

**CHAPTER 9**

**MEASUREMENT PROCEDURE**

## **SYNOPSIS**

This Chapter describes the criteria to be adopted, the procedures to be followed and the documentation that is required in the measurement of civil engineering works and to be read in conjunction with the relevant departmental guidelines where appropriate. It should be noted that these are guidelines for good practice rather than mandatory procedures. The project officer should ensure the suitability of the use of these guidelines by taking into account the scale and the complexity of the project and the availability of staff resources.

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## **1. GENERAL**

### **1.1 TYPE OF CONTRACTUAL ARRANGEMENT**

It is desirable to begin by defining the type of contractual arrangement in relation to the 'measurement' of civil engineering works (see also Chapter 5 - Contract Documents).

#### **1.1.1 Lump Sum Contracts with Drawings and Specification**

The contract sum is based on the drawings and specifications, and measurement is only required to assist in valuation of the variations. This contractual arrangement is also applicable to the electrical and mechanical works (see WBTC No. 19/2000) and those works of which an alternative design proposed by the Contractor is accepted (see ETWB TC (W) No. 25/2004).

#### **1.1.2 Lump Sum Contracts with Firm Bills of Quantities**

The quantities for the works form the basis of the contract sum and are not subject to remeasurement. Accurate quantities have to be measured from the fully completed design in the pre-contract stage. During the contract period, measurement is required for provisional quantities and valuation of variations only (see WBTC No. 17/95).

#### **1.1.3 Remeasurement Contracts with Approximate Bills of Quantities**

The quantities in the Bills of Quantities (BQ) are approximate only and are subject to remeasurement upon completion of works on site. This form of contractual arrangement is adopted in the General Conditions of Contract for Civil Engineering Works (1999 Edition) (GCC) and is commonly used for capital works projects.

#### **1.1.4 Schedule of Rates Contracts**

This type of contract is suitable where it is not possible or practical at the tender stage to give realistic and accurate quantities of the works that are to be undertaken. For these contracts, a Schedule of Rates is drawn up as a list of all the items that are expected to be required for the Works. The tenderers need to insert prices against each item or state the percentages above or below the given rates for which they would be prepared to execute the Works (see paragraph 4.2.2 for details). This contractual arrangement is usually applicable to term contracts for execution of maintenance or minor works and for provision of services (e.g. watchmen). This form of contractual arrangement is adopted in the General Conditions of Contract for Term Contracts for Civil Engineering Works (2002 Edition).

#### **1.1.5 Design and Build Contracts**

This type of contract is suitable where the Contractor is required to design and construct the works in accordance with the Employer's Requirements. They are normally lump-sum contracts and tenderers are required to respond to the Employer's Requirement by submitting a "breakdown of the Contractor's rates and prices" on which his tender prices are

based. For more details, please refer to the Administrative Procedures for use with the General Conditions of Contract for Design and Build Contracts (1999 Edition).

## **1.2 STANDARD METHOD OF MEASUREMENT (SMM)**

### **1.2.1 Purpose**

It is important to establish a considerable degree of standardization in the method of preparing the BQ and the units used in them. To achieve this aim, a Standard Method of Measurement is used, the purpose of which can be summarized as follows:

- (a) To facilitate pricing by standardizing the layout and content of the BQ,
- (b) To provide a systematic structure of bill items, leading to uniform itemization and descriptions,
- (c) To provide a rational system of billing suitable for both manual and computer operation,
- (d) To simplify the measurement of works and the administration of contracts,
- (e) To provide a uniform basis for measuring the works so as to avoid misunderstanding and ambiguities, and
- (f) To assist in the financial control of the works.

### **1.2.2 Adopted Document**

In general, capital works shall be measured in accordance with the "Standard Method of Measurement for Civil Engineering Works (1992 Edition)" (SMM) including Corrigenda thereof.

Any amendment or amplification to the SMM required for a specific contract shall be included in the contract documents as a Particular Preamble to the BQ (see paragraph 7.3 of Chapter 5 (Contract Documents)) and the relevant ETWB or WB technical circulars as listed in Section 7 of Chapter 9.

For term contracts, the method of measurement shall be as set out in the contract documents of individual contracts.

### **1.2.3 Guidelines for Use**

The SMM is divided into five parts:

- (a) Part I, which gives general definitions of the terms used in the document.
- (b) Part II, which states the general principles of how to use the document and how item descriptions are built up.



- (c) Part III, which contains the rules for the preparation of the BQ. It defines the sections into which the Bills are to be split, how items are to be grouped within these sections, and the units to be used. It also describes how amendments or amplifications to the SMM are to be dealt with.
- (d) Part IV, which is the General Preambles to the BQ. This part provides information to the tenderer to price the items, and must be reproduced in the BQ.
- (e) Part V is the units and method of measurement, and is divided into sections. Each section details:
  - (i) The items to be measured,
  - (ii) The units of the measurements,
  - (iii) The method of measurement of each item,
  - (iv) The wording for the build-up of descriptions, and
  - (v) An item coverage for each item listing everything which is deemed to be included in that item, enabling the contractor to price the item fully.

#### **1.2.4 Standard Phraseology of Item Descriptions**

WBTC No. 21/93, 21/93A and 21/93B introduce the document, "Standard Phraseology of Item Descriptions" (SPID). The BQ prepared in accordance with the SMM shall comply with the requirements of the SPID. The purpose of the document is to ensure uniformity in item descriptions used in the BQ and to form a database for preparing cost estimates.

### **1.3 ACCURACY OF MEASUREMENT**

Dimensions should be as accurate as possible, but it should be noted that they should not be recorded to a degree of accuracy which is greater than that to which the works can be executed, or greater than that to which the actual measurement is made.

When measurements are taken from drawings, specified dimensions on the drawings should always be used whenever possible (see paragraph 3.4.2). When measurements of the works are made on site, they shall be recorded to the smallest division on the appropriate measuring instrument used to record to a degree of accuracy, which is not less than that to which the works are to be executed.

### **1.4 MEASUREMENT RESPONSIBILITY**

After a Contract is entered into, the Engineer for the Contract is responsible for discharging the measurement function and he may delegate his authority to the Engineer's Representative to carry out the measurement work with the assistance from the survey officers (quantity) (SO(Q)) and the site staff. Emphasis should be made to ensure a consistent and systematic approach throughout the pre- and post- contract stages and the need

to implement an independent checking system for all the measurement works. The Engineer's Representative should also be responsible for co-ordinating measurement input from other professional staff such as the land surveyors, E&M engineers or landscape architects. For record purposes, the persons preparing and checking the measurement should initial for all his work.

The division of labour regarding the taking of measurements for a project varies under different circumstances and depends on:

- (a) The nature and complexity of the works,
- (b) The experience and availability of the staff,
- (c) The time within which the measurement is to be completed, and
- (d) The standing instructions in the Department.

## **2. CAPITAL WORKS CONTRACTS PRE-CONTRACT MEASUREMENT**

### **2.1 BILLS OF QUANTITIES**

#### **2.1.1 Definition**

The term Bills of Quantities (BQ) is defined in the SMM as a list of items giving brief identifying descriptions and estimated quantities of the works to be performed. The BQ forms a part of the contract documents, and is the basis of payment to the Contractor.

#### **2.1.2 Objectives**

To ensure that the BQ are prepared correctly, it is important during preparation to always bear in mind the three main objectives of the document. These are:

- (a) To enable tenders to be obtained from tenderers and to form the basis for tender comparison,
- (b) To provide a means of valuing the works, and
- (c) To form a basis for fixing any rates not included in the BQ, or valuing any variations.

#### **2.1.3 Preparation**

The BQ should be prepared by the project engineer (or the project QS) in accordance with the SMM (see also paragraphs 1.2.2, 2.6.1 & 2.6.2).

Measurement for works of different types of nature, locations, date of commencement, time for completion, charged to different votes, shall be taken and billed separately so that it is possible to identify them separately.

In case there are Sections subject to excision in the Contract, reference should be made to paragraph 7.6 of Chapter 5 (Contract Documents).

### **2.2 TAKING OFF**

#### **2.2.1 General Rules**

Taking off is the procedure by which dimensions of the works are calculated or scaled from the drawings and entered onto dimension paper (G.F. 516) or other similar computerized formats.

The normal format of dimension paper is indicated below.

1	2	3	4	1	2	3	4
---	---	---	---	---	---	---	---

Column 1 is the 'timesing' column in which multiplying figures are entered when there is more than one of the particular item being measured.

Column 2 is the 'dimension' column in which the actual dimensions taken from the drawings are entered.

Column 3 is the 'squaring' column in which the product of the figures in column 1 and column 2 is recorded ready for transfer to the abstract or bill.

Column 4 is the 'description' column in which the written description and SPID codes of each item are entered. The right-hand side of this column is known as the 'waste' area. It should be used for preliminary calculations, build up of lengths, explanatory notes and related matters. All steps that have been taken in arriving at dimensions, no matter how elementary or apparently trivial, should be entered here, as this will neatly aid remeasurement, valuing the works done for interim certificates, and answering any queries regarding the measurements which may arise.

### 2.2.2 Entering Dimensions

A constant order of entering dimensions must be maintained throughout, that is (1) length, (2) breadth or width, and (3) depth or height, so that there can be no doubt as to the shape of the item being measured. If this is not possible, dimensions should be annotated to indicate length, width or breadth, height or depth, diameter, etc.

Dimensions should usually be recorded in metres to three decimal places and a line drawn across the dimension column under each set of measurements.

Very often when measuring a number of dimensions for one item of construction it will be necessary to deduct some dimensions from the total. To ensure that this is done clearly, it is good practice to enter such dimensions in the timesing column under the heading DDT (meaning deduction).

Many of the words entered in the description column can be abbreviated to save both space and time.

Ample space should be left between all items on the dimension sheets so that it is possible to follow the dimensions with ease and to enable any items, which may have been omitted when the dimensions were first taken off, to be inserted subsequently.

All entries in the dimension sheet should be made in ink or blue/black ball pen. Erasable ball pens should not be used. If it becomes necessary to amend any dimensions that have been entered on the dimension paper, this should never be done by the use of correction fluid or eraser, or by altering the actual figures. The correct procedure is to write

NIL in the squaring column against the dimensions to be amended, and to write new dimensions in the normal manner under the last dimension listed for that item.

