer's representative so that payment without dispute is assured.

The Federation of Piling Specialists guidance is that piling work and embedded retaining walls, etc. *should always be billed as 'provisional' and measured and valued as executed*, but no guidance is given on how this should be done. The solution to the problem with regard to piling depends on the type of pile.

Driven piling, for instance, requires the development of a static design from the geotechnical information supplied with the contract documents or from a subsequent subsoil survey. This determines an estimated depth for the pile which is used for estimating purposes and as the basis for an order or contract. If billed, this work would have to identified as provisional in a lump sum contract.

For driven piles, a 'pile set' calculation is performed according to the 'industry standard' *Hiley Formula*,[2] which takes into account the weight of the piling hammer, the efficiency of the rig, the drop height of the hammer and the safe working load of the pile. The set calculation ensures

that the pile is driven to the correct depth to carry the required loads. The pile set is a measurement of how much the pile moves for every 10 blows of the piling hammer. The site operative makes a mark on the pile section, hits the pile 10 times with the hammer and then marks the pile again and measures the distance between the two marks.

As the ground can vary from the geotechnical information supplied, there will invariably be variations in pile depths for each of the driven piles supplied. The desired length of pile will be made up as required from standard lengths (typically 3, 4 or 6 m) in order to minimise any waste pile protruding from the ground.

The driven piles are measured to the 'pitched length' which is the depth of the pile in the ground including any pile length protruding above the ground. The lengths of piles are calculated from the sum of the lengths of pile sections installed as noted on a 'pile record sheet' by the piling operative. The sheet is then signed off as a true record by the operative, the contractor/employer representative and the piling engineer.

In the case of driven cast in situ piles (Cementation Skanska's FRANKI® pile), the hydraulic hammer rigs have digital instruments in cab which provide a continuous display of depth, driving resistance and set. The data is recorded for each pile and can be saved to a PC for analysis and measurement purposes. Site printouts can be made from the in-cab printer which produces a record on-site in graphical form for verification and signing off, if required.

In the case of augered (not rotary bored) piles, the design process is the same as for driven piles, but the measurement process is different.

The augered pile is installed to the design depth, taking into account the borehole commencement level, the piling platform level and the cut-off level for the pile. Within the auger rig cab is a computer system which the operator uses to measure the depth of the pile, torque, rotation speed, concrete pressure and a few other things. This information is manually written onto a pile record sheet. The difference with augered piles is that the computer also produces a pile synthesis which states the depth of the pile and, as they are installed to the designed depth, there is very rarely any variation on pile length.

Notes

1. http://en.wikipedia.org/wiki/Measurement (accessed 29 April 2015).
2. http://anbeal.co.uk/hiley.html (accessed 29 April 2015).

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