CIVIL ENGINEERING QUANTITIES

SI edition

Ivor H Seeley

Civil Engineering Quantities

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By the same author:
Building Quantities Explained
Civil Engineering Specification
Municipal Engineering Practice
Planned Expansion of Country Towns

Civil Engineering Quantities

by

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Preface

THIS BOOK IS concerned with the measurement of all types of civil and municipal engineering work, in accordance with the principles laid down in the *Standard Method of Measurement of Civil Engineering Quantities*, and contains many worked examples covering all classes of work.

The book is specially designed to meet the needs of students studying for the examinations of the Royal Institution of Chartered Surveyors (Quantity Surveying Section), the Institute of Quantity Surveyors, The Council of Engineering Institutions, the Institution of Civil Engineers, the Institution of Municipal Engineers, the Institution of Structural Engineers, the Building Surveyors' Institute and the Institute of Building and also for those proceeding to degrees, higher national certificates and diplomas in civil engineering, building and quantity surveying.

In addition, it is felt that this book will be of considerable use to practising civil, municipal and structural engineers and quantity surveyors, as a handy means of reference. It should also prove helpful to civil engineering contractors.

This book is on the recommended reading lists of the Royal Institution of Chartered Surveyors and the Institute of Quantity Surveyors.

The S.I. edition uses metric units throughout and where rationalised metric sizes have not yet been decided, equivalent metric dimensions have been incorporated. Readers wishing to familiarise themselves with the relative values of metric and imperial measure may find the metric conversion table in Appendix III to be helpful. This is an analogue conversion table using the nearest, neatest 'rounded-off' equivalent values.

On the drawings, all dimensions in metres are shown with a decimal marker, while all other sets of figures represent millimetres. This procedure eliminates the need for the use of the 'm' and 'mm' symbols for dimensions on drawings.

I. H. SEELEY

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All engineers, surveyors, lecturers, students and examinees who have in any way contributed, however indirectly, to the subject-matter of this book.

Some of the worked examples follow a similar pattern to those which the author prepared some years ago for the Ellis School of Architecture, Surveying and Building, London and Worcester.

Grateful thanks are also due to the publishers for abundant help and consideration during the production of the book, and to the author's family for helping with the tedious job of checking proofs, etc.

Abbreviations

Will be found listed in Appendix I.

Contents

Subjects Illustrated by Examples

Chapter	*Description*	*Example No.*	*Drawing No.*
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1 - Scope of Civil Engineering Works and Method of Measurement

IT IS CONSIDERED desirable to commence by defining some of the terms which are extensively employed in the 'measurement' of civil engineering works, in order that their meaning and purpose shall be generally understood. The term 'measurement' covers both (i) 'taking-off' dimensions by scaling or reading from drawings and entering them in a recognised form on specially ruled paper, called 'dimension paper' (illustrated on page 82, Chapter 4), and (ii) the actual measurement of the work, as executed, on the site.

The term 'quantities' refers to the estimated amounts of labour and materials required in the execution of the various items of work, and together these items give the total requirements of the contract.

These quantities are set down in a standard form on 'billing paper', as illustrated on page 87, Chapter 4, which has been suitably ruled in columns, in order that each item of work may be conveniently detailed with a description of the work, the probable quantity involved and a reference number or letter. The billing paper also contains columns in which the contractor, tendering for the particular job, enters the rates and prices for each item of work. These prices, when added together, give the 'Contract Price' or 'Tender Sum'.

Recognised 'units of measurement' are detailed in *The Standard Method of Measurement of Civil Engineering Quantities*, issued by the Institution of Civil Engineers*. This covers the majority of items of civil engineering work that are normally encountered. Most items are measured in metres and may be cubic, square or linear. Some items such as structural steelwork and steel reinforcing rods or bars are measured by weight, in which case the megagramme will be the appropriate unit of measurement.

The primary function of a 'bill of quantities' is to set down the various items of work in a logical sequence and recognised manner, in order that they may be readily priced by contractors. The bill of quantities thus enables all contractors to tender on the same information. It also provides a good basis for the valuation of 'variations', resulting from changes in design as the work proceeds.

A contractor will build-up in detail a price for each item contained in the bill of quantities, allowing for the cost of the necessary labour, materials and plant, together with the probable wastage on materials, associated temporary work, establishment charges and profit. It is most important that each billed item should be so worded that there is no doubt at all in

*(Reference 1 at end of this chapter).

the mind of a contractor as to the nature and extent of the item which he is pricing. Contractors generally tender in keen competition with one another and this calls for very skilful pricing by contractors to secure contracts.

The subject of estimating for civil engineering contracts is outside the scope of this book, but detailed information on this subject can be found in the books listed at the end of this chapter (4).

The bill of quantities normally constitutes a 'contract document' and a contractor is accordingly bound by its contents when he signs the contract. He does, in fact, undertake to execute the contract works in full accordance with all the contract documents.

SOURCES OF INFORMATION

The Institution of Civil Engineers published a report of a committee dealing with engineering quantities in 1933, and thus provided, for the first time, a standard procedure for drafting bills of quantities for civil engineering work. Prior to the introduction of this document there was no uniformity of practice in the measurement of civil engineering quantities, and engineers responsible for the preparation of civil engineering bills of quantities, largely worked up their own systems of measurement as they thought fit. The order and nature of the billed items, the units of measurement and even the method of tabulating the information in specific columns, usually referred to as 'ruling', which was adopted for the bills of quantities varied considerably.

It will be appreciated that this lack of uniformity in the preparation of civil engineering bills of quantities, made the task of civil engineering contractors in pricing them, far more difficult than it is today, now that a more uniform method of measurement has been generally adopted.

In 1953, after much deliberation and consultation, a revised document, entitled *The Standard Method of Measurement of Civil Engineering Quantities* was issued by the Institution of Civil Engineers, and this was re-issued with slight amendments in 1963 and a metric addendum added in 1968 (1). This amended the previous report, issued in 1933, to meet the changing needs of civil engineers and contractors, and tied up with the provisions of the General Conditions of Contract for use in connection with Works of Civil Engineering Construction. Certain sections of the 1933 report were simplified, particularly those dealing with concrete and pipe lines. New sections covering site investigation and site clearance were added and provision was made for the measurement of prestressed concrete.

SCOPE OF CIVIL ENGINEERING WORKS

Before comparing the methods adopted for the measurement of civil engineering work with those used for building work, some consideration should be given to the nature and scope of civil engineering works, in order to fully appreciate and understand the need for a different and quite separate mode of measurement to operate in respect of these latter works.

This comparison is included primarily for the use and guidance of quantity surveyors, many of whom are mainly concerned with the measurement of building works. A comparison of the two methods of measurement is presented in tabular form in Table I. Some comments on this comparison follow Table I.

Civil engineering works cover a large variety of different jobs, some of which are of great magnitude. Vast cuttings and embankments; large mass and reinforced concrete structures, such as frameworks of large industrial buildings and blocks of flats to large reservoirs, sea walls, bridges and cooling towers for power stations; structural steel frameworks of large buildings; piling for heavy foundations; jetties and wharves; long pipe lines and tunnels and railway tracks, all form the subject-matter of civil engineering contracts.

'Civil engineering work' may also include structural engineering projects in reinforced concrete, steel, brick, timber, etc., and municipal engineering projects carried out on behalf of local authorities and including roads, bridges, sewers, sewage pumping stations, sewage disposal works, water mains, reservoirs, water towers, works of river and sea defence, refuse disposal plants, swimming baths, etc.

These works require considerable skill, ingenuity and technical knowledge in both their design and construction. The constant introduction of new materials and techniques is for ever changing the nature and methods of construction employed in these projects, and the increasing size and intricacy of these works demands a greater knowledge and skill for their measurement and valuation.

Some works involve elements of uncertainty, as for example the excavation work for extensive deep foundations or the laying of underground services under very variable site conditions. Many civil engineering projects are carried out on the banks of rivers or on the sea coast, and on low-lying marshy land, thus making the operations that are involved, even more difficult and exacting. For these reasons it is absolutely essential that a code of measurement specially applicable to this class of work should be used.

Due to the magnitude of most civil engineering works, it is advisable that the code of measurement adopted should be relatively simple, to avoid the separate measurement of many labours and smaller items, which are separately dealt with when measuring building work. The term 'labours' refers to relatively small items of work, involving labour but no materials, such as labour in eaves filling and rough cutting to brickwork and forming grooves in timber members. Furthermore, due to the very nature of the works, there is a great deal more uncertainty than on building works, and the method of measurement needs to be more flexible to allow for variations in the methods of construction employed and changes effected during the course of the constructional work, made necessary by site conditions. The main function of a bill of quantities is to enable prices to be obtained for the job on a uniform basis and precise dimensions cannot always be prepared at the 'taking-off' stage. The quantities should always be as accurate as possible but they can be adjusted following the measurement of the completed work on the site and the work, as executed, valued at billed or comparable rates.

Extensive temporary works may well be required during the construction of civil engineering works and the contractor will need to cover the cost of these works in his billed rates.

COMPARISON OF CIVIL ENGINEERING AND BUILDING METHODS OF MEASUREMENT

There are two separate and distinct practices of measurement operating for civil engineering and building works. There is, however, considerable common ground, as regards the general approach, units of measurement employed and items of work which can be measured under both codes.

As previously stated, civil engineering work should be measured in accordance with *The Standard Method of Measurement of Civil Engineering Quantities*, prepared by the Institution of Civil Engineers (1). Building works are generally measured in accordance with *The Standard Method of Measurement of Building Works*, issued by the Royal Institution of Chartered Surveyors and the National Federation of Building Trades Employers (5th edition, metric, July 1968) (2). There is a separate code for the measurement of building work in small dwellings (3).

The details of building works are usually in a far more precise stage at the time of preparing the bill of quantities, than is the case with civil engineering works. Furthermore, the building work normally covers more trades and is, in consequence, subject to much more detailed measurement. In the absence of variations in design, most building work, with the exception of sub-structural, drainage and external works, will not be subject to re-measurement and the contractor will be paid for the quantities of work incorporated in the bill of quantities.

In a building contract the bill of quantities will constitute a contract document, whereas in the majority of cases the specification will not.

Consequently the bill of quantities in a building contract will invariably be far more detailed, with much lengthier descriptions than that operating in civil engineering work. The measurement of building work also involves a much greater number of measured items with the monetary rate entered against some of them being very low indeed.

The contractor, when pricing a civil engineering bill of quantities, will need to refer constantly to the specification for detailed information on the billed items, and must generally include for any necessary temporary work and incidental labours. There is, in consequence, far more risk of certain aspects being missed and of low rates being inserted against billed items, than with building jobs.

In some of the larger civil engineering contracts there is also an extensive amount of building work. With these contracts the question often arises as to how the works as a whole are to be measured.

Take, for example, a large power station contract. The best procedure would appear to be to measure the main superstructure, the ancillary buildings and probably the chimneys in accordance with the *Standard Method of Measurement of Building Works*. The structural steel frameworks could be measured under either code of measurement and it is interesting to note that the Institution of Structural Engineers will accept either method for candidates taking their examinations. The remainder of the power station contract, comprising heavy foundations, piling, wharves and jetties, railway sidings, cooling towers, circulating water ducts, roads, sewers and water mains, etc., are all essentially civil engineering work, and are best measured in accordance with the *Standard Method of Measurement of Civil Engineering Quantities*.

A comparison, in tabular form for ease of reference, of the two principal methods of measurement, as far as they are applicable to similar forms of constructional work, is given in some detail in Table I. This brings out the main differences between the two forms of measurement.

Note: A useful book on building quantities has been prepared by the author (5).