Each dimension sheet should be headed with the contract number, and the abbreviated contract title, section of the job and the drawing number(s) to which the taking-off sheet referred at the head of each sheet. Each sheet should be numbered consecutively at the bottom.

At the top of the first dimension sheet for each main section of works the list of drawings from which the measurement is taken should be entered. Revisions to the drawing used should be precisely stated so that in the event of any change being made to work as originally planned it can be clearly seen what was measured in the BQ.

Dimension sheets should be punched in the top left-hand corner on completion and fastened together with treasury tags.

An example of a dimension sheet, incorporating the above procedures is shown at Appendix 9.1.

### **2.2.3 Drawings and Information**

Taking off of dimensions should be based on the tender drawings, which should be registered in a drawing record (Appendix 9.2) showing the date of issue and of any revisions. Taking off drawings should be clearly marked, preferably by the use of a rubber stamp, stating "Drawing used in the preparation of Bills of Quantities", as this will avoid any confusion as to what is included in the BQ. Drawings should be marked to show that the works have been measured. Should revised tender drawings be issued for tender addendum purposes, all changes should be marked in red circles and the measured quantities should be adjusted for the changes, and incorporated in the revised BQ. Queries should be raised and to be confirmed by the project engineer before making the necessary amendments.

### **2.2.4 Use of Schedules**

Schedules should be used to assist in measuring a number of items of similar characteristics but of varying components. When a large number of dimensions are taken off, it is more efficient and clearer to set out the dimensions in schedule form rather than on dimension paper. A blank drainage schedule is shown at Appendix 9.3 as an example.

## **2.3 MENSURATION**

### **2.3.1 Measurement of Areas**

Measurement of regular areas may be carried out by using the standard formulae shown at Appendix 9.4.

Irregular areas may be measured by one of the following methods, and then checked independently using one of the two other methods:

- (a) By Planimeter; or

- (b) By dividing the area into a number of regular areas. The smaller the regular areas adjacent to the irregular outline, the greater the degree of accuracy; or
- (c) By Simpson's Rule or Trapezoidal Rule. The smaller the interval between sections, the greater the degree of accuracy.

Where areas are measured by using a planimeter, the average of two readings should be taken, provided that the two readings do not differ by more than 12mm<sup>2</sup> when the average is less than 3,000mm<sup>2</sup>, or 24mm<sup>2</sup> when the average is greater than 3,000mm<sup>2</sup>, or in accordance with the instruction manual of the planimeter. If the two readings differ by more than these limits, one or more check readings should be taken until two readings are obtained which satisfy these limits, and the average of these two readings should then be accepted.

### 2.3.2 Measurement of Volumes

Measurement of regular volumes may be carried out by using the standard formulae shown at Appendix 9.4.

Irregular volumes may be measured by one of the following methods, and then checked independently by using one of the four other methods :

- (a) By dividing the volume into a number of regular volumes,
- (b) By End-areas method,
- (c) By Simpson's Rule to obtain the areas of contours,
- (d) By Simpson's Rule to obtain the areas of equally spaced cross-sections, and
- (e) By Planimeter, (c) or (d), for contours or cross-sections.

The formulae for measuring irregular volume by End Area Methods and Simpson's Rule are shown at Appendix 9.4.

When measurements of volumes require the use of contours or cross-sections, the spacings should be taken in accordance with the following table :

Type of Volume	Spacing
Bulk volume by contour	5m
Bulk volume by cross-section	10m
Volumes of roads, trenches and items with regular cross-sections over a given length	one at each change in direction or cross-section

It should be noted that if the position of cross-sections are altered, the volume will change. To avoid any problems of this nature that may occur when the works are remeasured on site, the measurement method adopted should be defined in a Particular Preamble to the BQ, and the position of the cross-sections to be used should be marked on the contract drawings.

### **2.3.3 Measurement of Bar Reinforcement**

Bar bending schedules should be prepared either manually in a schedule (see Chapter 7 (Contract Management), Appendix 7.13) or by computer. They should never be incorporated into contract drawings.

Specific requirements for scheduling, dimensioning of steel reinforcement are given in BS 4466 whilst the mass of the bars is calculated on the basis that steel has a mass of 0.00785 kg/mm<sup>2</sup> per metre run as given in Clause 11.02 of SMM (1992). In the case of manually computed bar schedules the total lengths and weights of the various sizes and types of bar should be summed on each sheet and transferred directly to abstract sheets. In the case of computerised bar schedules, the computed totals of weights of reinforcement bars should be transferred directly to the abstract sheets. In both cases, the schedule or computer print-out should, as for drawings, be clearly marked "Schedules used in the preparation of the BQ".

## **2.4 PREPARATION OF BILLS OF QUANTITIES**

This section deals with the final stages leading to the preparation of the BQ, after the dimensions have been taken off.

### **2.4.1 Squaring**

The term 'squaring the dimensions' refers to the calculation of the numbers, lengths, areas or volumes and their entry in the third or squaring column on the dimension paper. Squaring should be carried out to three decimal places, with the final squared quantities rounded off in accordance with paragraph 3.4.7.

Squaring must be independently checked to eliminate errors. Any incorrect figures should be neatly crossed out in red ink and the correct figures written above the incorrect ones. Correcting fluid shall not be used nor shall incorrect figures be erased. All squared dimensions and waste calculations should be ticked in red ink on checking and any alterations should be made in a similar manner. Amended figures must be further checked.

### **2.4.2 Abstracting**

Abstracting is the process whereby the squared dimensions are transferred to an abstract sheet (G.F. 520) or other similar computerized formats, where they are written in a recognised order, ready for billing, under the appropriate section headings, and are subsequently reduced to the recognised units of measurement in readiness for transfer to the bills.

As each item is transferred to the abstract, the description of the appropriate dimension should be crossed through with a vertical line on the dimension sheet, with short horizontal lines at each end of the vertical line, so that there is no doubt as to what has been transferred.

Each abstract sheet should be headed with the contract number, abbreviated contract title, sheet number and section of the works to which the abstracted dimensions refer. The section headings normally should follow those given in the SMM, in the same order.

Entries in the abstract should be well spaced. The items should be entered in the same order as they will appear in the bill, since the primary function of the abstracting is to classify and group the various items preparatory to billing, and to reduce the dimensions to the recognised unit of measurement.

Descriptions should be spread over two columns, with a line drawn underneath, and the appropriate dimensions listed below in the first column, with any deductions in the second column. Against each dimension, the number of the dimension sheet from which that dimension has been transferred should be inserted in brackets, for easy cross-referencing.

When the total quantity for each item is calculated, any deductions from the second column, which have been taken into account in arriving at the total quantity should then be lined through to ensure that they are not deducted twice.

It is a good practice to precede each description in the abstract with the prefix C, S, L or Nr denoting that the item is cubic, square, linear or enumerated to reduce the risk of errors arising with regard to units or quantities. The order of items in each section of the abstract should, as much as possible, be standardized. It is usual to adopt the order of cubic, square, linear and finally enumerated items, with smaller items preceding larger ones, and cheaper items preceding more expensive ones in each group, but attention should also be paid to the sequence of items in the SMM. Where it is necessary to abstract a number of similar items, but of different sizes, these should be grouped under a single heading with each size entered in a different column.

On completing the entry of all items on the abstract, all entries must be checked, columns of figures cast, deductions made, totals reduced, and all the latter work checked and ticked in red ink in the same procedure as described for squaring.

An example of an abstract sheet completed in accordance with the above procedures is shown in Appendix 9.5.

### **2.4.3 Billing**

Billing is the final stage in the bill preparation process in which the items and their associated quantities are transferred from the abstract onto the standard billing sheets (G.F. 519) or other similar computerized formats that are in a format that enables the tenderer to price each item and arrive at a total tender sum.

As each item is transferred to the bill it should be lined through on the abstract to prevent any risk of errors occurring during the transfer stage. Generally, all quantities transferred are to be billed to the nearest whole unit (see SMM). Fractional quantities are not generally necessary but, where required, should not be given to more than one place of decimals. The order of billed items should be the same as in the abstract, and they should be grouped under suitable section headings as they appear in the SMM. Items should be indexed, either by a letter or a number, in the first column of the billing sheet.

The total sum on each page should be carried to a collection or summary for each section, and the totals from these carried to a Grand Summary, the total of which constitutes the tender sum.



Unless for those abbreviations as defined in Part III of the SMM, abbreviations must not be used in the descriptions and the wording and layout of each description must follow the rules laid down in the SMM and its amendments in the Particular Preamble.

On completion, the draft bill must be carefully checked against the abstract, and the abstract suitably marked in red ink as each item is dealt with. Particular care should be taken to ensure that all the quantities, units and descriptions are correct, and that the sequence of items, the section and sub-section headings, and the transfer of totals to collection and summary, are satisfactory and adequately covered.

Finally, a further check should be carried out once the bill is typed.

## **2.5 ALTERNATIVE METHODS OF BILL PREPARATION**

The traditional bill preparation process can be a lengthy and time-consuming exercise, unnecessarily so for simpler projects. A number of ways of shortening this process can be adopted, as described below. The project engineer (or the project QS) should decide on, and follow the procedures for, the method most suited to the particular project in hand.

### **2.5.1 Billing Direct**

In this method, the abstracting stage is omitted by transferring the items directly from the dimension sheet to the bill. Particular care must be taken, however, when adopting this method, and a methodical order of transfer must be adopted to ensure that the items are listed correctly and in the right sequence in the bill.

Items transferred should be clearly crossed out on the dimension sheet, and an independent check must be carried out on all calculations, which should be ticked in red ink, and also on all transfers.

This method should be adopted where the number of similar items is not too extensive, and the job is not too complex in character.

### **2.5.2 Alternative Form of Billing Direct**

This method has the taking-off and billing process done on the same 'special' ruled paper, a sample of which is shown at Appendix 9.6. Each sheet contains the measurement of one item only, and it consists of an upper and lower part. A full description of the item, unit and quantities are to be listed on the upper part of the paper whilst the dimensions are to be listed in rows on the lower part of the paper. The build-up and cross-reference of dimensions should be neatly done in the space beyond the timesing column. If measurement exceeds the number of rows, a separate sheet should be used and stapled to the first sheet. Upon completion of the taking-off and squaring, the quantity is entered in the space on the upper part of the sheet. The sheets are then sorted into sections and placed in bill order ready for typing onto billing paper.

The method is convenient to use and has the advantage of eliminating the process of abstracting and having the description of the item written once. However, extreme care must be exercised in keeping the sheets, as losing any sheet may result in the omission of an item in the Bills.

### 2.5.3 'Cut and Shuffle'

The 'cut and shuffle' system of bill preparation operates as follows:

- (a) The taking-off is carried out to the same procedures as described in paragraph 2.2, but the dimensions are entered on special 'cut and shuffle' paper. Each sheet comprises a white original and a yellow carbon copy, and is ruled in such a manner that it forms three separate small dimension sheets, which are commonly referred to as 'slips'.

Each 'slip' should be numbered, and have the job number stamped on the top. Taking-off then proceeds in the usual manner, except that a separate 'slip' must be used for each individual item. An example of a 'cut and shuffle' page fully completed is shown at Appendix 9.7.

- (b) When the taking-off is completed, or in the case of a large job, substantial sections are completed, the dimensions on each 'slip' are squared and checked.
- (c) The person who carries out the taking off retains the yellow carbon copy as a record, but the white original sheets are cut into three separate 'slips', each containing one item or part of an item.
- (d) The 'slips' are shuffled, or sorted, into sections, such as Earthworks, Drainage, Concrete, etc., similar items are collected and stapled together, and the whole of the slips placed, as near as possible, in bill order.
- (e) The slips are then edited to form the preliminary draft bill, with further slips inserted as necessary to provide headings. The correct unit is entered in the box provided on each slip, or on the top slip where a number of similar items are stapled together.
- (f) The total quantity for each item is calculated and inserted in the box provided on the slip. This process must be independently checked and ticked in red ink.
- (g) Once completed, these slips are attached together in bill order by a treasury tag from the draft bill, and can be passed directly for typing onto billing paper.
- (h) The typed bill must be closely checked with the draft to ensure that all descriptions, quantities and units have been transferred correctly.
- (i) As a final check, the cut slips should be counted and compared to the yellow carbon copy sheet to ensure that all slips are accounted for.

Although this system takes a longer time during the taking-off stage owing to the need to write descriptions out in full, the time saved in the bill preparation process means a considerable reduction in overall time spent on pre-contract measurement.

This method of bill preparation can be used for all projects, but is best suited to large complex jobs where there are a large number of similar items.

Used correctly, it can result in great savings in time in the bill preparation process, as it omits both the abstracting and billing stages.

All staff involved in pre-contract measurement should familiarize themselves with this method and should adopt it wherever possible.

## **2.6 PREAMBLES**

### **2.6.1 General Preambles**

The General Preambles to the BQ is included in Part IV of the SMM. They provide the tenderers with the information needed for pricing the bill items and must be included in all contract documents. The exact wording shown in the SMM must be used, and reproduced in full.

### **2.6.2 Particular Preambles**

Particular Preambles shall be included in the BQ to give details of any amendments to the method of measurement given in the SMM to meet specific needs of the Contract (see Paragraph 7.3 of Chapter 5 (Contract Documents)). They should be presented in the same format as that used in the SMM.

## **2.7 PRELIMINARY ITEMS**

Preliminary items are defined in the SMM as items in respect of works and/or general obligations and risks antecedent to or involved in the execution of the Contract.

## **2.8 PRIME COST ITEMS**

Prime Cost Items shall be inserted in the BQ to cover works carried out by Nominated Sub-contractors.

Where the works to be carried out by a Nominated Sub-contractor are the supply and fixing of materials, or the execution of works, then separate items should also be included for:

- (a) Contractor's General Attendance, as specified in the General Preambles, which shall be a lump sum.
- (b) Contractor's Special Attendance, if required, to allow for any particular attendance requirement not covered in (a). These requirements should be clearly specified in the BQ, and the unit shall be a lump sum.
- (c) Contractor's profit and overheads expressed in the form of a percentage applicable to the Prime Cost Sum.

Where the works to be carried out by a Nominated Sub-contractor are for the supply only of goods or materials, then only one separate item is to be provided for Contractor's profit and overheads as in (c) above.

Prime Cost Items should be grouped under the bill for "Provisional and Prime Cost Sums" in the BQ.

## **2.9 PROVISIONAL SUMS**

A Provisional Sum means a sum provided for works or expenditure which has not been quantified or detailed at the time tender documents are issued, which sum may include provision for works to be executed, or for materials or services to be supplied by a Nominated Sub-Contractor.

All Provisional Sums, and that for contract price fluctuations, should be grouped together under the bill for "Provisional and Prime Cost Sums" in the BQ.

Due to the problems encountered in agreeing the rates when works under Provisional Sums is ordered, the number of such sums should be kept to a minimum and they should only be used where it is impossible to define or detail the requirements at the tender stage.

## **2.10 PROVISIONAL ITEMS**

The definition of a Provisional Item is given in the SMM. However, the use of Provisional Items should be avoided as far as possible. If the requirement of the works is very remote, issuing variations during the Contract is generally more advisable than including Provisional Items to cover the works.

## **2.11 DAYWORK**

The BQ should provide for the valuation of various works on daywork basis. Section 27 of the SMM defines how daywork should be measured.

## **2.12 ADJUSTMENT ITEM**

An Adjustment Item should be included in the Grand Summary as a convenient means by which a tenderer can make an adjustment without having to alter all the rates in his tender.

The rules pertaining to the pricing and payment of this item are defined in the General Preamble to the BQ as shown in the SMM.

## **2.13 CONTINGENCY SUM**

A Contingency Sum means the sum provided for works or expenditure, which cannot be foreseen at the time the tender documents are issued, and this sum may include provision for works to be executed or materials or services to be supplied by a Nominated Sub-contractor. Contingency Sum should be included in the Grand Summary.

## **2.14 BULK CHECK**

Before the BQ are issued to tenderers, the BQ should undergo a bulk checking process. The purpose of a bulk check is to ensure the accuracy of the measured quantities

and to eliminate any major errors. It should be carried out by experienced staff who are familiar with the nature of the project and the SMM, and who should not be the same staff responsible for preparing the respective part(s) of the BQ.

Bulk checking should be carried out on simple forms in order to expedite the process and records should be kept in the measurement file. The check should comprise the following:

- (a) Items involving large quantities or of major cost.
- (b) The item coverage of cost significant items should be checked for consistency against the design requirements and those shown on the drawings.
- (c) Ensuring that the squaring, abstracting and billing of all items have been independently checked.

### **3. CAPITAL WORKS CONTRACTS POST-CONTRACT MEASUREMENT**

#### **3.1 GENERAL**

##### **3.1.1 Considerations**

Post-contract measurement is the measurement of the Works completed, either for interim or for final payment purposes.

Although the principles to be adopted are similar to those described in Section 2 of this Chapter, post-contract measurement differs because the Works have been constructed and full information is available for the Works to be measured in greater detail.

##### **3.1.2 Keeping of Records**

All information, sketches and drawings, and any subsequent revisions, which are pertinent to the measurement of the Works, should be carefully kept. They should be signed, dated and filed in such a manner that they can be easily retrieved.

Similarly all taking-off sheets, abstracts and bill sheets should be cross-referenced, signed, dated, indexed and kept in a measurement file. A Site Measurement Record Sheet (Appendix 9.8) should be filled in at the commencement of the works and when there is a change in the staff responsible for measurement, and kept at the front of the measurement file, for easy reference.

##### **3.1.3 Care of Documents**

The BQ priced by the Contractor are an important document, and GCC Clause 8 requires that no information from them should be divulged to anyone, except for use on the contract. For this reason, the priced BQ should never be left lying around the site office unattended. Whenever it is not in use, it should be kept in a locked drawer.

The site measurement book and any other documents pertaining to measurement fall into a similar status and should be treated in the same way.

#### **3.2 BASIC PROCEDURES**

This Section should be read in conjunction with the following paragraphs of this Chapter:

- 1.2 Standard Method of Measurement
- 1.3 Accuracy of measurement
- 1.4 Measurement responsibility
- 2.2 Taking off

2.3 Mensuration

2.4.1 Squaring

2.4.2 Abstracting

The principles and procedures described in these clauses should be adopted when the Works at post-contract stage are measured, both for interim and final payment purposes.

### **3.3 INTERIM MEASUREMENT**

#### **3.3.1 General**

GCC Clause 79 requires the Engineer to value and certify the Contractor's monthly statements. Interim measurements are required in respect of the following:

- (a) The estimated value of the permanent works executed,
- (b) The estimated value of any Temporary Works or preliminary item for which a separate sum is provided in the BQ,
- (c) The estimated value of materials for inclusion in the permanent works and not being prematurely delivered to and being properly stored on the Site,
- (d) The estimated sums payable in respect of Nominated Sub-contractors,
- (e) Any other estimated sums to which, in the opinion of the Engineer, the Contractor is entitled in accordance with the Contract, and
- (f) The estimated sum deductible in respect of the value of materials supplied by the Government, value of works carried out by other Government Department on behalf of the Contractor in connection with the Works and liquidated damages etc.

Whilst this measurement shall be accurate enough to ensure that there is no large over-payment or under-payment made to the Contractor, no attempt should be made to carry out the measurement to the same degree of accuracy and detail as is used for final measurement. Quantities, for example should be taken to the nearest whole unit, and the paperwork concerned with the measurement shall be kept to a minimum. It is more important for the final measurement to be kept up-to-date than to spend time preparing the monthly interim measurement in too great a detail.

Interim payments for firm quantities of lump sum with firm BQ contracts are to be treated differently. For interim payments the Engineer estimates the amount of works done (if possible in agreement with the Contractor) and values it. The Engineer also estimates the financial effect of all works done that have been varied under GCC Clause 60. The Engineer should measure variations as soon as practicable in order to make a full and proper adjustment at the appropriate time i.e. when the varied work is executed/omitted. However, an estimate is not an inspired guess, it is a professional assessment.

### **3.3.2 Measurement**

At the start of the Works, an Interim Payments Record Book should be drawn up. In this book, the quantity of each completed item in the BQ is recorded at the same time as the Contractor makes his application for payment. This book can take any form, but the best system is the loose-leaf file. Basically, the record book consists of running abstract sheets (Appendix 9.10) for each completed item to date, of which quantities are transferred from the dimension sheets, rough measurement book and Site Measurement Book. For major capital works, it is desirable to contain the build-up such as measurements, calculations, lorry load, material invoices, etc., for each Interim Payment in separate files.