TABLE I

Description of Work	*Civil Engineering Method of Measurement*		*Building Method of Measurement*	
	Unit of Measurement	*S.M.M. of C.E.Q. (Section & Clause no.)*	*Unit of Measurement*	*S.M.M. of B.W. (Section & Clause ref.)*
SITE INVESTIGATION				
		Site investigation		
Bringing plant to site, etc.	Lump sum	31	Not covered	
Moving plant	Number	31		
Sinking test pits and carrying out penetration tests or borings	Linear metre of depth	31		
Removal of obstructions	Hour	31		
Undisturbed samples	Number	31		
SITE CLEARANCE				
		Site clearance		*Excavation and earthwork*
Removal of bushes, undergrowth, small trees and tree stumps, hedges, fences and rubbish	Lump sum or per hectare (hedges and fences may alternatively be measured by the linear metre)	36	Square metre with hedges measured in linear metres	D5(b) & (c)

Trees (300 mm girth and over)	Number (in 300 mm stages)	36 and 37	Enumerated, up to 600 mm girth, classified as small trees and larger trees grouped in 300 mm stages of girth	D5(a)
Tree stumps (100 mm diameter and over)	Number (in 100 mm stages)	36 and 37		
				Demolitions and alterations
Demolition of buildings, giving cubic contents above ground level	Lump sum	36	Lump sum (with allowance for credits where applicable)	C1 & C2
Demolition of steelwork, giving approx. weight of steel	Lump sum	36	Not covered	—
Demolition of pipe lines, etc., including supports	Linear metre	36		
EXCAVATION, DREDGING AND FILLING				
		Excavation, dredging and filling		*Excavation and earthwork*
General excavation	Cubic metre	40	Cubic metre	D6, D10 and D11
Excavation of pipe trenches	Linear metre (in 1·50 m stages of depth up to 6 m deep and thence in 3 m stages)	40	Linear metre (in 1·50 m stages of depth)	X3a (Drainage)

TABLE I—continued

Description of Work	*Civil Engineering Method of Measurement*		*Building Method of Measurement*	
	Unit of Measurement	*S.M.M. of C.E.Q. (Section & Clause no.)*	*Unit of Measurement*	*S.M.M. of B.W. (Section & Clause ref.)*
EXCAVATION, DREDGING AND FILLING—*continued*				
		Excavation, dredging and filling		*Excavation and earthwork*
Excavation of top soil	Square metre as 'extra over' excavation, if it is to be re-used	40	Square metre	D4
Stripping turf	Square metre as 'extra over' excavation	40	Square metre	D3
Filling	Cubic metre (where not included in excavation rates)	47	Cubic metre (where used in making up levels not exceeding 300 mm thick, measured in square metres)	D16
Back filling	Normally included in excavation rates	46	Cubic metre except for pipe trenches where included with excavation	D16(c)
Forming embankments and terraces	Normally included in excavation rates	46	As for filling	D16

Trimming slopes, soiling and seeding, or turfing	Square metre	48	Square metre	D17 & D18
Pipe and drain trenches	Linear metre in stages of depth not exceeding 1·50 m, 1·50 m to 3 m, 3 m to 4·50 m, 4·50 m to 6 m, 6 m to 9 m, 9 m to 12 m and continuing in 3 m stages	40	Linear metre in stages of depth of 1·50 m	X3 (Drainage)
Dredging	Cubic metre	43	Not covered	—
Trimming or levelling and ramming bottom of excavation	Included in excavation rates	41	Square metre but may be included with superficial items of excavation, hardcore or concrete	D17(a)
Planking and strutting or timbering trenches, etc.	Included in excavation rates	41	Square metre	D20 & D21
Working space	Square metres to sides of excavation, where necessary	40	0·60 m from face of any work requiring formwork over 1 m deep, 0·25 m where not exceeding 1 m deep, etc.	D6(g)

TABLE I—continued

Description of Work	*Civil Engineering Method of Measurement*		*Building Method of Measurement*	
	Unit of Measurement	*S.M.M. of C.E.Q. (Section & Clause no.)*	*Unit of Measurement*	*S.M.M. of B.W. (Section & Clause ref.)*
EXCAVATION, DREDGING AND FILLING—*continued*				
		Excavation, dredging and filling		*Excavation and earthwork*
Breaking up old structures of concrete, brickwork and masonry in excavation	Cubic metre as 'extra over' excavation	42	Cubic metre as 'extra over' excavation; surface concrete, etc., by the square metre	D13 & D 14
Pitching to slopes	Square metre	49	Square metre	D22(f)
GEOTECHNICAL PROCESSES				
	Various methods of measurement listed	51	Not covered	—
CONCRETE WORK				
		Concrete		*Concrete work*
(a) *Mass concrete*				
Concrete	Cubic metre	54	Cubic metre with various classifications for foundations, etc.	F3, F4, F9, F10 & F11

Concrete in slabs, floors and roofs, not exceeding 300 mm thick	Square metre or cubic metre	54	Square metre whatever the thickness, but beds and walls exceeding 300 mm thick in cubic metres	F5, F7 & F8
Shuttering or formwork	Presumably in square metres (although not expressly stated) with each type of shuttering kept separate (shuttering to construction joints, stunt heads, etc., included in the concrete rates). Shuttering 300 mm wide and under and to splays exceeding 50 mm in width are measured in linear metres	57	Square metre, under various classifications, with formwork to edges and risers in linear metres. Formwork to chases, chamfers, etc., over 50 mm wide and internal angles over 15 mm wide measured in linear metres	F20, F21, F22, F23, F24 & F26
Special facework on concrete	Square metre, as 'extra over' concrete	58	Square metre, as 'extra over' concrete	F13
Rails, joists, etc., embedded in concrete	Megagramme	59	Not specifically mentioned	—

TABLE I—continued

Description of Work	*Civil Engineering Method of Measurement*		*Building Method of Measurement*	
	Unit of Measurement	*S.M.M. of C.E.Q. (Section & Clause no.)*	*Unit of Measurement*	*S.M.M. of B.W. (Section & Clause ref.)*
CONCRETE WORK—*continued*		*Concrete*		*Concrete work*
(b) *Reinforced concrete*				
Reinforced concrete floors and roofs, etc.	Cubic metre (slabs, floors and roofs, not exceeding 300 mm thick, in square metres or cubic metres	54	Square metre, whatever the thickness, but beds and walls exceeding 300 mm thick in cubic metres	F5, F7 & F8
Reinforced concrete columns, beams, etc.	Cubic metre	54	Cubic metre, classified according to cross sectional area	F10
Shuttering or formwork	Presumably in square metres. Shuttering 300 mm wide and under and to splays exceeding 50 mm in width are measured in linear metres	57	Square metre under various classifications. Certain items in linear metres as for formwork to mass concrete	F20, F21, F22, F23, F24 & F26
Shuttering to columns, beams, etc.	Ditto	57	Square metre separately classified	F21 & F24

Bar or rod reinforcement	Megagramme with rods or bars of less than 25 mm diameter or side separately classified and lengths over 12 m kept separate in 1·50 m stages	59 and 60	Kilogramme under various classifications, with each size given separately, also bars over 10 m in length given separately in 2 m stages	F17
Fabric reinforcement	Square metre	59	Square metre	F18
(c) *Prestressed concrete*				
In situ prestressed concrete	Cubic metre	54	Cubic metre	F10 & F48
Precast prestressed concrete				
(A) (i) Factory made precast members, pretensioned, supplied and delivered, including steel	Linear metre, cubic metre or number	56	Number, under various classifications, and grouped according to length, not exceeding 3 m long and exceeding 3 m in further stages of 1·50 m	F54
(A) (ii) Site made precast members, pretensioned (steel to be measured separately)	Linear metre, cubic metre or number	56		
(B) Precast members to be post-tensioned, supplied and delivered	Linear metre, cubic metre or number	56		
(C) Assembly and post-tensioning of item (B) (steel to be measured separately)	Number of assemblies	56		

TABLE I—continued

Description of Work	*Civil Engineering Method of Measurement*		*Building Method of Measurement*	
	Unit of Measurement	*S.M.M. of C.E.Q. (Section & Clause no.)*	*Unit of Measurement*	*S.M.M. of B.W. (Section & Clause ref.)*
CONCRETE WORK—*continued*		*Concrete*		*Concrete work*
(D) Erection of members of items (A) and assemblies item (C)	Number	56	As in A–C	
Steel wire or cable for pre-stressing on site	Megagramme or linear metre with separate items for wire of different cross section and cable of different construction, length and form of construction being stated	59 and 60	Supplying wires or cables by kilogramme, each size given separately and fixing by number, with full particulars	F50
Post-tensioning on site				
Forming holes including, where necessary, ducts, casings, sheathing or chases	Linear metre	61	Linear metre, stating number and size and lengths over 6 m given separately in 3 m stages. Forming air-holes enumerated	F49

Anchorages, including fixing	Number	61	Number	F50(c)
Tensioning	Number of wires or cables	61	Number of wires or cables	F50(d)
Grouting of cables	Linear metre	61	Included with formation of ducts, but filling in anchoring recesses enumerated	F49
Pneumatic mortar (thickness stated)	Square metre	61	Covered in unit rates, and described in preamble clauses	F47, F53 & F54
Bringing plant for tensioning to site and removing it	Lump sum	61		
Pre-tensioning on site				
Tensioning, including temporary and permanent anchorages	Number of wires or cables	62	Number of wires or cables	F50(d)
(d) *Precast concrete*				
Heavy concrete blockwork as in quay walls, breakwaters, etc.	Cubic metre stating approximate size and weight of blocks	55	Not specifically mentioned, but probably in square metres	G33 (blockwork)

TABLE I—continued

Description of Work	*Civil Engineering Method of Measurement*		*Building Method of Measurement*	
	Unit of Measurement	*S.M.M. of C.E.Q. (Section & Clause no.)*	*Unit of Measurement*	*S.M.M. of B.W. (Section & Clause ref.)*
CONCRETE WORK—*continued*		*Concrete*		*Concrete work*
Joggles and Dowels to ditto	Measured as 'extra over' blockwork	55	Dowels are generally enumerated, but joggles are included in the description of the precast concrete or cast stonework item	K1 & K45 (masonry)
Beams, columns, dressings, cornices, sills, copings, steps, kerbs, etc.	Linear metre, cubic metre or number	55	Stanchions, beams, etc., enumerated. Sills, copings, steps, kerbs, etc. in linear metres, with those over 2 m in length separately classified, stating the number. Dressings measured in square metres	F27, F28, F31, F33, F34 & F38
Quoins, etc.	Number, or measured as 'extra over' blockwork	55	Not specifically mentioned, but probably in linear metres	—

Slabs, as in pavings and landings	Square metre	55	Landings enumerated. Pavings in square metres	F31(b) & F38
BRICKWORK		*Brickwork*		*Brickwork and blockwork*
General brickwork up to and including 700 mm thick	Square metre, stating thickness	64	Square metre stating thickness if under 2 bricks thick. If 2 bricks thick or over measured in square metres reduced to one-brick thick, each under various classifications	G3
Ditto, exceeding 700 mm in thickness	Cubic metre	64		
Half-brick walls and one-brick walls, faced or finished fair face on both sides	Square metre, with facings measured separately	64	Each measured separately in square metres, including the facework	G25
Cavity walls	Square metre	64	Both skins and cavity, including ties, measured separately in square metres	G3(a) & G8(a)