The cumulative total is then used to check the figures in the monthly statement submitted by the Contractor.

The quantities that are entered monthly shall fall into two categories:

- (a) Quantities within completed Sections of the Works, and
- (b) Quantities from Sections of the Works which are still being constructed.

For the first category, the quantities can simply be extracted from the Site Measurement Book (assuming final measurement is completed) or dimension sheets and transferred to the running abstract sheets, with suitable cross-reference.

For the second category, it is necessary to assess the quantity completed to date. The most common way of doing this is by measuring the Works completed on the Site, entering the dimensions in the rough measurement book and subsequently transferring them to the running abstract sheets.

Two points should be remembered when measuring the Works for interim payment purposes. First, when measuring quantities for a partially completed Section of the Works, the quantity for the month should be calculated by measuring the total quantity to date and deducting the total quantity up to the end of the previous month. Attempting to measure the amount completed in the current month only, and adding it to the previous month's total could lead to errors and should be avoided. Secondly, when the quantities for a partially completed Sections of the Works are measured, much time can be saved in checking and correcting the Contractor's monthly statements by carrying out joint measurements, which are to be agreed and signed by both parties prior to the Contractor's submission of the monthly statements. In normal circumstances, at the commencement of the Works to the parties shall agree a date on each month, when the representatives responsible for measurement from both the Engineer and the Contractor will be available to prepare the monthly measurement of the Works.

### **3.3.3 Payment Procedure**

Once the Contractor's monthly statement is received, it should be checked using the quantities recorded in the running abstract sheets and any errors should be corrected.

To ensure that the certifying process is carried out speedily and efficiently, the procedure set out in Chapter 7 (Contract Management) particularly paragraphs 7.2.1 and 7.2.2 should be strictly adhered to.



### **3.3.4 Materials on Site**

According to GCC Clause 79(1)(c), only materials for inclusion in the permanent work and not being prematurely delivered to and being properly stored on the Site should be measured and included in the Interim Payment. It should be ensured that the quantity of each material delivered to the Site does not exceed the quantities of that material required to complete the Contract having regard to wastage.

As far as practical and taking into consideration of GCC Clause 89(3)(d), materials on the Site are to be valued using prices applicable at the time of tender or by considering the delivery of the material to be part performance of a BQ item recognizing that invoices may (but not necessarily always) prove to be a reasonable basis for this valuation. Materials incorporated in the permanent works, including wastage, shall be deducted from the aggregated total of the materials delivered.

## **3.4 FINAL MEASUREMENT**

### **3.4.1 General**

Final measurement is the measurement of the Works, which have been completed in accordance with the Drawings, for the purpose of making final payment to the Contractor.

In lump sum with firm BQ contracts where the quantities contained in the BQ are firm, this only involves the measurement of variations, adjustment of provisional sums, items with provisional quantities and errors.

In remeasurement contracts however, it is necessary to measure all the Works as they are completed on the Site.

All items in the BQ shall be measured on one of the following bases in accordance with the Method of Measurement of the Contract, i.e.

- (a) The Drawings,
- (b) Input by the land surveyor, landscape architect, etc., and
- (c) Site measurements.

It is advisable to have a joint measurement programme with the Contractor in order to ensure all measurements are completed in time.

Final measurement should be carried out as the Works progress, and this should be continued throughout the Contract to ensure that measurement is completed as soon as possible after completion of the Works.

### **3.4.2 Sources of Information for Final Measurement**

- (a) Drawings -

Measurement should be taken from the latest Drawings issued to the Contractor. Any amendments that are ordered after the issue of the Drawings should be

marked up on a set of record Drawings, with a note beside the amendment cross-referencing it to the relevant instruction.

Many of the amendments to the Drawings issued to the Contractor, if of a minor nature, will require to be measured on the Site before they can be marked on the record Drawings. The preferable procedure is to take the measurements, enter them in the rough measurement book (see paragraph 3.4.3) and transfer these to the record Drawings.

The practice of entering such dimensions in the Site Measurement Book directly should be discontinued, as the opportunity to check them at a later date is then lost, especially if the works have been subsequently covered up. If they are marked on the record Drawings there is a clear record, and any dimensions taken-off can be easily checked. When all such amendments and notes have been marked on the record Drawings, it should be signed by the site staff and the Contractor's representative as being a true record. Reference should be made to GCC Clauses 59(5)(a),(b) & (c) in this regard.

The record Drawings should then be marked clearly that it has been used for final measurement purposes, and passed to the person responsible for measurement.

- (b) Surveys - surveys will usually be carried out by a land surveyor or his supporting staff

All survey data should be plotted on dimensionally stable materials, such as polyester drawing film, i.e. original survey plans or drawings should be made of these material. The squared drawing sheets printed by the Government Printer may be used for cross-sections. It should be noted that measurements should be taken from original plans and drawings so as to avoid errors due to distortion.

All surveys should be closed (preferably onto Lands Department Traverse Stations or Triangulation Stations) and adequate checks done to ensure that no errors have been made in the survey. All survey computations should be independently checked.

Where measurements are made from survey data, the final quantities calculated by the land surveyor should be recorded, with his signature, against the appropriate bill item description. These quantities should be fully cross-referenced, and the calculations taken to arrive at the final quantities should be kept in file for future reference.

The Contractor's representative shall either indicate his agreement to the measurement by signing the final figures, or shall state his reason for disagreement.

Where the calculation of the volume is done by computer, the Contractor's representative shall either indicate his agreement by signing on the set of plans used as input to the computer, or signing on the final quantities, or he shall state his reason for disagreement.

- (c) Site measurements - Measurements taken on the Site and transferred directly to the site measurement book, as opposed to marking them on the record Drawings, are usually restricted to the following:
- (i) Works involving removal of soft spots, excavation in rock, or the like, which cannot be shown or measured the on Drawings, and
  - (ii) Items that are impossible to measure accurately from the Drawings, because the scale of the Drawing is too small to serve such purpose.

Measurements taken for these items should be recorded in the site measurement book, which is described in paragraph 3.4.4.

- (d) Bar bending schedules - Clause 15.16 of the General Specification for Civil Engineering Works, 2006 Edition requires the Contractor to submit bending schedules to the Engineer and these have to be checked and kept updated. The total lengths and weights of bars, under separate BQ items, should be transferred to the abstract sheets with a detailed cross-reference.
- (e) Daywork - Daily record of labour, plant and material employed on any work executed on daywork basis should be made on the site diaries or on rough site measurement sheets as the Works progress. This record should be used to check against the Contractor's submission in accordance with GCC Clause 62. At the end of each monthly period (see GCC Clause 78(1)), a summary of all daywork ordered, as detailed in the statements agreed by the Engineer's Representative in accordance with GCC Clause 62(4), showing the total cost incurred for the monthly period, shall be prepared for interim and final payment purposes. The standard forms for recording daywork are included in Chapter 7 (Contract Management).

### **3.4.3 Rough Measurement Book**

The rough measurement book is the book used to record dimensions, which are actually taken on the Site. Its use should be restricted to the following:

- (a) Taking dimensions of variations and minor amendments which will then be marked up on the record Drawings for subsequent measurement purposes,
- (b) Taking dimensions of work which cannot be accurately measured from the Drawings, which will be subsequently transferred to the Site Measurement Book, and
- (c) Taking dimensions of partially completed works for interim payment purposes, which will be subsequently transferred to the running abstract.

It is recommended that these measurements should be entered into the rough measurement book immediately after being taken on the Site.

This book should be treated with the same care as all measurement documents. All dimensions taken, squaring, and transfer of items should be checked independently.

It is advisable to have the measurements entered into the rough measurement book agreed and signed by both parties, and the duplicate copies of the records should be passed to the Contractor for record purpose.

#### **3.4.4 Site Measurement Book**

The Site Measurement Book is used in the same way as dimension sheets. Its design is more suitable for use on the Site, where individual loose sheets can easily be mislaid, and it also contains a copy of each sheet for the Contractor's record.

The Site Measurement Book to be used is GF 534.

The appropriate BQ item number plus description should be entered into the book with the measurement dimensions.

At the end of each section of measurement, the last page of both the original and duplicate sheets should be endorsed as follows:

"Pages ..... to ..... I certify that the dimensions entered have been checked to be correct by me against supporting evidence (Government Site Staff) (Date)"  
"Site Measurement agreed on behalf of (Contractor) by (Contractor's Representative.) (Date)"

Reference should also be made to GCC Clause 59(5) regarding the contractual requirements of preparing site measurements and subsequent agreement by the Contractor.

After endorsement, the duplicate sheets should be detached from the Site Measurement Book and given to the Contractor's representative to enable him to prepare his statements for interim and final payments.

Each measurement book shall be provided with an index sheet, which is to be completed by the officer who measures the Works and returned to the issuing office for filing immediately after all other pages in the measurement book have been removed.

All entries of site measurements should be made in ink or blue/black ball pen. Erasable ball pen should never be used in entering measurements. It should be noted that no erasures should be made to any records connected with measurements. Any entries which are in error should be boldly crossed out and the correct entry written clearly. All amendments should be initialled and dated.

#### **3.4.5 Measurement**

As soon as a Section of the Works is completed, the final measurement of that section shall commence.

The actual arrangement regarding the taking of site measurement depends on individual department's practice. On small-sized to medium-sized contracts of a straightforward nature, the measurement shall be carried out by either a WS or an assistant inspector of works, whilst on larger or more complex contracts measurement is usually carried out by a SO (Q), or an inspectorate officer depending on departmental practice, with assistance from other site staff concerning the measurement of items such as those to be covered up or removed.

When each Section of the Works is completed, and the end pages are endorsed as previously described, the original sheets should be stapled together with the Site Measurements Binding Cover and passed for checking.

The first check carried out on the Site will cover the followings:

- (a) The descriptions and bill item reference numbers,
- (b) The dimensions taken from drawings,
- (c) The dimensions taken on the Site, and
- (d) The transfer of dimensions from survey data, schedules, and the rough measurement book.

Once this is done, the officer who has carried out the above check will sign the Site Measurements Binding Cover (Appendix 9.9), and pass the measurements to the QS or Engineer's Representative.