TABLE I—continued

Description of Work	*Civil Engineering Method of Measurement*		*Building Method of Measurement*	
	Unit of Measurement	*S.M.M. of C.E.Q. (Section & Clause no.)*	*Unit of Measurement*	*S.M.M. of B.W. (Section & Clause ref.)*
BRICKWORK—*continued*				
		Brickwork		*Brickwork and blockwork*
Facings and fair faced work	Square metre as 'extra over' cost of ordinary brickwork	69	Square metre, as 'extra over' common brickwork	G14 & G15
Copings, sills, etc.	Linear metre	64	Linear metre	G26
Chases, etc.	Linear metre as 'extra over' general brick-work	64	Horizontal rough chases in new work included in brickwork rates, all other chases measured in linear metres	G11 & G17
Corbels, over-sailings, etc.	Linear metre as 'extra over' general brick-work	64	Additional common brickwork measured in square metres re-duced to one-brick thick as 'in projec-tions' and facework measured in linear metres	G4, G18 & G19

Arches measured on face and soffit (facings only)	Square metre as 'extra over' cost of ordinary brickwork	69	Linear metre ('extra over' common brickwork)	G22
Rough cutting	To be covered by rates for brickwork	86	Square metre	G10
Fair cutting			Linear metre under various classifications	G16
Cutting and fitting to masonry			Included in description of brickwork	G4
Cutting to steelwork			Square metre as 'rough cutting'	G10(a)
Building in or cutting and pinning ends of steel joists			Number, in 3 separate stages of depth	G56(b) & (c)
Cutting and pinning ends of concrete lintols			Number, ditto.	G56(c)
Damp-proof courses		*Water-proofing*		
Horizontal and vertical, exceeding 225 mm in width	Presumably measured in square metres, with strips less than 300 mm wide in linear metres	76	Square metre	G44(a)
Ditto—not exceeding 225 mm wide			Linear metre (vertical and horizontal work is separately measured)	G44(a)

TABLE I—continued

Description of Work	*Civil Engineering Method of Measurement*		*Building Method of Measurement*	
	Unit of Measurement	*S.M.M. of C.E.Q. (Section & Clause no.)*	*Unit of Measurement*	*S.M.M. of B.W. (Section & Clause ref.)*
MASONRY		*Masonry*		*Rubble walling*
Rubble masonry (mass masonry or stone walling)	Cubic metre	73	Square metre under various classifications	J3
Facework to rubble masonry	Square metre as 'extra over' cost of rubble masonry	74	Included in rubble walling item, but measured in square metres if used with another backing material	J2 and J7
				Masonry
Ashlar and dressed stone	Cubic metre facework to concrete measured in square metres	70	Square metre under various classifications	K3 and K6
Cornices, sills, steps, copings, etc.	Cubic metre, as separate items	71	Linear metre	K19, K20 and K28(a)
Voussoirs, keystones, etc. to arches	Cubic metre, as separate items	71	Number	K22
Cramps, dowels and plugs	Number	72	Number	K45

ASPHALT WORK		*Water-proofing*		*Asphalt work*
Asphalt work generally, water-proof sheeting, rendering and waterproof painting	Square metre	76	Square metre under several classifications and measured in linear metres, in 100 mm stages of width, when not exceeding 300 mm wide	L1 and L3
Skirtings, angle fillets, etc.	Linear metre	76	Linear metre	L5 & L3(f)
Lining to small sumps	Number	76	Number	L8(a)
PILING		*Piling*		*Piling*
(a) *Concrete piles*				
Concrete	Cubic metre (separately classified in 3 m stages of length)	79 and 80	Linear metre	E4(a)
Reinforcement	Megagramme	79	Kilogramme	E4(b)
Cutting off or stripping heads of piles	Number and length stripped to be stated	79	Number, as 'extra over' piles	E4(f)
Shoes	Number of each size and weight of each stated	79	Number as 'extra over' piles giving weight of each shoe (heads similarly measured)	E4(c)

TABLE I—continued

Description of Work	Civil Engineering Method of Measurement: Unit of Measurement	Civil Engineering Method of Measurement: S.M.M. of C.E.Q. (Section & Clause no.)	Building Method of Measurement: Unit of Measurement	Building Method of Measurement: S.M.M. of B.W. (Section & Clause ref.)
PILING—*continued*		*Piling*		*Piling*
Handling and pitching piles	Number (grouping together those not exceeding 9 m in length, and those over 9 m in 3 m stages)	79 and 84	Number	E4(d)
Driving piles	Number or linear metre of penetration	79	Linear metre of penetration	E4(e)
(b) *Timber piles*				
Timber	Cubic metre (if over 9 m long, separately classified in 3 m stages)	82 and 83	Linear metre (if over 9 m long separately classified in 3 m stages)	E3(a)
Cutting off tops and ringing	Included in price of timber	83	Number, as 'extra over' piles	E3(e)
Shoes	Number of each size and weight of each stated	82	Number of each size, stating weight of shoe and including pointed end	E3(b)

Handling and pitching piles	Number (grouping as for concrete piles)	82 and 84	Number	E3(c)
Driving piles	Number or linear metre of penetration	82	Linear metre of penetration	E3(d)
(c) *Steel sheet piling*	(*Permanent work only*)		*Permanent and temporary work*	
Piling	Square metre (lengths over 12 m measured separately in 3 m stages)	87 and 88	Square metre, where over 12 m long, separately classified in stages of 3 m including handling and pitching	E8(b)
Corner and junction piles	Linear metre, as 'extra over' steel sheet piling	87	Linear metre, as 'extra over' sheet piling	E8(d)
Cutting or burning through piling	Linear metre	87	Linear metre as 'extra over' piling	E8(e)
Handling, pitching and driving of piling	Included in rates for steel sheet piling	87 and 88	Driving only by square metre (if over 6 m deep, separately classified in 3 m stages)	E8(c)
(d) *Steel box piles*	Linear metre (handling and driving measured as for concrete piles)	89	Not specifically mentioned	—

TABLE I—continued

Description of Work	Civil Engineering Method of Measurement: Unit of Measurement	Civil Engineering Method of Measurement: S.M.M. of C.E.Q. (Section & Clause no.)	Building Method of Measurement: Unit of Measurement	Building Method of Measurement: S.M.M. of B.W. (Section & Clause ref.)
PILING—*continued*		*Piling*		*Piling*
(e) *Cast 'in-situ' piling*				
Bringing plant to site, and erecting, dismantling and removing it	Lump sum	90	*Bored piles* in linear metres with reinforcement measured in kilogrammes	E5
Driving casings	Linear metre of penetration	90	*Contractor-designed concrete piles* enumerated, giving length, superimposed load and method of disposing of spoil	E7
Providing pile-shoes and/or formation of enlarged bases	Number, as 'extra over' length of pile	90 and 91		
Forming pile-shafts including concrete and reinforcement	Linear metre, classified as not exceeding 9 m and over 9 m in 3 m stages	90 and 91		
Projecting reinforcement	Number of sets, as 'extra over' length of pile and giving length of projection	90 and 91		

TIMBERWORK IN JETTIES, WHARVES AND SIMILAR STRUCTURES

		Timber-work in jetties, etc.		*Carpentry*
Timber in constructional members and timber decking (including all labours)	Cubic metre (lengths over 9 m given separately in 3 m stages)	94 and 95	Linear metre (lengths exceeding 6 m given separately in stages of 1·50 m)	N3 and N4
Timber hand-rails, guard rails, treads to steps, etc.	Linear metre	94	Probably by linear metre	No specific reference
Steel or wrought iron straps, spikes, coach screws, bolts, plates, etc., including boring and fixing	Number	94	Various items separately enumerated, stating nature of material to which the metalwork is to be fixed. Boring measured separately	N26(a), N30 and N31
STEEL AND IRONWORK				
		Steel and ironwork		*Structural steelwork*
General steelwork	Megagramme	97	Kilogramme under various classifications as to function and in some cases as to weight and length also	Q1 to Q13

TABLE I—continued

Description of Work	*Civil Engineering Method of Measurement*		*Building Method of Measurement*	
	Unit of Measurement	*S.M.M. of C.E.Q. (Section & Clause no.)*	*Unit of Measurement*	*S.M.M. of B.W. (Section & Clause ref.)*
STEEL AND IRONWORK—*continued*				
		Steel and ironwork		*Structural steelwork*
Holding-down bolts, etc.	Megagramme stating the weight of each item	98 and 100	Kilogramme with each diameter given separately	Q21
Site riveting	Weight of rivet heads added to steelwork	99	Enumerated in hundreds (weight of heads added to steelwork)	Q18(a)
Painting of steelwork by steel fabricators or erectors	Covered by the rates per megagramme for steelwork	101	Kilogrammes of steelwork to be painted	Q23
				Painting & decorating
Painting of steelwork on the site by general contractor	Square metre, with bars and longitudinal members, not exceeding 300 mm girth, in linear metres	101	Square metre	W6
				Roofing
Corrugated sheeting, etc.	Square metre	102	Square metre	M 16 and M17

Ridge-cappings, barge-boards, filler-pieces, etc., to last	No method of measurement given, but presumably measured in linear metres	102	Linear metre	M19, M21 and M22
ROADS AND PAVINGS				
		Roads and Pavings		*Finishings*
Road surfacings	Square metre	103	Square metre	U2, U3 and F5
Footway pavings	Square metre	103	Square metre	(Concrete work)
				Excavation & earthwork
Foundations to roads and paths, including preparation of formation	Measured with the surfacing	104 & 105	Hardcore measured in square metres if not exceeding 300 mm thick, otherwise in cubic metres	D22
				Concrete work
Concrete foundations to kerbs and channels	Linear metre	103	Not specifically mentioned	—
Kerbs and channels	Linear metre	103	Linear metre	F33
Channels formed in surface of concrete roads	Linear metre, as 'extra over' rates for concrete road	105	Linear metre	F14(c)
Fabric reinforcement	Square metre	103	Square metre	F18
Bar or rod reinforcement	Megagramme	103	Kilogramme	F17
Expansion joints	Linear metre	103	Linear metre	F15

TABLE I—continued

Description of Work	*Civil Engineering Method of Measurement*		*Building Method of Measurement*	
	Unit of Measurement	*S.M.M. of C.E.Q. (Section & Clause no.)*	*Unit of Measurement*	*S.M.M. of B.W. (Section & Clause ref.)*
SEWERS AND DRAINS				
		Sewers, drains and pipe lines		*Drainage*
Stoneware and concrete pipe sewers and drains, with cement joints	Linear metre, including laying and jointing pipes	112	Linear metre, including laying and jointing pipes	X5(a)
Bends, junctions, etc.	Number of each type, measured as 'extra over' pipe sewers and drains	112	Number, as 'extra over' drain pipes	X5(b)
Cuts to pipes	Number	112	Not separately measured	—
Concrete beds, haunchings, etc., to pipes	Cubic metre	54 (concrete)	Linear metre, stating size of concrete and internal diameter of pipe and including formwork	X4
Gullies, intercepting traps, penstocks, etc.	Number, with full description	116	Number, with full description	X6
Manholes, inspection chambers, etc.	Measured in detail	116	Measured in detail	X7

PIPE LINES *(Cast iron, steel, wrought iron, concrete, composite or asbestos pipes with caulked lead or other special joints)*		*Sewers, drains and pipe lines*		*Drainage and plumbing and engineering installations*
Supplying and delivering pipes	Linear metre (effective length)	113	Linear metre, including laying and jointing	X5(a) and S8(a)
Making-up pieces, collars, bends, tees and other specials, supplied and delivered	Number of each type	113	Number, as 'extra over' pipes, including laying and jointing	X5(b) and S11(a)
Taking delivery of pipes, bends and other fittings and transporting (pipes supplied to contractor)	Linear metre (effective length)	113	See previous items	—
Distributing and laying pipes, bends, etc.	Linear metre of pipe as laid	113	See previous items	—
Jointing, including all materials required	Number of joints	113	See previous items	—
Brackets, slings and other supports supplied and fixed	Number of each type	113	Number of each type	S12(d)
Insulating covering for pipes	Linear metre of pipe line	113	Linear metre	S97

TABLE I—continued

Description of Work	*Civil Engineering Method of Measurement*		*Building Method of Measurement*	
	Unit of Measurement	*S.M.M. of C.E.Q. (Section & Clause no.)*	*Unit of Measurement*	*S.M.M. of B.W. (Section & Clause ref.)*
PIPE LINES—*continued*				
(*Cast iron, steel, wrought iron, concrete, composite or asbestos pipes with caulked lead or other special joints*)		*Sewers, drains and pipe lines*		*Drainage and plumbing and engineering installations*
Cuts to pipes	Number	113	Not separately measured	—
Valves, expansion joints, etc., supplied and fixed	Number of each type	113	Number of each type	S86
Valve chambers, hydrant boxes, etc.	Measured in detail	115	Measured in detail	X7
RAILWAY TRACKWORK		*Railway trackwork*		
See Chapter 16	Units of measurement detailed for all component parts of railway trackwork	119 to 121	Not covered	—

CONCLUSIONS TO BE DRAWN FROM A COMPARISON OF THE TWO METHODS OF MEASUREMENT

In building work a much larger number of items have to be measured separately, with various labours and other incidental work itemised, but this is not the civil engineering practice. For instance, in building work, back filling trenches, levelling and ramming trench bottoms and planking and strutting or trench timbering are each measured separately, whereas in civil engineering work, these items are included in the excavation rates. Similarly, in building work, separate items are included to cover rough and fair cutting to brickwork, cutting and fitting brickwork to masonry and building in ends of joists, etc., whereas the civil engineering practice is to include all these items in the brickwork rates on account of their relative financial insignificance in this class of work. Furthermore, an item for protecting the work is to be provided in most sections of work under the building method of measurement, whereas in civil engineering work this item will be covered in the unit rates, without specific mention.

The civil engineering practice, on the other hand provides greater flexibility in the method of measuring certain types of work. For example reinforced concrete suspended floors and roofs can be measured in cubic metres or square metres, according to their thickness, and reinforced concrete columns and beams in cubic metres, whereas in building work, the respective units of measurement are square metres for floors and roofs and cubic metres for columns and beams. It will be appreciated that in civil engineering work, the items of work will often be much larger in size and more extensive in scope and will probably be carried out under greatly different and more uncertain conditions than those operating on most building sites, with the more extensive use of mechanical plant and equipment.

In building work the bill headings may relate to sections of work or trades, such as excavator; concretor; bricklayer; drainlayer; mason; carpenter and joiner, etc. The normal civil engineering practice is to use bill headings covering the main sections of the work, such as excavation, dredging and filling; concrete work; brickwork; piling, etc.

In both civil engineering and building work dimensions are 'taken-off' in the same manner, but the 'abstracting' will be rather different in the civil engineering method, with a smaller number of sectional headings and with different trades grouped in the same section in some cases. The 'abstract' is a schedule or classified list of the items taken-off, presented in the correct order ready for 'billing' and reduced to the recognised units of measurement. Abstracting and billing are considered in detail in Chapter

17. In the civil engineering method many items are often 'billed direct' from the dimension sheets, without the need for an abstract.

Note: The *Standard Method of Measurement of Civil Engineering Quantities* contains (pages 19 to 22) a useful index.

REFERENCES

(1) *Standard Method of Measurement of Civil Engineering Quantities* (1953 edition, reprinted in 1963 and metric addendum added in 1968) issued by the Institution of Civil Engineers

(2) *Standard Method of Measurement of Building Works*, Fifth Edition, metric, July 1968, issued by the Royal Institution of Chartered Surveyors and the National Federation of Building Trades Employers

(3) *Code for the Measurement of Building Works in Small Dwellings* (Second Edition metric, 1968). (R.I.C.S.)

(4) *Estimating for Building and Public Works*, B. Price Davies (Building Estimator Publications). *Estimating for Building and Civil Engineering Works*, Spence Geddes (Newnes)

(5) *Building Quantities Explained*, S.I. edition, 1970, Ivor H. Seeley (Macmillan)

II – Civil Engineering Contracts and Contract Documents

THE FIRST PART of this chapter is concerned with the general characteristics of contracts and the remedies available when a contract is broken by a party to it. It gives the legal background to work under a contract and is required by many examining bodies. For more comprehensive and detailed information on the law of contracts, which is a most complicated subject, the reader might consult, for example, the books of reference (1), listed at the end of the chapter.

The Nature and Form of Contracts

The law relating to civil engineering contracts is one aspect of the law relating to contract and tort or civil wrongs. It is, therefore, desirable to have some knowledge of the law relating to contracts generally before the main characteristics and requirements of civil engineering contracts are considered.

A simple 'contract' consists of an agreement entered into by two or more parties, whereby one of the parties undertakes to do something in return for something to be undertaken by the other. A 'contract' has been defined as an agreement which directly creates and contemplates an obligation. The word is derived from the Latin 'contractum', meaning drawn together.

We all enter into contracts almost every day for the supply of goods, transportation and similar services, and in all these instances we are quite willing to pay for the services we receive. Our needs in these cases are comparatively simple and we do not need to enter into lengthy or complicated negotiations and no written contract is normally executed. Nevertheless, each party to the contract has agreed to do something, and is liable for breach of contract if he fails to perform his part of the agreement.

In general, English law requires no special formalities in making contracts but, for various reasons, some contracts must be made in a particular form to be enforceable and, if they are not made in that special way, then they will be ineffective. Notable amongst these contracts are contracts for the sale, disposal, etc., of land, and 'land', for this purpose, includes anything built on the land, as for example houses.

Some contracts must be made 'under seal', e.g. Deeds of Gift or any contract where 'consideration' is not present (consideration is defined later in the chapter). Some other contracts must be in writing, e.g. that covering the Assignment of Copyright, where an Act of Parliament specifically states that writing is necessary. Contracts covering guarantee and land transactions may be made orally but will be unenforceable unless they are in writing, by virtue of the Law Reform (Enforcement of Contract) Act, 1954.

Since the passing of the Corporate Bodies Contracts Act, 1960, the contracts entered into by corporations, including local authorities, can be binding without being made under seal. The standing orders of most local authorities, however, will require major contracts to be made under seal, but the new Act will avoid a repetition of the results of Wright *v.* Romford Corporation, where the local authority was able to avoid its responsibilities under a contract, merely because the contract had not been made under seal.

It is sufficient in order to create a legally binding contract, if the parties express their agreement and intention to enter into such a contract. If, however, there is no written agreement and a dispute arises in respect of the contract, then the Court which decides the dispute will need to ascertain the terms of the contract from the evidence given by the parties, before it can make a decision on the matters in dispute.

On the other hand if the contract terms are set out in writing in a document which the parties subsequently sign, then both parties are bound by these terms even if they do not read them. Once a person has signed a document he is assumed to have read and approved its contents, and will not be able to argue that the document fails to set out correctly the obligations which he actually agreed to perform. Thus by setting down the terms of a contract in writing one secures the double advantage of affording evidence and avoiding disputes.

The law relating to contracts imposes upon each party to a contract a legal obligation to perform or observe the terms of the contract, and gives to the other party the right to enforce the fulfilment of these terms or to claim 'damages' in respect of the loss sustained in consequence of the breach of contract.

Enforcement of Contracts

An agreement can only be enforced as a contract if:

(1) The agreement relates to the future conduct of one or more of the parties to the agreement.

(2) The parties to the agreement intend that their agreement shall be enforceable at law as a contract.

(3) It is possible to perform the contract without transgressing the law.

Validity of Contracts

The legal obligation to perform a contractual obligation only exists where the contract is valid. In order that the contract shall be valid the following conditions must operate:

(a) There must be an offer made by one person (the offeror), and the acceptance of that offer by another person (the offeree), to whom the offer was made. Furthermore, the offer must be definite, and made with the intention of entering into a binding contract. The acceptance of the offer must be absolute, be expressed by words or conduct, and be accepted in the manner prescribed or indicated by the person making the offer.

An offer is not binding until it is accepted and, prior to acceptance, the offer may come to an end by lapse of time, by revocation by the offeror or by rejection by the offeree, and in these cases there can be no acceptance unless the offer is first renewed.

(b) The contract must have 'form' or be supported by 'consideration'. The 'form' consists of a 'deed' which is a written document, which is signed, sealed and delivered, and this type of contract is known as a 'formal contract' or contract made by deed.

If a contract is not made by deed, then it needs to be supported by 'consideration', in order to be valid, and this type of contract is known as a 'simple contract'. 'Consideration' has been defined as some return, pecuniary or otherwise, made by the promisee in respect of the promise made to him.

(c) Every party to a contract must be legally capable of undertaking the obligations imposed by the contract. For instance, persons under 21 years of age may, in certain cases, avoid liability under contracts into which they have entered. Similarly a corporation can only be a party to a contract if it is empowered by a statute or charter to enter into it.

(d) The consent of a party to a contract must be genuine. It must not be obtained by fraud, misrepresentation, duress, undue influence or mistake.

(e) The subject matter of the contract must be legal.

Remedies for Breach of Contract

Whenever a breach of contract occurs a right of action exists in the Courts to remedy the matter. The remedies generally available are as follows:

(1) Damages.
(2) Order for payment of a debt.
(3) Specific performance.
(4) Injunction.
(5) Rescission.

Each of these remedies will now be considered further:

(1) *Damages.* In most cases a breach of contract gives rise to a right of action for damages. The 'damages' consist of a sum of money which will, as far as it is practicable, place the aggrieved party in the same position as if the contract had been performed.

The parties to a contract, when entering into the agreement, may agree that a certain sum shall be payable if a breach occurs. This sum is usually known as 'liquidated damages', where it represents a genuine estimate of the loss which is likely to result from the breach of contract. Where, however, the agreed sum is in the nature of a punishment for the breach of contract, then the term 'penalty' is applied to it, and penalties are not normally recoverable in full.

For instance, in civil engineering contracts it is often stipulated that a fixed sum shall be paid per day or per week, if the contract extends beyond the agreed contract period. If this sum is reasonable it constitutes liquidated damages and, unlike a penalty, is recoverable in full.

(2) *Order for payment of a debt.* A debt is a liquidated or ascertained sum of money due from the debtor to the creditor and is recovered by an 'action of debt'.

(3) *Specific performance.* The term 'specific performance' refers to an order of the Court directing a party to a contract to perform his part of the agreement. It is now only applied by the Courts on rare occasions when damages would be an inadequate remedy, but specific performance constitutes a fair and reasonable remedy and is capable of effective supervision by the Court. This remedy will not be given if it requires the constant supervision of the Court.

(4) *Injunction.* An injunction is an order of Court directing a person not to perform a specified act. For instance, if A had agreed not to carry out any further building operations on his land, for the benefit of B, who owns the adjoining land, and B subsequently observes A commencing building operations, then B can apply to the Court for an injunction restraining A from building. Damages, in these circumstances, would not be an adequate remedy.

(5) *Rescission.* Rescission consists of an order of Court cancelling or setting aside a contract and results in setting the parties back in the position that they were before the contract was made.

CIVIL ENGINEERING CONTRACTS

Most contracts entered into between civil engineering contractors and their employers are of the type known as 'entire' contracts. These are contracts in which the agreement is for a definite job of work to be undertaken by the contractor and no payment is due until the work is complete.