#### **3.4.6 Squaring**

Squaring shall be carried out by the SO(Q), or an inspectorate officer in case there is no SO(Q) available, and shall follow the procedure laid down in paragraph 2.4.1. When the squaring has been completed, the (SO(Q), or the relevant inspectorate officer in case there is no (SO(Q) available, shall sign the Site Measurements Binding Cover to indicate that his task has been completed.

#### **3.4.7 Abstracting**

Abstracting shall be carried out by a SO(Q), or an inspectorate officer depending on departmental practice, following the procedures set out in paragraph 2.4.2. The final squared quantity on the abstract sheet that is used to check the Contractor's statement of final account shall be rounded off as follows unless otherwise specified in the SMM or the contract documents:

- (a) Items measured in nr : whole number
- (b) Items measured in m, m<sup>2</sup>, m<sup>3</sup>, wk, & mth : to the nearest two decimal places.
- (c) Items measured in ha & t : to the nearest three decimal places
- (d) Items measured in hr : to the nearest hr.

#### **3.4.8 Statement of Final Account and Payment Procedure**

(ref. SETW's memo ref. ETWB (W) 925/50/01 Pt.4 dated 7.7.2004, ICAC's Assignment No. 92/2001, Site Supervision of Civil Engineering works).

When the statement of final account produced by the Contractor is received (see GCC Clause 79(6)), it shall first be passed to the Survey Officer (Quantity), or an inspectorate officer depending on departmental practice, for checking.

A complete technical and arithmetical check shall be carried out which shall include, but not limited to, the following:

- (a) Appropriate items are used and correct rates applied,
- (b) All items covered by variation orders are included,
- (c) All items ordered under daywork are included and are offset against any provisional sums included to cover daywork,
- (d) Adjustments of Provisional Sums and, where included, Prime Cost Sums are made,
- (e) Correct quantities based on the remeasurement are included,
- (f) Complete arithmetical check,
- (g) Value of materials supplied by Government, value of works carried out by other department(s) in connection with the Works, liquidated damages, where applicable, and all other necessary deductions are made,
- (h) Add/deduct the maximum amount of the Adjustment Item, and
- (i) Prepare the calculation of the Contract Price Fluctuation.

Errors in Contractor's statement of final account shall be amended in red ink and the corrected Contractor's statement of final account should then be passed to the Engineer's Representative who will carry out an overall check to satisfy himself of the correctness of it. As part of the overall check, the Engineer's Representative should also carry out a bulk checking on the major cost-bearing items using both the Contract Drawings and the as-built drawings in order to check if there is likeliness of the quantities of the major cost-bearing items being over-stated.

The bill shall then be passed to the Accounts Office for preparation of the payment vouchers. It should be noted that there is a time limit for the preparation of the final payment certificate stipulated in GCC Clause 79(6).

All documents relating to the final measurements should then be bound together and filed for future reference.

#### **3.4.9 Measurement Records by Electronic Means**

At their discretion, Departments can prepare measurement records with electronic means as long as the principles in this Chapter are complied with. However, care should be taken to guard against unauthorised access. Departments should consult their departmental computer services units for advice on up keeping measurement records with electronic means.

## **4. TERM CONTRACTS PRE-CONTRACT MEASUREMENT**

NOTE: The computerised system, called HyD MAIN SYSTEM (Maintenance Accounting and Information System) and WSD Maintenance Works Management System (MWMS), have been developed by the Highways Department and the Water Supplies Department respectively for use on their term contracts. Detailed procedures are given in the HyD's Main Manual and WSD's MWMS Application User Manual Payments. Sections 4 and 5 refer only to contracts that are not carried out under this system.

### **4.1 GENERAL**

Owing to the nature of term contracts, it is not possible to define or detail the amount of works that will be required during the contract period and, therefore, the BQ cannot be produced practically. However, it is still necessary for competitive tenders to be sought and for the rates for different types of works to be agreed before the contract is signed. For this purpose, the Schedule of Rates is prepared and incorporated in the contract documents.

### **4.2 SCHEDULE OF RATES**

#### **4.2.1 Method of Measurement**

Measurement of works under term contracts shall be made according to the procedures set forth in the method of measurement referred to in the Contract. At present, each works department has devised a method of measurement that best suits its own use.

#### **4.2.2 Application**

The Schedule of Rates is basically a schedule of rates where quantities are normally not included. It may take one of the following two forms.

One common form is that the Government supplies a schedule containing unit rates for each item of works, and asks the tenderers to tender a percentage above or below the given rates for which they are prepared to execute the works. The upper and lower limits on these percentages are usually specified to avoid unreasonably high or low tendered figures. For tender analysis purposes, weighting factors are provided to various sections of the Works and a combined single-contract percentage is used for comparing tenders.

Another form is that the tenderers are requested to insert a price against each item of works, and a comparison of the prices entered will enable the most favourable offer to be accepted. However, in this form it is extremely difficult to make a fair comparison among the figures submitted by the various tenderers, since the unit rates may fluctuate greatly among various tenderers. For this reason, the works department may include a very approximate quantity against each item in the Schedule of Rates, which will both assist the tenderers in their pricing, and the Engineer in the subsequent comparison of tenders.

In both cases, work departments must clearly indicate in the contract documents that the weighting factors or approximate quantities provided in the contract documents are to be used for tender evaluation purposes only, and do not indicate the extent of the works.

#### **4.2.3 Preparation**

A list of all the items that could reasonably be expected to be required in the contract shall be drawn up. This should be done with reference to previous term contracts of similar nature and additional allowance shall be made for any specific items as required in this contract. This list should then be arranged in the bill order and follow the section headings as listed in the method of measurement.

Item descriptions taken from the method of measurement should be used throughout, as described previously. Where an approximate quantity is to be included against each item, it should as far as possible form a realistic estimate, based on previous contracts of similar nature. Daywork sections should also be included, but owing to the very nature of the Schedule-of-Rates contracts, there would be no Provisional Sums or Provisional Items.



## **5. TERM CONTRACTS POST-CONTRACT MEASUREMENT**

NOTE: See the NOTE at the beginning of Section 4.

### **5.1 INTRODUCTION**

This section concerns final measurement and payment of works orders under term contracts.

The procedure is designed to ensure that the interval between completion of the works completed and payment to the Contractor is as short as possible, whilst a satisfactory checking system is still maintained. It is the responsibility of the Engineer to ensure that the measurement and payment procedures be followed correctly, and without delay. He should also collaborate with the Contractor to expedite and monitor the processing of the Final Account.

### **5.2 MEASUREMENT**

In accordance with Clause 61(3) of the General Conditions of Contract for Term Contracts for Civil Engineering Works, 2002 Edition, the Contractor shall measure all works in the presence of the Engineer and record the measurements in such form and/or drawings as may be specified by the Engineer for agreement. A Site Measurement Binding Cover as shown in Appendix 9.9 shall be attached to the Contractor's submission for each Works Order. SO(Q) should record the date of receipt of the Contractor's measurement in the Payment Record Register. One suggested format is as shown in Appendix 9.11. The Register can also be stored electronically, in particular where a term contract accounting and information system approved for use by the department concerned is available.

When the measurement has been completed, the last page should be endorsed by both parties, as previously described. The Contractor should be required to submit to the Engineer the original agreed measurement records and retain a duplicate.

The Engineer's Representative or appropriate officer should first check the measurements against the works orders and/or sketches available and then square the dimensions. When these processes are completed he should file the measurement sheets in readiness for checking against the final accounts submitted by the Contractor.

### **5.3 STATEMENT OF FINAL ACCOUNT**

Pursuant to Clause 78(1) of the General Conditions of Contract for Term Contracts for Civil Engineering Works, 2002 Edition, within 60 days of the date of issue of the certificate of completion for any Works in accordance with Clause 55 of the General Conditions of Contract for Term Contracts for Civil Engineering Works, 2002 Edition, the Contractor shall submit to the Engineer and copy to the Engineer's Representative a statement of final account. A receipt should be issued to the Contractor and a Payment Voucher Routing Sheet (Appendix 9.12) should be attached to the Contractor's statement of final account.

The statement of final account should be sent by Engineer's Representative with a covering letter that should list the number of works order, and comprise the following:

(a) Abstract (Appendix 9.13)

The abstract is divided into upper and lower portions. The upper portion is basically a bill paper whilst the lower portion is a combination of an abstract sheet and bill paper. Measurements from the site measurement book are transferred to the lower portion of the Abstract and the appropriate rate selected from the Schedule of Rates. Each item should be separately extended and a total of the items carried forward to the Summary. The final quantities, the full description, rates and extended total are then entered on the upper portions.

(b) Summary (Appendix 9.14)

The Contractor shall submit three copies of the Summary. For computation of the total value of the works order, the contract percentage for the section of works shall be applied to the respective sections of works and the fluctuations shall be applied to works subject to such.

(c) Statement of Final Account (Appendix 9.15)

The Contractor shall submit three copies of the statement of final account of which the value of works should be the same as that in the Summary.

(d) Original copy of works order

Upon the receipt of the statement of final account, the SO(Q) shall record it in the Payment Record Register (Appendix 9.11), or electronically in the term contract accounting and information system approved for being used by the department concerned.

#### **5.4 CHECKING OF THE STATEMENT OF FINAL ACCOUNT**

The SO(Q) should carry out the initial check on the Contractor's submitted statement of final account and should check the following :

- (a) Items and the respective quantities, by comparison with the agreed and squared original site measurements.
- (b) Rates, by comparison with the Schedule of Rates.
- (c) Correctness in trades and percentage adjustments.
- (d) Quantities and extensions as entered on the top portion of the Abstract against those shown on the bottom portion.
- (e) Transfers and arithmetic.

Correct figures should be ticked in red ink. Where the Contractor's figures do not tally with the measurement record as agreed, the site staff and Contractor should be called upon to sort out the discrepancy and, if necessary, the statement of final account should be returned to the Contractor for amendment and resubmission. The Contractor's figure should be amended in red ink and initialled by the respective parties. It should be noted that any minor differences in figures, which occur because the Contractor adopt a different method of calculation, should be recognised and accepted if valid, with a note made to state the reason for the differences.

On completion of the checking procedure, the SO(Q) should endorse the bottom of each Abstract and Summary sheet, and pass it to the Engineer's Representative. The Engineer's Representative will check the abstract thoroughly for correctness and certify the abstract by entering his signature into the appropriate box onto the Payment Voucher Routing Sheet.