In an entire contract, where the employer agrees to pay a certain sum in return for civil engineering work, which is to be executed by the contractor, the contractor is not entitled to any payment if he abandons the work prior to completion, and will be liable in damages for breach of contract. Where the work is abandoned at the request of the employer, or results from circumstances which were clearly foreseen when the contract was entered into and provided for in its terms, then the contractor will be entitled to payment on a 'quantum meruit' basis, i.e. he will be paid as much as he has earned.

It is, accordingly, in the employer's interest that all contracts for civil engineering work should be entire contracts, to avoid the possibility of work being abandoned prior to completion. Contractors are usually unwilling to enter into any contracts, other than the very smallest, unless provision is made for interim payments to them as the work proceeds. For this reason the standard form of civil engineering contract provides for the issue of interim certificates at various stages of the works, with the proviso that payment, or the issue of a certificate as a preliminary to payment, shall not be taken as approval of the work performed up to the time of payment.

It is usual for the contract to further provide that only a proportion of the sum due on the issue of a certificate shall be paid to the contractor. In this way the employer retains a sum, known as 'retention money', which will operate as an insurance against any defects that may arise in the work. The contract does, however, remain an entire contract, and the contractor is not entitled to demand payment in full until the work is satisfactorily completed, the maintenance period expired and the maintenance certificate or final certificate of completion issued.

That works must be completed to the satisfaction of the employer, or his representative, does not give to the employer the right to demand an unusually high standard of quality throughout the works, in the absence of a prior express agreement. Otherwise the employer might be able to postpone indefinitely his liability to pay for the works. The employer is normally only entitled to expect a standard of work that would be regarded as reasonable by competent men with considerable experience in the class of work covered by the particular contract. The detailed requirements of the specification will, of course, have a considerable bearing on these matters.

The employer or promoter of civil engineering works normally determines the conditions of contract, which define the obligations and performances to which the contractor will be subject. He usually selects the contractor for the job by some form of competitive tendering and any contractor who submits a successful tender and subsequently enters into a contract, is deemed in law to have voluntarily accepted the conditions of contract adopted by the promoter.

The obligations which a contractor accepts when he submits a tender are determined by the form of the invitation to tender. In most cases the tender may be withdrawn at any time until it has been accepted and may, even then, be withdrawn if the acceptance is stated by the promoter to be 'subject to formal contract', as is often the case.

The promoter will not be bound to accept the lowest or any tender and this is often stated in the advertisement. A tender is, however, normally required to be a definite offer and acceptance of it gives rise legally to a binding contract.

TYPES OF CONTRACT ENCOUNTERED IN CIVIL ENGINEERING WORKS

Contracts for the execution of civil engineering works may be broadly classified as follows:

(1) *Bill of quantities contracts.* This type of contract which incorporates a bill of quantities priced by the contractor is the most commonly used form of contract for works of civil engineering construction of all but the smallest in extent, where the quantities of the bulk of the work can be ascertained with reasonable accuracy before the work is commenced. A bill of quantities is prepared giving, as accurately as possible, the quantities of each item of work to be executed and the contractor enters a unit rate against each item of work. The extended totals are added together to give the total cost of the job, or 'contract sum' or 'tender sum', as it is frequently termed.

The preparation of detailed bills of quantities for civil engineering works can have an important and far-reaching effect on the cost of the works. The contractor tendering for the specific contract has a detailed schedule giving particulars and quantities of all the items of work involved. In the absence of such a bill of quantities, each contractor tendering will have to assess the amount of work involved and this will normally have to be undertaken in a very short period of time, in amongst other jobs.

Under these circumstances a contractor, unless he is extremely short of work, is almost bound to price high in order to allow himself a sufficient margin of cover for any items which he may have missed. Furthermore, there is no really satisfactory method of assessing the cost of variations and the contractor may feel obliged to make allowance for this factor also, when building up his contract price.

Bills of quantities greatly assist in keeping tender figures as low as possible. They should be prepared, whenever possible, on all but the smallest civil engineering contracts.

(2) *Lump sum contracts.* In a lump sum contract the contractor undertakes to carry out certain specified works for a fixed sum of money. The nature and extent of the works are normally indicated on drawings and the nature of the materials and workmanship described in a specification, but no bill of quantities is provided.

This form of contract is largely employed in conjunction with works which are small in extent, and where the work is above ground and clearly visible.

It has, however, occasionally been used where the works required are very uncertain in character, and by entering into a lump sum contract the employer hoped to place the onus on the contractor for deciding the full extent of the works and the responsibility for the payment of any additional costs, which could not be foreseen before the works were commenced. The employer would then pay a fixed sum for the works, regardless of their actual cost, and this constitutes an undesirable practice from the contractor's point of view.

(3) *Schedule contracts.* This type of contract may take one of two forms. The employer may supply a schedule of unit rates covering each item of work and ask the contractors, when tendering, to state a percentage above or below the given rates for which they would be prepared to execute the work. Alternatively, and as is more usual, the contractors may be requested to insert prices against each item of work, and a comparison of the rates so entered will enable the most favourable offer to be ascertained. Approximate quantities are sometimes included to assist the contractors in pricing the schedules and the subsequent comparison of the tendered figures.

This type of contract is really only suitable for use with maintenance, jobbing and similar contracts, where it is impossible to give realistic and accurate quantities of the work to be undertaken. In this form of contract it is extremely difficult to make a fair comparison between the figures submitted by the various contractors, particularly where approximate quantities are not inserted in the schedules, as there is no total figure available for comparison purposes and the unit rates may fluctuate extensively between the various tenderers. Occasionally schedules of rates are used as a basis for negotiated contracts.

(4) *Cost plus percentage contracts.* In a cost plus percentage contract, the contractor is paid the actual cost of the work plus an agreed percentage of the actual or allowable cost to cover overheads, profit, etc. It is useful in an emergency, when there is insufficient time available to prepare a detailed scheme before work is commenced, but it will be apparent that an unscrupulous contractor could increase his profit by delaying the completion of the works. No incentive exists for the contractor to complete the works as quickly as possible or to try to reduce costs.

(5) *Cost plus fixed fee contracts.* In this form of contract the sum paid to the contractor will be the actual cost incurred in the execution of the works plus a fixed lump sum, which has been previously agreed upon and does not fluctuate with the final cost of the job. No real incentive exists for the contractor to secure efficient working, although it is to his advantage to earn the fixed fee as quickly as possible and so release his resources for other work. This type of contract is superior to the 'cost plus percentage' type of contract.

(6) *Cost plus fluctuating fee contracts.* In this form of contract the contractor is paid the actual cost of the work plus a fee, with the amount

of the fee being determined by reference to the allowable cost by some form of sliding scale. Thus the lower the actual cost of the works, the greater will be the value of the fee that the contractor receives. An incentive then exists for the contractor to carry out the work as quickly and cheaply as possible, and it does constitute one of the best of the 'cost plus' type of contract, from the employer's point of view.

(7) *Target contracts.* Target contracts have been introduced in recent years to encourage the contractor to execute the work as cheaply as possible. A basic fee is generally quoted as a percentage of an agreed target estimate obtained from a priced bill of quantities. The target estimate may be adjusted for variations in quantity and design and fluctuations in the cost of labour and materials, etc. The actual fee paid to the contractor is arrived at by increasing or reducing the basic fee by an agreed percentage of the saving or excess between the actual cost and the adjusted target estimate. In some cases a bonus or penalty based on the time of completion may also be applied.

The first three types of contract are often referred to as 'fixed price' contracts, and the four latter forms of contract as 'cost reimbursement' contracts.

All-in contracts. With this type of contract the employer or promoter, often using the services of an engineer, gives his requirements in broad outline to contractors, who are asked to submit full details of design, construction and cost, probably including maintenance of the works for a limited period. This procedure has been used for gas and chemical works, oil-refineries and nuclear power stations. The use of this form of contract may have some advantages in a few special cases but is not the most satisfactory method for the majority of contracts.

(See *Civil Engineering Procedure* issued by the Institution of Civil Engineers (7).)

CONTRACT DOCUMENTS

The contract documents normally used in connection with a civil engineering contract are as follows:

(a) Form of Contract.
(b) General Conditions of Contract.
(c) Specification.
(d) Bill of Quantities.
(e) Contract Drawings.
(f) Form of Tender.

Consideration will now be given to the nature and purpose of each of these documents.

(a) *Form of Contract*

The 'Form of Contract' constitutes the formal agreement between the promoter and the contractor for the execution of the work in accordance with the other contract documents. This is now generally covered by the 'Form of Agreement' incorporated in the General Conditions of Contract for use in connection with works of civil engineering construction (2).

(b) *General Conditions of Contract*

The 'General Conditions of Contract' define generally the terms under which the work is to be undertaken, the relationship between the promoter or employer, the engineer and the contractor, the powers of the engineer and the terms of payment. For many years it had been considered desirable to use a standard set of conditions which could, as far as practicable, be applicable to all civil engineering contracts. Any special conditions relating to an individual contract can be added to the general clauses.

In 1945, the Institution of Civil Engineers and the Federation of Civil Engineering Contractors issued a standard set of 'General Conditions of Contract' for use in connection with works of civil engineering construction (2). In the later editions of this document the Association of Consulting Engineers was concerned with its preparation, in addition to the other two bodies previously mentioned. Furthermore, other sets of conditions have been specially prepared to cover civil engineering works to be carried out overseas (3).

For building work it is usual to make use of the standard conditions issued under the sanction of the Royal Institute of British Architects and various other bodies, and generally referred to as the 'R.I.B.A. Conditions' (4). There are alternative forms for use where quantities do or do not form part of the contract and there is, in addition, a set of conditions specially devised for use on local authority contracts.

Standard conditions are also issued by the Institution of Structural Engineers for use on structural engineering contracts (5).

Where the contract is of very limited extent and the use of the standard comprehensive set of conditions is not really justified, an abbreviated set of conditions, often worked up from the appropriate set of standard conditions, is frequently adopted.

With certain specialised classes of civil engineering work the responsible authorities have seen fit to introduce a number of clauses which modify or supplement the standard clauses of the 'I.C.E. Conditions'. Typical examples are the clauses prepared by the Central Electricity Generating Board for use on power station contracts and the clauses introduced by the Ministry of Transport in connection with contracts for roads and bridges.

The General Conditions of Contract for use in connection with works of civil engineering construction, is almost invariably included as one of the contract documents on a civil or municipal engineering contract. The principal clauses of the General Conditions of Contract for works of civil engineering construction, commonly referred to as the 'I.C.E. Conditions' (2) covering the measurement and valuation of the works are clauses 51 and 52, dealing with alterations, additions and omissions, clauses 55, 56 and 57 covering measurement, clauses 58 and 59 relating to provisional and prime cost sums and clauses 60, 61 and 62, which are concerned with certificates and payment.

The contents of these clauses are now reproduced in full, together with explanatory notes regarding their meaning and effect.

ALTERATIONS, ADDITIONS AND OMISSIONS

CLAUSES IN GENERAL CONDITIONS OF CONTRACT
(abstracted from reference 2)

51(1) *Variations*

The Engineer shall make any variation of the form quality or quantity of the Works or any part thereof that may in his opinion be necessary and for that purpose or if for any other reason it shall in his opinion be desirable shall have power to order the Contractor to do and the Contractor shall do any of the following:

(a) increase or decrease the quantity of any work included in the Contract
(b) omit any such work
(c) change the character or quality or kind of any such work
(d) change the levels lines position and dimensions of any part of the Works and
(e) execute additional work of any kind necessary for the completion of the Works

and no such variation shall in any way vitiate or invalidate the Contract but the value (if any) of all such variations shall be taken into account in ascertaining the amount of the Contract Price.

EXPLANATORY NOTES

This clause enables the scope of the contract to be altered considerably by the engineer. The contractor cannot object to this, but can charge for extra work.

Such alterations are not uncommon.

The profit on a job may be reduced if certain items in the bill of quantities are increased considerably in quantity and the rates for these items are underestimated. (See clause 52(1) and (2) concerning price fixing.)

51(2) *Orders for Variations to be in Writing.*

No such variation shall be made by the Contractor without an order in writing of the Engineer. Provided that no order in writing shall be required for increase or decrease in the quantity of any work where such increase or decrease is not the result of an order given under this Clause but is the result of the quantities exceeding or being less than those stated in the Bill of Quantities. Provided also that if for any reason the Engineer shall consider it desirable to give any such order verbally the Contractor shall comply with such order and any confirmation in writing of such verbal order given by the Engineer whether before or after the carrying out of the order shall be deemed to be an order in writing within the meaning of this Clause. Provided further that if the Contractor shall confirm in writing to the Engineer any verbal order of the Engineer and such confirmation shall not be contradicted in writing by the Engineer it shall be deemed to be an order in writing by the Engineer.

Note the necessity for the contractor to obtain all variation orders in writing or confirm in writing any verbal orders given by the engineer.

52(1) *Valuations of Variations*

The Engineer shall determine the amount (if any) to be added to or deducted from the sum named in the Tender in respect of any extra or additional work done or work omitted by his order. All such work shall be valued at the rates set out in the Contract if in the opinion of the Engineer the same shall be applicable. If the Contract shall not contain any rates applicable to the extra or additional work then reasonable prices shall be fixed by the Engineer.

This clause gives the engineer power to decide the addition or deduction to be made to the Tender Sum to cover any variations, based on contract rates or, where there are no such rates applicable, at reasonable prices fixed by the engineer. Thus the engineer is given far-reaching powers with regard to the valuation of variations but he should, of course, adopt a reasonable approach throughout.

CLAUSES IN GENERAL CONDITIONS OF CONTRACT

EXPLANATORY NOTES

52(2) *Power to Engineer to fix Rates*

Provided that if the nature or amount of any omission or addition relative to the nature or amount of the whole of the contract work or to any part thereof shall be such that in the opinion of the Engineer the rate or price contained in the Contract for any item of the Works is by reason of such omission or addition rendered unreasonable or inapplicable the Engineer shall fix such other rate or price as in the circumstances he shall think reasonable and proper.

Provided also that no increase of the Contract Price under sub-clause (1) of this Clause or variation of rate or price under sub-clause (2) of this Clause shall be made unless as soon after the date of the order as is practicable and in the case of extra or additional work before the commencement of the work or as soon thereafter as is practicable notice shall have been given in writing:

(a) by the Contractor to the Engineer of his intention to claim extra payment or a varied rate or

(b) by the Engineer to the Contractor of his intention to vary a rate or price as the case may be.

This clause empowers the engineer to vary a rate or price in the contract, if the nature or amount of the whole of this work in the contract renders the rate or price unreasonable or inapplicable. The contractor can also claim extra payments and request a variation of rates.

52(3) *Daywork*

The Engineer may if in his opinion it is necessary or desirable order in writing that any additional or substituted work shall be executed on a daywork basis. The Contractor shall then be paid for such work under the

The general effect of this clause is that the engineer may order any additional or substituted work to be done on a daywork basis. If there is no daywork schedule in the bill of conditions set out in the Daywork Schedule included in the Bill of Quantities and at the rates and prices affixed thereto by him in his Tender and failing the provision of a Daywork Schedule he shall be paid at the rates and prices and under the conditions contained in the 'Schedules of Dayworks carried out incidental to Contract Work' issued by the Federation of Civil Engineering Contractors current at the date of submission of the Contractor's Tender for the execution of the Works.

The Contractor shall furnish to the Engineer such receipts or other vouchers as may be necessary to prove the amounts paid and before ordering materials shall submit to the Engineer quotations for the same for his approval.

In respect of all work executed on a daywork basis the Contractor shall during the continuance of such work deliver each day to the Engineer's Representative an exact list in duplicate of the names occupation and time of all workmen employed on such work and a statement also in duplicate showing the description and quantity of all materials and plant used thereon or therefor (other than plant which is included in the percentage addition in accordance with the Schedule under which payment for daywork is made). One copy of each list and statement will if correct or when agreed be signed by the Engineer's Representative and returned to the Contractor.

At the end of each month the Contractor shall deliver to the Engineer's Representative a priced statement of the labour material and plant (except quantities, then the work shall be valued in accordance with the current 'Schedules of Dayworks carried out incidental to contract work' issued by the Federation of Civil Engineering Contractors (6).

The contractor shall obtain the engineer's approval to all quotations for materials before ordering them. He shall pass over daily to the engineer's representative details in duplicate of all labour, materials and plant used on the work. One copy of each sheet, when found correct, shall be signed by the engineer's representative and returned to the contractor. The engineer will authorise payment to the contractor on a monthly statement.

CAUSES IN GENERAL CONDITIONS OF CONTRACT

EXPLANATORY NOTES

52(3) *Daywork—continued*

as aforesaid) used and the Contractor shall not be entitled to any payment unless such lists and statements have been fully and punctually rendered. Provided always that if the Engineer shall consider that for any reason the sending of such list or statement by the Contractor in accordance with the foregoing provision was impracticable he shall nevertheless be entitled to authorise payment for such work either as daywork (on being satisfied as as to the time employed and plant and materials used on such work) or at such value therefor as he shall consider fair and reasonable.

52(4) *Claims*

The Contractor shall send to the Engineer once in every month an account giving full and detailed particulars of all claims for any additional expense to which the Contractor may consider himself entitled and of all extra or additional work ordered by the Engineer which he has executed during the preceding month and no claim for payment for any such work will be considered which has not been included in such particulars. Provided always that the Engineer shall be entitled to authorise payment to be made for any such work notwithstanding the Contractor's failure to comply with this condition if the Contractor has at the earliest practicable opportunity notified the Engineer that he intends to make a claim for such work.

It will be noted that the contractor is expected to submit every month claims for any work done additional to that specified in the contract.

MEASUREMENT

55 *Quantities*

The quantities set out in the Bill of Quantities are the estimated quantities of the work but they are not to be taken as the actual and correct quantities of the Works to be executed by the Contractor in fulfilment of his obligations under the Contract.

It is desirable that the quantities given should represent as accurately as possible, the amount of work to be executed in a particular contract, in order that the contractor shall have the clearest possible picture of the nature and extent of the works to be undertaken, and the contract price will, as far as possible, accurately represent the probable cost of the job.

56 *Works to be Measured*

The Engineer shall except as otherwise stated ascertain and determine by admeasurement the value in accordance with the Contract of work done in accordance with the Contract. He shall when he requires any part or parts of the Works to be measured give notice to the Contractor who shall forthwith attend or send a qualified agent to assist the Engineer or the Engineer's Representative in making such measurement and shall furnish all particulars required by either of them. Should the contractor not attend or neglect or omit to send such agent then the measurement made by the Engineer or approved by him shall be taken to be the correct measurement of the work.

The effect of this clause is that the engineer is generally required to measure and value the work done by the contractor. Before doing this, the engineer should notify the contractor so that the latter may send a representative to assist the engineer. Then measurements made by the engineer, even if he is on his own, are taken as the correct measurements of the work.

57 *Method of Measurement*

Except where any general or detailed description of the work in the Bill of Quantities expressly shows to the contrary Bills of Quantities shall be deemed to have been prepared and

The Standard Method of Measurement of Civil Engineering Quantities is to be the basis for measurements under the contract, unless there is an

CLAUSES IN GENERAL CONDITIONS OF CONTRACT

57 *Method of Measurement—continued*

measurements shall be made according to the procedure set forth in the Standard Method of Measurement of Civil Engineering Quantities issued by the Institution of Civil Engineers (1953) and any subsequent amendment or modification thereof notwithstanding any general or local custom.

PROVISIONAL AND PRIME COST SUMS

58(1) *Provisional Sums*

Every provisional sum (other than P.C. prices under sub-clause (2) of this Clause) set out in the Bill of Quantities (whether for work to be executed by the Contractor which has not been specified in detail when the Contract is entered into or for work to be executed by a nominated Sub-Contractor as hereinafter defined) together with the charges and profits (if any) which the Contractor shall have added to such sums shall be deducted from the Contract Price and in lieu thereof there shall be added to the Contract price:

(a) where work to which the provisional sum relates has been ordered by the Engineer and executed by the Contractor the value of the work so executed valued in accordance with Clause 52 hereof and
(b) where work to which the provisional sum relates has been ordered by the Engineer and executed by a nominated Sub-Contractor (as here-

EXPLANATORY NOTES

express provision to the contrary in the bill of quantities.

The effect of this clause is that when valuing work executed under the contract, the engineer shall deduct provisional sums allowed for this work and add in lieu:

(a) The actual cost of the work done priced as 'daywork'.
(b) The cost to the contractor of work done for him by a subcontractor.

inafter defined) the sum or sums actually paid by the Contractor to such Sub-Contractor on the direction of the Engineer and (if the Contractor shall have added to the provisional sum to which the work relates any sums in respect of charges and profits) a sum in the same proportion to the sum so actually paid as the said charges and profits bear to the said provisional sum.

58(2) *Prime Cost Items*

Every sum in the Bill of Quantities which contains (either as the whole or part of the sum) a prime cost (P.C.) price for goods or materials to be supplied for or for incorporation into the Works shall be varied by the substitution for the prime cost price of the actual price paid by the Contractor for the goods or materials on the direction of the Engineer and the Contract Price shall be increased or decreased (as the case may be) by the amount by which the sum in the Bill of Quantities is increased or decreased by such substitution. No variation shall be made to or in respect of any sum added for labours to the prime cost price on account of the said actual price being greater or less than the prime cost price but in respect of all other charges and profit there shall be added or deducted as the case may be a sum representing such percentage as is provided in the Bill of Quantities in relation to the particular item of prime cost concerned or (if none) as is inserted by the Contractor in the form of Tender as the percentage for the adjustment of prime cost sums.

The prime cost item for goods or materials incorporated in the bill of quantities is deducted, and the sums actually paid by the contractor, on the direction of the engineer, are added back plus the percentage quoted for charges and profit.

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58(3) *Use of Provisional and Contingency Items*

All sums set out in the Bill of Quantities which shall be stated to be provisional or for contingencies shall be used only at the direction and discretion of the Engineer and if not used either wholly or in part shall as to the amount not used be deducted from the Contract Price.

It will be noted that these sums are to be expended only at the direction and discretion of the engineer.

58(4) *Production of Vouchers, etc.*

The Contractor shall when required by the Engineer produce all quotations invoices vouchers and accounts or receipts in connection with expenditure in respect of provisional or prime cost items.

58(5) *Cash Discount*

In so far as any sum is paid by the Contractor to a Sub-Contractor or supplier by direction of the Engineer under sub-clause (1)(b) or (2) of this Clause before the Contractor shall have received payment of that sum from the Employer the Contractor shall be entitled to receive from the Sub-Contractor or supplier a cash discount on the sum so paid not exceeding $2\frac{1}{2}$ per cent. which shall not be deducted in determining the sums actually paid by the Contractor under the said sub-clauses.

This clause means that the contractor only retains the discount for cash which a sub-contractor allows, if on the order of the engineer, he has to pay the sub-contractor before he himself is paid. The discount is normally passed on to the employer.

58(6) *Assignment of Sub-Contractor's Obligations*

In the event of a nominated Sub-Contractor (as hereinafter defined) having undertaken towards the Con-

This clause covers the transfer from the contractor to the employer of any obligations of a tractor in respect of the work executed or the goods or materials supplied by such nominated Sub-Contractor any continuing obligation extending for a period exceeding that of the Period of Maintenance under this Contract the Contractor shall at any time after the expiration of the Period of Maintenance assign to the Employer at the Employer's request and cost the benefit of such obligation for the unexpired duration thereof.

sub-contractor which continue beyond the maintenance period for the contract.