If there are substantial alterations on the Abstract, Summary or statement of final account, it is advisable to request the Contractor to correct and re-submit all the documents to avoid ambiguity.

## **5.5 CERTIFICATION - WORKS COMPLETED**

The documents should be passed to the inspectorate staff of the Engineer's Representative concerned, who will sign the appropriate space on the original copy of the Works Order, fill in the date of completion (to be signed/certified by Engineer's Representative) and attach to it the duplicate copy of the Works Order.

At this stage, the inspectorate staff concerned should check on site to see if the works area has been cleared.

## **5.6 ACCOUNTANCY CHECK**

The completed bill should be passed to the Accounts Section of the works department (??) for conducting a final check to ensure that all items are correctly entered. The officer conducting this check should sign and date the appropriate space on the statement of final account.

## **5.7 CERTIFICATION BY THE ENGINEER**

The Accounts Section should pass all the documents back to the Engineer's Representative, who should examine the documents and initial the certificate on the front of the Statement of Final Account (3 copies), which should then be passed to the Engineer or the officer delegated by the Engineer for signature.

Site measurement checks should be conducted by the Engineer's Representative periodically (actual frequency depending on work load of ER, quarterly checking may be adequate) and the SO(Q) should record this in the Payment Record Register, or electronically in the term contracts accounting and information system approved for use by the department concerned.

## **5.8 PAYLISTING**

The Accounts Section will produce a Payment Voucher List through Treasury's Web-enabled Payment of Creditors System (WPOCS) attached with copies of the Works Order and the final account (payment Voucher List should be cross-referenced to the Works Order No. and the Contractor's Account No.). The Accounts Section should enter the Departmental Voucher No. onto the Payment Voucher Routing Sheet which should then be passed to the SO(Q), recorded on the Payment Record Register, and retained, or recorded electronically in the term contracts accounting and information system approved for use by the department concerned.

## **5.9 FILING**

The following documents should be bound together and filed in the contract payment file:

- (a) Original pages from the Site Measurement Book, together with any drawing/plan, if appropriate,
- (b) The bottom portion of the Abstract,
- (c) A duplicate copy of the Summary and Statement of Final Account, and
- (d) Copies of works orders.

## **5.10 INTERIM MEASUREMENT**

The general principles outlined in paragraph 3.3.1 (please check if this is still correct, Yes, it is applicable.) would generally be applicable to the interim measurement for the works order. Because of the simpler nature, and shorter period, of construction, the use of an Interim Payment Record Book is at the discretion of the Engineer's Representative. The Payments on Account for Works Order (Appendix 9.16) should be used for making payments to the Contractor.

## **6. MEASUREMENT FOR COST ESTIMATION**

### **6.1 GENERAL**

The objectives of measurement for cost estimation are:

- (a) To help to define the scope of work,
- (b) To enable a quantitative comparison of alternative methods of construction, and
- (c) To highlight the cost significant items and facilitates cost monitoring.

It should be noted that estimating should be a continuous process and carried out at each stage of the design process to enable a check on the cost effectiveness of the design. The accuracy of an estimate depends very much on the experience of the person preparing it, the availability of cost data, and the correctness of the measurement.

### **6.2 METHOD OF MEASUREMENT**

The method of measurement adopted should be appropriate to the various forms of estimates and will depend on the completeness of the design.

### **6.3 FORM OF ESTIMATES**

#### **6.3.1 Order of Cost**

Where unit costs for different design features have been compiled by the Department, the units of measurement shall correspond to the way the unit costs are compiled.

#### **6.3.2 Schedule of Major Items**

A list of cost significant items, which are expected to be encountered in the project should be sorted out and a forecast on the quantities for the respective items should be made.

#### **6.3.3 Project Estimate**

Priced bills of quantities should be prepared from the detailed design and drawings as far as possible. This will ensure that the tenders and the project estimate are priced on the same basis. Where a design has been substantially completed but detailed drawings are not yet available, approximate quantities for the major items should be measured from the available drawings. It is important that the estimates for all relevant Sections of the Works have been included in the project estimate. If any part of the project has not been included in the project estimate, this should also be stated. Financial risk coming from the uncertainty about the cost consequences of incomplete information or from planning decisions should be estimated according to WBTC No. 22/93. "Estimating using Risk Analysis".

**6.3.4 Estimate for Works Order**

The estimate for works orders shall be in accordance with the Schedule of Rates set forth in the Contract.

## 7. REFERENCES

WBTC No. 18/92	General Specification and Standard Method of Measurement for Civil Engineering Works
WBTC No. 21/93	Standard Phraseology of [Bills of Quantity] Item Descriptions (SPID)
WBTC No. 21/93A	Standard Phraseology of [Bills of Quantities] Item Descriptions (SPID)
WBTC No. 21/93B	Standard Phraseology of [Bills of Quantities] Item Descriptions (SPID)
WBTC No. 22/93	Estimating Using Risk Analysis
WBTC No. 17/95	The Use of Lump Sum Bills of Quantities for Civil Engineering Works
WBTC No. 17/95A	The Use of Lump Sum Bills of Quantities Contracts for Civil Engineering Works
WBTC No. 18/2000	Works Bureau Library of Standard Special Conditions of Contract for use with G.C.C. for Building Works, Civil Engineering Works and Electrical & Mechanical Engineering Works 1999 Editions
ETWB TC (W) No. 18/2000A-	Works Bureau Library of Standard Special Conditions of Contract for use with G.C.C. for Building Works, Civil Engineering Works and Electrical & Mechanical Engineering Works 1999 Editions
ETWB TC (W) No. 18/2000B	Works Bureau Library of Standard Special Conditions of Contract for use with G.C.C. for Building Works, Civil Engineering Works and Electrical & Mechanical Engineering Works 1999 Editions
WBTC No. 19/2000	General Conditions of Contract for Building Works, 1999 Edition, General Conditions of Contract for Electrical and Mechanical Engineering Works, 1999 Edition
WBTC No. 20/2000	General Conditions of Contract for Civil Engineering Works, 1999 Edition
WBTC No. 16/2002	General Conditions of Contract for Term Contracts for Civil Engineering Works, 2002 Edition
ETWB TC(W) No. 21/2003	Contract Price Fluctuation System for Civil Engineering and Building Contracts

The ETWB Website quoted below provides the latest edition of the above contract documents: -

[http://www.etwb.gov.hk/press\\_releases\\_and\\_publications/publications/contract\\_doc/index.aspx?langno=1&nodeid=852](http://www.etwb.gov.hk/press_releases_and_publications/publications/contract_doc/index.aspx?langno=1&nodeid=852)





**APPENDIX 9.2     DRAWING RECORD**

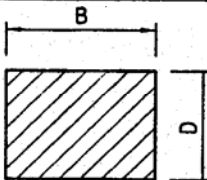
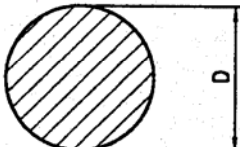
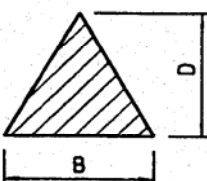
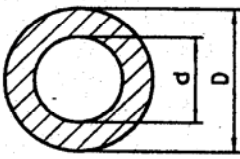
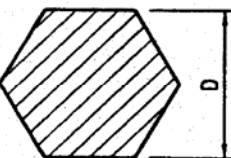

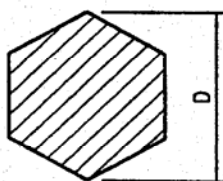
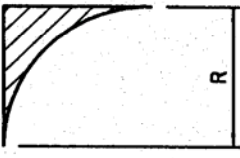
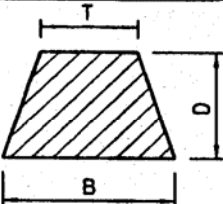
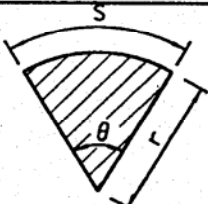
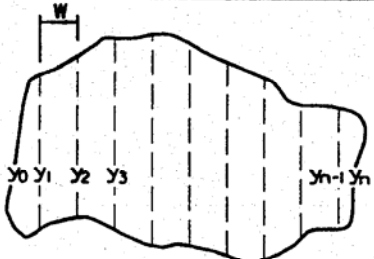
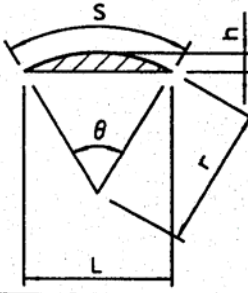
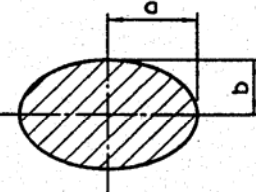
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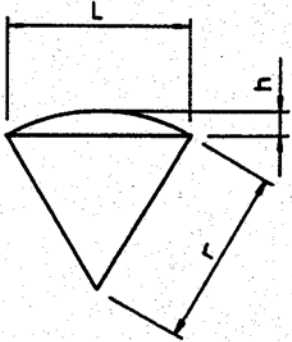
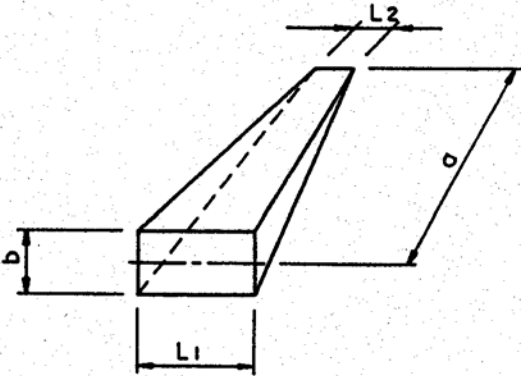
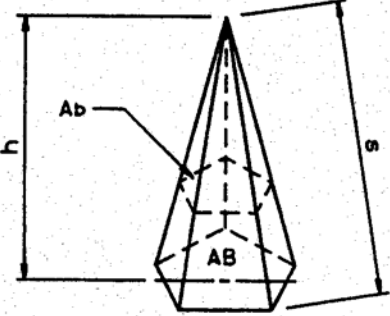
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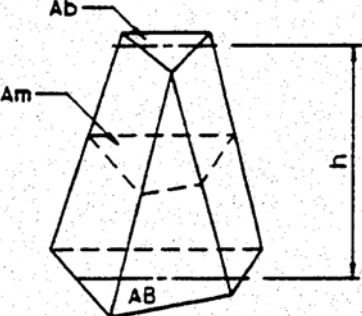
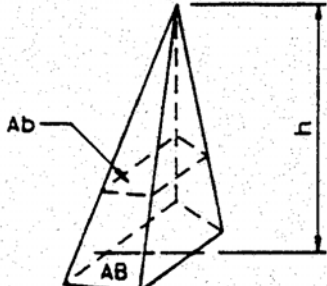
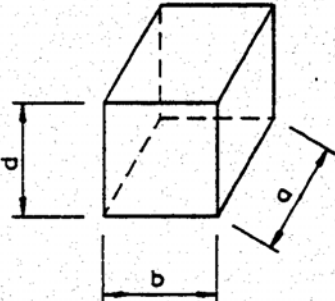
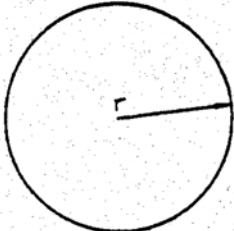
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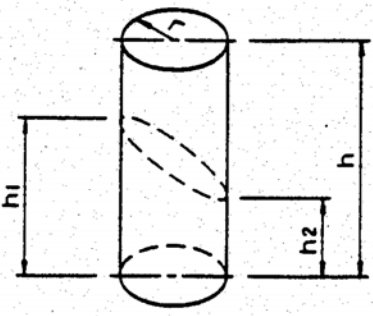
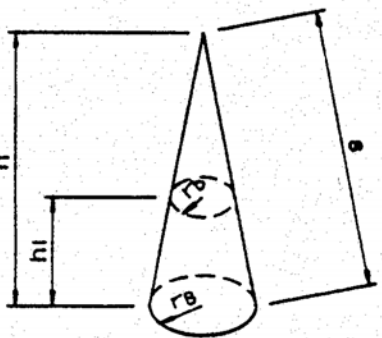
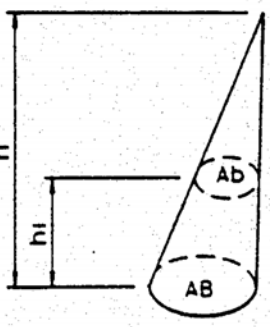