59(1) *Nominated Sub-Contractors*

All specialists merchants tradesmen and others executing any work or supplying any goods for which provisional or prime cost sums are included in the Bill of Quantities who may have been or be nominated or selected or approved by the Employer or the Engineer and all persons to whom by virtue of the provisions of the Bill of Quantities or Specification the Contractor is required to sub-let any work shall in the execution of such work or the supply of such goods be deemed to be Sub-Contractors employed by the Contractor and are herein referred to as 'nominated Sub-Contractors'. Provided always that the Contractor shall not be required by the Employer or the Engineer or be deemed to be under any obligation to employ any nominated Sub-Contractor who shall decline to quote to the Contractor subject to discount for cash within such number of days as the nominated Sub-Contractor shall stipulate, or to enter into a sub-contract with the Contractor containing provisions:

This clause deals with the subcontract into which a nominated sub-contractor should enter with the contractor, whereby the subcontractor indemnifies the contractor against the same liabilities and obligations, as the contractor undertakes towards the employer under the main contract. In addition the subcontractor also indemnifies the contractor against any negligence of the sub-contractor's employees or misuse of constructional plant or temporary works.

It will be noted that a nominated sub-contractor may be a specialist, merchant, tradesman or other person executing work or supplying goods, who has been duly nominated.

A person nominated for the supply of goods under a building contract is termed a 'nominated supplier', and is covered by different provisions in the contract conditions from a nominated sub-contractor.

CLAUSES IN GENERAL CONDITIONS OF CONTRACT

59(1) *Nominated Sub-Contractors—continued*

(a) That in respect of the work or goods the subject of the sub-contract the Sub-Contractor will undertake towards the Contractor the like obligations and liabilities as are imposed upon the Contractor towards the Employer by the terms of the Contract and will save harmless and indemnify the Contractor from and against the same and from all claims demands proceedings damages costs charges and expenses whatsoever arising out of or in connection therewith or arising out of or in connection with any failure to perform such obligations or to fulfil such liabilities and

(b) That the Sub-Contractor will save harmless and indemnify the Contractor from and against any negligence by the Sub-Contractor his agents workmen and servants and from and against any misuse by him or them of any Constructional Plant or Temporary Works provided by the Contractor for the purposes of the Contract and from all claims as aforesaid.

59(2) *Payments to Nominated Sub-Contractors*

Before issuing under Clause 60 hereof any certificate which includes any payment in respect of work done or goods supplied by any nominated Sub-Contractor the Engineer shall be entitled to demand from the Contractor reasonable proof that all payments (less retentions) included in previous certificates in respect of the work or goods of such nominated Sub-

EXPLANATORY NOTES

Under this clause, when the engineer is certifying payment for work executed under the contract, which includes nominated sub-contractors' services, and he finds that the sub-contractor has not received sums due to him from the contractor and covered by previous certificates, the employer

Contractor have been paid or discharged by the Contractor in default whereof unless the Contractor shall

(a) inform the Engineer in writing that he has reasonable cause for withholding or refusing to make such payment and (b) produce to the Engineer reasonable proof that he has so informed such nominated Sub-Contractor in writing,

the Employer shall be entitled to pay to such nominated Sub-Contractor direct upon the certificate of the Engineer all payments (less retentions) which the Contractor has failed to make to such nominated Sub-Contractor and to deduct by way of set-off the amount so paid by the Employer from any sums due or which become due from the Employer to the Contractor.

Provided always that where the Engineer has certified and the Employer has paid direct as aforesaid the Engineer shall in issuing any further certificate in favour of the Contractor deduct from the amount thereof the amount so paid direct as aforesaid but shall not withhold or delay the issue of the certificate itself when due to be issued under the terms of the Contract.

may pay the sub-contractor direct and deduct this sum from the payment due to the contractor.

The employer shall not, however, take this action if the contractor informs the engineer that he has reasonable cause for withholding or refusing payment and that he has so informed the nominated sub-contractor in writing.

CERTIFICATES AND PAYMENT

60(1) *Monthly Payments*

The Contractor shall submit to the Engineer after the end of each month a statement showing the estimated contract value of the permanent work executed up to the end of the month (if such value shall justify the issue of an interim certificate) and the

The contractor is to submit a statement to the engineer after the end of each month, showing the estimated value of the work executed and, if the sum due is sufficient, the engineer will issue a certificate covering the

CLAUSES IN GENERAL CONDITIONS OF CONTRACT

60(1) *Monthly Payments—continued*

Contractor will be paid monthly on the certificate of the Engineer the amount due to him on account of the estimated contract value of the permanent work executed up to the end of the previous month together with such amount (if any) as the Engineer may consider proper on account of materials for permanent work delivered by the Contractor on the Site and in addition such amount as the Engineer may consider fair and reasonable for any Temporary Works or Constructional Plant for which separate amounts are provided in the Bill of Quantities subject to a retention of the percentage named in the Tender until the amount retained shall reach the 'Limit of Retention Money' named in the Tender (hereinafter called 'the retention money'). Provided always that no interim certificate shall be issued for a less sum than that named in the Tender at one time.

60(2) *Payment of Retention Money*

One half of the retention money shall become due and shall be paid to the Contractor when the Engineer shall certify in writing that the Works have been substantially completed and the other half shall be paid to the Contractor fourteen days after the expiration of the Period of Maintenance notwithstanding that at such time there may be outstanding claims by the Contractor against the Employer. Provided always that if at such time there shall remain to be executed by the Con-

EXPLANATORY NOTES

work executed, materials on site and also temporary works and constructional plant, where covered by separate amounts in the bill of quantities. The contractor will receive payment based on this statement less an agreed percentage retained temporarily by the employer and known as 'retention money'.

It will be noted that there is a minimum value for interim certificates and this does not apply on building contracts.

Under this clause one half of the retention money shall be paid to the contractor when the engineer certifies that the works have been substantially completed, and the other half shall be paid 14 days after the expiration of the maintenance period, less the cost of any outstanding work.

tractor any works ordered during such period pursuant to Clauses 49 and 50 hereof the Employer shall be entitled to withhold payment until the completion of such works of so much of the second half of the retention money as shall in the opinion of the Engineer represent the cost of the works so remaining to be executed.

Provided further that in the event of different maintenance periods having become applicable to different parts of the works pursuant to Clause 48 hereof the expression 'expiration of the Period of Maintenance' shall for the purposes of this sub-clause be deemed to mean the expiration of the latest of such periods.

60(3) *Time of Payment*

Payment upon each of the Engineer's certificates shall be made by the Employer within the number of days named in the Tender after such certificate has been delivered to the Employer and in the event of failure by the Employer to comply with the provisions of this sub-clause or to pay the retention money or any part thereof at the times prescribed by sub-clause (2) of this Clause he shall pay to the Contractor interest at the rate of 5 per cent. per annum upon all over-due payments from the date on which the same should have been made.

It will be seen that the employer is required to pay on the engineer's certificate within the period stated in the tender, and the contractor is entitled to interest at the rate of 5 per cent. per annum on all over-due payments.

60(4) *Correction and Withholding of Certificates*

The Engineer may by any certificate make any correction or modification in any previous certificate which shall have been issued by him and shall have power to withhold any certificate if the Works or any part thereof are not being carried out to his satisfaction.

CLAUSES IN GENERAL CONDITIONS OF CONTRACT

EXPLANATORY NOTES

61 *Approval only by Maintenance Certificate*

No certificate other than the Maintenance Certificate referred to in Clause 62 hereof shall be deemed to constitute approval of any work or other matter in respect of which it is issued or shall be taken as an admission of the due performance of the Contract or any part thereof or of the accuracy of any claim or demand made by the Contractor or of additional or varied work having been ordered by the Engineer nor shall any other certificate conclude or prejudice any of the powers of the Engineer.

By virtue of this clause, the maintenance certificate alone indicates approval of the work executed, etc.

62(1) *Maintenance Certificate*

The Contract shall not be considered as completed until a Maintenance Certificate shall have been signed by the Engineer and delivered to the Employer stating that the Works have been completed and maintained to his satisfaction. The Maintenance Certificate shall be given by the Engineer fourteen days after the expiration of the Period of Maintenance or as soon thereafter as any works ordered during such period pursuant to Clauses 49 and 50 hereof shall have been completed to the satisfaction of the Engineer and full effect shall be given to this Clause notwithstanding any previous entry on the Works or the taking possession working or using thereof or any part thereof by the Employer. Provided always that the issue of the Maintenance Certificate shall not be a condition precedent to

Under this clause, the contract cannot be considered complete until a maintenance certificate is issued by the engineer, 14 days after the expiration of the maintenance period or the completion of maintenance work.

payment to the Contractor of the second half of the retention money in accordance with Clause 60 hereof.

62(2) *Cessation of Employer's Liability*

The Employer shall not be liable to the Contractor for any matter or thing arising out of or in connection with the Contract or the execution of the Works unless the Contractor shall have made a claim in writing in respect thereof before the giving of the Maintenance Certificate under this Clause.

62(3) *Unfulfilled Obligations*

Notwithstanding the issue of the Maintenance Certificate the Contractor and (subject to sub-clause (2) of this Clause) the Employer shall remain liable for the fulfilment of any obligation incurred under the provisions of the Contract prior to the issue of the Maintenance Certificate which remains unperformed at the time such certificate is issued and for the purposes of determining the nature and extent of of any such obligation the Contract shall be deemed to remain in force between the parties hereto.

A variation of price (labour and materials) clause may or may not be incorporated in the contract. Where the contract is to be commenced within a relatively short time and the contract is not unduly long, nor likely to be varied to any great extent, this clause will probably be omitted.

CONTRACT DOCUMENTS (continued)

(c) *Specification*

The specification amplifies the information given in the contract drawings and the bill of quantities. It describes in detail the work to be executed under the contract and the nature and quality of the materials and workmanship. It gives details of any special responsibilities to be borne by the contractor, apart from those covered by the general conditions of contract. It may also contain clauses specifying the order in which the various sections of the work are to be carried out, the methods to be adopted in the execution of the work, and details of any special facilities that are to be afforded to other contractors.

The report on *Civil Engineering Procedure* (7) issued by the Institution of Civil Engineers recommends that the specification should also require tenderers to submit an outline programme and a description of proposed methods and temporary works with their tenders.

The specification will always constitute a contract document in civil engineering contracts, whilst in the case of building contracts, under the R.I.B.A. form of contract, it will only be a contract document, if there is no bill of quantities or when it is specifically made a contract document in the particular contract.

A sub-committee of the Institution of Civil Engineers in a report entitled *The Contract System in Civil Engineering*, issued in 1946, drew attention to the desirability of standardising specifications, particularly with regard to materials, where there had been wide variations in the descriptions used. The use of British Standards helps considerably in this respect, ensures the use of good quality materials, complying with the latest requirements prepared by expert technical committees representing the user, producer, research and other interests. Their use also simplifies the work of the engineer, as in most cases he no longer needs to draft clauses specifying in detail the materials to be used.

It is, however, most important that any references to British Standards should include the appropriate class or type of material required, where a number of classes or types are given in the British Standard, e.g. Clauses sometimes appear in specifications relating to 'first quality' and 'second quality' glazed-ware pipes complying with B.S.65, whereas the only classes of pipe recognised by that standard are 'British Standard', 'British Standard Tested' and 'British Standard Extra'.