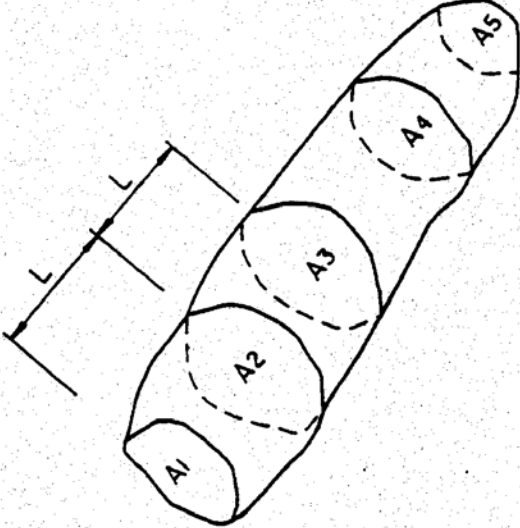
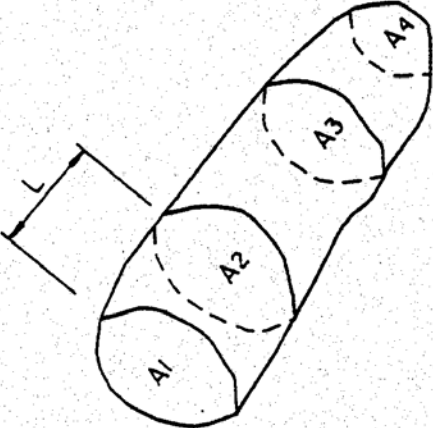
APPENDIX 9.4 MEASUREMENT OF AREAS AND VOLUMES

SECTION	AREA	SECTION	AREA
	$A = B \times D$		$A = 0.7854 D^2$
	$A = \frac{BD}{2}$		$A = 0.7854(D^2 - d^2)$
	$A = 0.866 D^2$		$A = 0.7854 R^2$
	$A = 0.65 D^2$		$A = 0.2146 R^2$
	$A = \frac{D(T + B)}{2}$		$A = \frac{\theta}{360} \times \pi r^2$ $A = \frac{\theta}{360} \times 3.14 r^2$ $= \frac{sr}{2}$
 <p>TRAPEZOIDAL RULE:-  <math>A = w \left[ \frac{y_0 + y_n}{2} + y_1 + y_2 + \dots + y_{n-1} \right]</math></p> <p>SIMPSON'S RULE:- (n MUST BE EVEN)  <math>A = \frac{w}{3} \left[ (y_0 + y_n) + 4(y_1 + y_3 + \dots + y_{n-1}) + 2(y_2 + y_4 + \dots + y_{n-2}) \right]</math></p>		 <p>A = AREA OF SEGMENT          = AREA OF SECTOR -          AREA OF TRIANGLE  <math>= \frac{1}{2} [sr \pm L(r-h)]</math>          (- If <math>h \leq r</math> ;          + If <math>h \geq r</math> )          or  <math>A = \frac{2Lh}{3}</math> (APPROX. FORMULA )</p>	
			$A = \pi ab$ $= 3.14ab$

SHAPE	VOLUME
<p>SPHERICAL SECTOR ( AND HEMISPHERE )</p> 	<p>FOR SPHERICAL SECTOR:</p> $A_t = \frac{\pi r}{3} (4h + L);$ $V = \frac{2\pi r^2 h}{3}$ <p>FOR HEMISPHERE ( LETTING <math>h = \frac{L}{2} = r</math> );</p> $A_t = 3\pi r^2;$ $V = \frac{2\pi r^3}{3}$
<p>WEDGE ( AND RIGHT TRIANGULAR PRISM )</p> 	<p>FOR WEDGE ( NARROW SIDE RECTANGULAR ):</p> $V = \frac{db}{6} (2L_1 + L_2)$ <p>FOR RIGHT TRIANGULAR PRISM ( OR WEDGE HAVING PARALLEL TRIANGULAR BASES PERPENDICULAR TO SIDES )</p> $L_2 = L_1 = L :$ $V = \frac{abl}{2}$
<p>RIGHT REGULAR PYRAMID ( AND FRUSTUM OF RIGHT REGULAR PYRAMID )</p> 	<p>FOR RIGHT REGULAR PYRAMID:</p> $AL = \frac{sPB}{2};$ $V = \frac{hAB}{3}$ <p>FOR FRUSTUM OF REGULAR PYRAMID:</p> $AL = \frac{s}{2} (PB + P_b)$ $V = \frac{h}{3} (AB + A_b + \sqrt{AB A_b})$
<p>NOTATION : LINES, a, b,.....; ALTITUDE ( PERPENDICULAR HEIGHT ), h, h ,.....; SLANT HEIGHT, s;          RADIUS, r; PERIMETER OF BASES, P<sub>b</sub> OR P<sub>B</sub> ; CHORD OF SEGMENT, L; RISE, h;          AREA OF BASE, A<sub>b</sub> OR A<sub>B</sub> ; TOTAL AREA OF CONVEX SURFACE, A<sub>L</sub> ;          TOTAL AREA OF ALL SURFACES, A<sub>t</sub> ; VOLUME, V.</p>	

SHAPE	VOLUME
<p>PRISMATOID</p> 	<p>LET AREA OF MID-SECTION = A</p> $V = \frac{h}{6} ( AB+Ab+4Am )$
<p>GENERAL PYRAMID ( AND FRUSTUM OF PYRAMID )</p> 	<p>FOR GENERAL PYRAMID:</p> $V = \frac{hAB}{3}$ <p>FOR FRUSTUM OF GENERAL PYRAMID:</p> $V = \frac{h}{3} ( AB+Ab+ \sqrt{AB \cdot Ab} )$
<p>CUBIC</p> 	$V = a.b.d$
<p>SPHERE</p> 	<p>LET DIAMETER = d</p> $At = 4\pi r^2 = \pi d^2$ $V = \frac{4\pi r^3}{3} = \frac{\pi d^3}{6}$
<p>NOTATION : LINES, a, b,.....; ALTITUDE ( PERPENDICULAR HEIGHT ), h, h ,.....; SLANT HEIGHT, s;          RADIUS, r; PERIMETER OF BASES, Pb OR PB ; CHORD OF SEGMENT, L; RISE, h;          AREA OF BASE, Ab OR AB ; TOTAL AREA OF CONVEX SURFACE, AL ;          TOTAL AREA OF ALL SURFACES, At ; VOLUME, V.</p>	

SHAPE	VOLUME
<p>RIGHT CIRCULAR CYLINDER ( AND TRUNCATED RIGHT CIRCULAR CYLINDER )</p> 	<p>FOR RIGHT CIRCULAR CYLINDER:  <math>AL = 2\pi r h;</math>  <math>A_t = 2\pi r (r+h);</math>  <math>V = \pi r^2 h</math></p> <p>FOR TRUNCATED RIGHT CIRCULAR CYLINDER:  <math>AL = \pi r (h_1 + h_2);</math>  <math>A_t = \pi r [h_1 + h_2 + r + \sqrt{r^2 + (\frac{h_1 - h_2}{2})^2}];</math>  <math>V = \frac{\pi r^2}{2} (h_1 + h_2)</math></p>
<p>RIGHT CIRCULAR CONE ( AND FRUSTUM OF RIGHT CIRCULAR CONE )</p> 	<p>FOR RIGHT CIRCULAR CONE:  <math>AL = \pi r B s = \pi B \sqrt{r^2 + h^2};</math>  <math>A_t = \pi r B (r + s);</math>  <math>V = \frac{\pi r B^2 h}{3}</math></p> <p>FOR FRUSTUM OF RIGHT CIRCULAR CONE:  <math>s = \sqrt{h_1^2 + (rB - rb)^2};</math>  <math>A_t = \pi s (rB + rb);</math>  <math>V = \frac{\pi h_1}{3} (rB^2 + rb^2 + rBrb)</math></p>
<p>GENERAL CONE ( AND FRUSTUM OF GENERAL CONE )</p> 	<p>FOR GENERAL CONE:  <math>V = \frac{ABh}{3}</math></p> <p>FOR FRUSTUM OF GENERAL CONE:  <math>V = \frac{h_1}{3} (AB + Ab + \sqrt{ABAb})</math></p>
<p>NOTATION : LINES, a, b,.....; ALTITUDE ( PERPENDICULAR HEIGHT ), h, h ,.....; SLANT HEIGHT, s;          RADIUS, r; PERIMETER OF BASES, pb OR PB ; CHORD OF SEGMENT, L; RISE, h;          AREA OF BASE, Ab OR AB ; TOTAL AREA OF CONVEX SURFACE, AL ;          TOTAL AREA OF ALL SURFACES, A+ ; VOLUME, V.</p>	

SHAPE	VOLUME
<p data-bbox="284 365 692 405">IRREGULAR SHAPE</p> 	<p data-bbox="922 376 1362 450">L = THE DISTANCE BETWEEN THE SECTIONS</p> <p data-bbox="922 472 1449 501">A1, A2, A3, A4 &amp; A5 = THEIR AREAS</p> $V = \frac{L}{3} ( A1 + 4A2 + 2A3 + 4A4 + A5 )$ <p data-bbox="922 770 1449 920">N. B. AN ODD NUMBER OF SECTIONS ARE REQUIRED FOR APPLICATION OF THIS RULE</p> <p data-bbox="986 1122 1347 1162">SIMPSON'S RULE</p>
<p data-bbox="284 1238 692 1279">IRREGULAR SHAPE</p> 	<p data-bbox="922 1357 1362 1431">L = THE DISTANCE BETWEEN THE SECTIONS</p> <p data-bbox="922 1453 1401 1482">A1, A2, A3 &amp; A4 = THEIR AREAS</p> $V = L \left( \frac{A1 + A4}{2} + A2 + A3 \right)$ <p data-bbox="922 1995 1417 2036">METHOD OF END AREAS</p>

APPENDIX 9.5 AN EXAMPLE OF AN ABSTRACT SHEET

ABSTRACT SHEET FOR CONTRACT No. 1140BS TITLE Sewage Treatment Works - Access Road  
 SHEET No. 1

Sub-base, 8cm mat, Type 1	60.00 @ 60m							
Roadbase, lean conc, 200mm th	240.00 @ 210m							
Wearing course, 14mm non off. sf, 20. width	400.00 @ 210m							
Edging, p.c conc 1/4 of curbed n.e	12.00m add	15.00 @ 15m						
Bases course, 10cm conc, 20mm agg, 140mm bit	240.00 @ 210m							
kerbing, p.c conc 1/4 of curbed n.e	12.00m add	20.00 @ 80m						
Note: Top 10 cm of abut removed to 114 for extension in 116 removed.								





**APPENDIX 9.7 AN EXAMPLE OF TAKING-OFF ON CUT AND SHUFFLE PAPER**

(Note : the yellow carbon copy is not reproduced for clarity)

Contract No.	Roads Pav	11AB/BS	11AB/BS	Sect 5 Roads Pav	11AB/BS
11AB/BS		60 ✓	210		
Sub-base, granular material Type 1			200mm brick		
		width 7.00 16.25 0.50 7.50		length 5.00 15.00 10.00 40.00	
		140.00 7.50 0.25		140.00 7.50	
		DOT 8.00 7.50 0.25		DOT 8.00 7.50	
		15.00 ✓		60.00 ✓	
				240.00 ✓ 1m <sup>2</sup>	

Note: The following drawings have been used in this taking off :- No's 1, 2, 3 etc

**APPENDIX 9.8 SITE MEASUREMENT RECORD SHEET**

\_\_\_\_\_ DEPARTMENT

CONTRACT NO. ....

(Title of Contract)

WORKS ORDER NO. ....(If Applicable)

SITE MEASUREMENT BOOK NO.

PAGES

.....	..... TO .....
.....	..... TO .....
.....	..... TO .....

Engineer's Representatives :

Engineer, Mr/Ms .....

\_\_\_\_\_  
Specimen Signature & Initials

Asst. Engineer, Mr/Ms.....

\_\_\_\_\_  
Specimen Signature & Initials

Inspector/Asst. Inspector  
of Works, Mr/Ms.....

\_\_\_\_\_  
Specimen Signature & Initials

Works Supervisor, Mr/Ms .....

\_\_\_\_\_  
Specimen Signature & Initials

SO(Q), Mr/Ms .....

\_\_\_\_\_  
Specimen Signature & Initials

Contractor :

Messrs. ....  
(name of company)

Site Representative authorised to  
sign measurements on behalf of the Contractor

Mr/Ms .....

\_\_\_\_\_  
Specimen Signature & Initials

Mr/Ms .....

\_\_\_\_\_  
Specimen Signature & Initials

**APPENDIX 9.9 SITE MEASUREMENTS BINDING COVER**

Contract No. :

Works Order No. :

Book No. : Pages \_\_\_\_\_ to \_\_\_\_\_

Works completed :

Action	Staff	Signature	Date
Works completion checked	IOW/ AIOW		
Measurements approved	IOW/ AIOW		
Dimension checked on site	IOW/ AIOW		
Schedule item numbers checked	IOW/ AIOW		
Measurements received	SO(Q)		
Measurements squared and checked	SO(Q)		
Dimensions checked on site	SO(Q)		



**APPENDIX 9.11 TERM CONTRACT – PAYMENT RECORD REGISTER**

CONTRACT No. \_\_\_\_\_

**PAYMENT RECORD REGISTER**

Works Order No.	Completion Date	Site Measurement Book		Submission of the Statement of Final Account		Returned for Resubmission		Resubmission of the Statement of Final Account		Bill			Remarks (State here if spot check on site has been carried out by AE and/or ER)
		Page Nos.	Date Rec'd	Date Rec'd	Amount/\$	Date	Contractor's signature	Date Rec'd	Amount/\$	Date of Certification	Amount Certified	Payment Voucher No.	

**APPENDIX 9.12 PAYMENT VOUCHER ROUTING SHEET**

(to be attached to every Contractor's incoming abstract/bill)

Contract No. \_\_\_\_\_

Works Order No. \_\_\_\_\_

Measurement book passed to SO(Q) on \_\_\_\_\_  
(date) (IOW/AIOW)\*

Document	Routing	Officer	Action Taken	Out	
				Date	Initial
Abstract & Bill Date : _____ Initial : _____ SO(Q)	1	ER(E/CTO/IOW)*	Works completed certification		
	2	SO(Q)	Recording, cross-checking and correction		
	3	SO(Q)	Casting check		
	4	E/AE	Technical check (Dimensions checked/not checked on site)		
	5	SO(Q)	Correction settled with Contractor		
Resubmission Abstract & Bill Date : _____ Initial : _____ SO(Q)	6	SO(Q)	Document returned to Contractor		
	7	CTO/IOW*	Disagreement settled. Amendment of original measurements made		
	8	SO(Q)	Cross-checking and correction		
	9	SO(Q)	Casting check		
	10	E/AE	Technical check		
Abstract & Bill Date : _____ Initial : _____ SO(Q)	11	Accounts	Accountancy check		
	12	ER	Certification (Dimensions checked/not checked on site)		
	13	Accounts	Vote record and paylisting		
	14	SO(Q)	Payment Voucher No.		

In case of unavoidable delay, the facts should be set out overleaf.

\* IOW and AIOW in WSD are called WWI and AWWI respectively

Remarks : Departments may modify the Routing Sheet to suit their practice

**APPENDIX 9.13 ABSTRACT SHEET FOR A WORKS ORDER**

CONTRACT NO. :

W.O. No.: \_\_\_\_\_ Folio No.: \_\_\_\_\_

DESCRIPTION OF WORK									Carried to Summary
ITEM NO.									
QUANTITY									
SCHEDULE RATE									
CONTRACT RATE									
ACTUAL RATE									
	¢								
	\$								

W.O. No.: \_\_\_\_\_ Folio No.: \_\_\_\_\_

ITEM NO.	Page		Page		Page		Page		Page		Carried to Summary
BOOK NO.											
TOTAL											
REDUCED TOTAL											
	¢										
	\$										

	Initial	Date	Initial	Date
Cross Check with Measurement				
Technical Check				





**APPENDIX 9.15 STATEMENT OF FINAL ACCOUNT FOR A WORKS ORDER**

\_\_\_\_\_ DEPARTMENT

WORKS ORDER NO. .... OF ..... CONTRACT  
 NO. ....  
 CONTRACT  
 NAME .....  
 CONTRACTOR .....

.....  
 SITE OF  
 WORKS .....  
 DETAILS OF WORK

.....  
 .....  
 .....  
 .....  
 .....

Total value of works executed as  
 Abstract of Quantities and Prices  
 DEDUCTIONS :  
 Previous Payments (Cert. No. 1 to .....

		\$	c
\$	c		
Amount Now Due \$			

I/We hereby certify that I/we have no  
 further claim under this Works Order.

.....  
 for the Contractor

Date .....

Bill Checked		I certify that the payment is in accordance with the terms of the agreement and the work has been properly executed.
SO(Q)	Accounts	
		..... for /The Engineer
Date .....	Date .....	Date .....

**APPENDIX 9.16 PAYMENT ON ACCOUNT FOR A WORKS ORDER**

\_\_\_\_\_ DEPARTMENT

Name of Contractor .....  
 Address .....

Title of Contract .....

Contract No. .... USER CODE .....

\* Works Order No.

Estimated value of works Order

Aggregate of Interim Payments

**CERTIFICATE NO.** .....

+ Total value of work completed to ..... (date)

Value of materials supplied by Contractor on site .....

Amount	
\$	c

**DEDUCTIONS**

Value of materials supplied by Employer .....

Total amount of previous payments (see overleaf) .....

Total Deductions .....

\$	c

**AMOUNT DUE ON CERTIFICATE NO.** .....

I certify that the above measurements represent the work actually carried out and that the deductions are in order.

Engineer's Representative .....

Date .....

I certify that this payment is in accordance with the terms of Contract No. .... and that work to the value of \$..... as shown at + above has been performed.

Payment of \$ ..... is now due.

Date: .....

.....

for The Engineer

\* Delete as applicable