An excellent arrangement for a specification covering civil engineering works is to commence with any special conditions relating to the contract and the extent of the contract. Then to follow with a list of contract drawings, details of the programme, description of access to the site, supply of electricity and water, offices and mess facilities, and statements regarding suspension of work during frost and bad weather, damage to existing services, details of borings, water levels and similar clauses.

This section could conveniently be followed by detailed clauses covering the various sections of the work, commencing with materials in each case and then proceeding with workmanship and other clauses.

There is a considerable difference in the method of preparing specifications and bills of quantities for civil engineering work as compared with building work.

The civil engineering practice is to use brief descriptions in the items in the bill of quantities and to give more comprehensive and detailed information concerning the materials and workmanship, etc., in the specification, which is also a contract document. With building contracts the billed item descriptions are more lengthy and preamble clauses at the head of each trade bill frequently take the place of the specification, which would not in any case be a contract document, where quantities form part of the contract.

The Contractor tendering for a civil engineering project must therefore refer in many instances to the specification for the details he needs on which to build up his contract rates, whilst on a building contract, much or all of the information will be contained in the one document, i.e. the bill of quantities. Once the contract is underway, the civil engineering method has much in its favour with a good comprehensive specification as a separate and strictly enforceable document.

(d) *Bill of Quantities*

The bill of quantities consists of a schedule of the items of work to be carried out under the contract with quantities entered against each item, the quantities being prepared in accordance with the *Standard Method of Measurement of Civil Engineering Quantities*. Due to the small scale of many of the drawings, the large extent of the works and the uncertainties resulting from difficult site conditions, the quantities inserted in the bill are often approximate. Nevertheless, the quantities should be as accurate as the information available allows and the descriptions accompanying each item must indicate clearly the nature and scope of the work involved.

The unit rates entered by the contractor against each item in the bill of quantities, normally includes all overhead charges and profit, so that the total of the prices for the various items gives the contract price.The contract usually makes provision for the quantities to be varied, and it is therefore highly desirable that separate items should be incorporated against which the contractor may enter the cost of meeting various contingent liabilities under the contract, such as special temporary works, and this aspect will be dealt with in more detail in the next chapter. The distribution of these liabilities over the measured items in the bill of quantities may make for difficulties in the event of any variations arising to the contract.

Provision is often made for the execution of certain work at daywork rates in a civil engineering bill of quantities.

One of the primary functions of a civil engineering bill of quantities is to provide a basis on which tenders can be obtained, and, when these are priced, they afford a means of comparing the various tenders received. After the contract has been signed, the rates in the priced bill of quantities can be used to assess the value of the work as executed.

(e) *Contract Drawings*

The contract drawings depict the details and scope of the works to be executed under the contract. They must be prepared in sufficient detail to enable the contractor to satisfactorily price the bill of quantities.

All available information as to the topography of the site and the nature of the ground should be made accessible to all contractors tendering for the job. The contract drawings will be subsequently used when executing the works and may well be supplemented by further detailed drawings as the work proceeds.

Existing and proposed work should be clearly distinguished on the drawings and full descriptions and explanatory notes should be entered on them. The more explicit the drawings, the less likelihood will there be of disputes subsequently arising concerning the character or extent of the works.

(f) *Form of Tender*

The 'Form of Tender' constitutes a formal offer to execute the contract works in accordance with the various contract documents for the contract price or tender sum. It usually incorporates the contract period within which the contractor is to complete the works.

The form of tender now largely used for civil engineering contracts is the form incorporated in the General Conditions of Contract for use in connection with works of civil engineering construction (2). This form of tender provides for a 'bond' amounting to 10 per cent. of the tender sum. The contractor is generally required to enter into a bond, whereby he provides two sureties or a bank or insurance company who are prepared to pay up to 10 per cent. of the contract sum if the contract is not carried out satisfactorily.

The appendix to this form of tender covers the amount of the bond, minimum amount of third party insurance, time for completion, amount of liquidated damages, period of maintenance, percentage for adjustment of prime cost sums, percentage of retention, limit of retention money, minimum amount of interim certificates and the time within which payment is to be made after a certificate is issued.

INVITATION TO TENDER

The inviting of tenders for civil engineering works is usually performed by one of three methods, viz.:

(1) By advertising for competitive tenders.
(2) By inviting tenders from selected contractors.
(3) By negotiating a contract with a selected contractor.

Advertisement for competitive tenders offers the most satisfactory method in many instances, as it ensures maximum competition. There is, however, the grave disadvantage that tenders may be received from firms who have neither the necessary financial resources nor adequate technical knowledge and experience of the class of work involved. Public authorities are often required to invite tenders in this way.

The invitation of tenders from a selected list of contractors is most desirable when the works involved are of great magnitude or are highly complex in character, such as the construction of large power stations and harbour works.

Negotiation of a tender with a selected contractor is only advisable in special circumstances, as for instance when the contractor is already engaged on the same site, where space is very restricted, and is executing another contract there. This procedure might also be usefully adopted when it is required to make an early start with the work or where the contractor in question has exceptional experience of the type of work covered by the particular contract.

Every case should be considered on its merits when deciding the method to be employed for the invitation of tenders.

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III – General Arrangement and Contents of Civil Engineering Bills of Quantities

THE *Standard Method of Measurement of Civil Engineering Quantities* defines a 'bill of quantities' as a list of items giving the quantities and brief descriptions of work comprised in an engineering contract.

The use of the word 'brief' in this description is rather significant and clearly indicates that lengthy descriptions of the labour and material requirements of items of work are to be avoided. Full descriptions will be incorporated in the specification and it is unnecessary to repeat them in the bill of quantities. The descriptions should accordingly be as brief and concise as possible, consistent with adequately describing the particular item of work and leaving the estimator in no doubt as to the nature and extent of the item in the bill which he is pricing.

The main function of all the items in the bill of quantities is to enable prices to be inserted against them, which, when totalled together, will give the contract price or tender sum for the contract complete. Where descriptions of billed items are vague or ambiguous in their wording, then the method of preparing the bill of quantities leaves room for improvement. The following examples illustrate inadequate or ambiguous descriptions relating to billed items in the reinforced concrete section of a bill of quantities:

DESCRIPTION OF BILLED ITEM	GENERAL REMARKS
(a) Concrete in carpet, 100 mm thick.	The class of concrete should be indicated in the item or a sub-heading in the bill, and some indication of the position of the carpet would be helpful to the estimator.
(b) Vertical shuttering to external face of wall, including all materials and labour in erecting shuttering and moulds, for all necessary strutting, supports, props, cleats and bearings, and for easing, striking and clearing away on completion.	The description of this item should state whether the shuttering is 'wrought' or 'sawn', as this has an important bearing on the price. The inclusion of the words 'including all materials and labour', etc., is quite superfluous and should all be covered in a preamble clause at the head of this section of the work, and not be included in the description of each appropriate billed item.

DESCRIPTION OF BILLED ITEM	GENERAL REMARKS
(c) *Extra only* over the last mentioned item for the use by the contractor of metal faced shuttering in lieu of ordinary wrot shuttering as approved by the Engineer.	This description is unnecessarily lengthy and very ambiguously worded. A better description is given below. '*Extra only* over last for use of approved metal faced shuttering in lieu of wrot shuttering.'
(d) 16 mm diameter mild steel rods, including all labour in bending and placing in the correct positions as shown on the working drawings, and all necessary tying wire.	This description can be limited to '16 mm diameter mild steel rods', with the remainder of the description incorporated in a suitable preamble clause at the head of this section of the work. The detailed requirements relating to the mild steel rods, such as the appropriate British Standard reference, freedom from scale and excessive rust, etc., would also be included in the preamble.
(e) 12 mm diameter mild steel rods, including ditto, and ditto, and ditto.	One use of the word 'ditto' would be sufficient to cover the whole of the previous description from 'including all labour to . . . necessary tying wire'. Although as indicated in the case of item (d) the description of the item can be confined to the diameter and material of the rods, with the remainder of the description included in a preamble clause.

Thus the bill of quantities should clearly and concisely set out the quantities of work and material required for carrying out the contract works, but care must be taken to avoid repeating descriptive material contained in any of the other contract documents. The basic principle, laid down in the *Standard Method of Measurement of Civil Engineering Quantities*, is that a bill of quantities should be as simple as possible provided that it covers adequately the work to be done.

Although descriptions of items contained in a civil engineering bill of quantities are to be as brief as possible, nevertheless, they must be in sufficient detail to clearly identify the work to be undertaken, in accordance with the details given on the contract drawings and in the specification. In some instances, the best procedure will undoubtedly be to include in the items contained in the bill of quantities, a reference to the appropriate clauses of the specification.

Unless the bill of quantities contains special directions to the contrary, in a preamble or in the descriptions of billed items, all quantities are deemed to be based on net measurements with no allowance made for waste. For instance, taking the fabric reinforcement in a concrete road slab, no additional measurements will be taken in determining the area of fabric reinforcement, to make allowance for the laps at joints in the reinforcement or any waste that may occur on cutting the sheets of reinforcement at the edges of the road slabs. The estimator will, accordingly, have to make allowance for this waste when assessing the price for this item in the bill of quantities.

In this connection, the contractor's engineer may deem it necessary to consider which arrangement of fabric reinforcement should be used in order to reduce the amount of cutting to a minimum. The same principle will apply to the design of shuttering used to support concrete. Blind pricing by a contractor without regard to such matters, may well lose him the contract, whilst if it becomes the general practice, then stagnation in design may well result.

Billed Rates

Furthermore, the rates and prices inserted in the bill of quantities are to be the full inclusive rates and prices for the finished work described under the respective items, covering all labour, materials, temporary work, plant, overhead charges and profit, as well as the general liabilities, obligations and risks resulting from the operation of the conditions of contract. Thus, no mention need be made of any of these items in the billed descriptions, as they are all deemed to be included in the appropriate rates and prices inserted by the contractor, unless there are specific directions to the contrary contained in the bill of quantities. All billed rates are, in consequence, comprehensive rates and this greatly assists in the valuation of variations.

Where special liabilities and obligations are to be borne by the contractor, opportunity is usually afforded to the contractor to insert suitable sums in the bill of quantities, where reference should be made to the appropriate clauses in the specification and conditions of contract dealing with these liabilities and obligations. An alternative method is to include a clause in the preamble to the bill of quantities emphasizing that the billed rates are to cover these special liabilities and obligations.

The task of a contractor pricing a civil engineering bill of quantities is, in consequence, much more difficult than that of the contractor tendering for building works, with his prices including for incidental labour items, temporary work, etc. He must satisfy himself that all the work involved in a given billed item has been adequately covered in his price.

Furthermore, he must have decided the method of performing the work in detail before he builds up his price.

General Arrangement of Items in Bills of Quantities

A bill of quantities relating to works of civil engineering construction should be split into sections, according to the location of the individual parts of the works in the general scheme or the nature of the works to be executed. This grouping of billed items into specific sections provides a ready means of reference and greatly assists all persons using the bill in locating any particular item.

For instance, a bill of quantities covering advance preparation work on a large housing site, might conveniently be separated into the following sections, the precise sections depending on the nature of the work involved.

(1) Site preliminaries. (2) Site clearance and earthworks for roads. (3) Excavation for sewers, manholes, etc. (4) Sewer pipes and tubes. (5) Manholes. (6) Gullies. (7) Carriageway and kerbs. (8) Water mains. (9) Sundry and Provisional items.

Similarly, a bill of quantities covering a riverworks contract associated with the construction of a large power station, might be split into the following sections.

(1) Preliminary items. (2) Demolition work and siteworks. (3) Access roads. (4) Pipework. (5) Dredging. (6) Pump chambers. (7) Circulating water ducts. (8) Wharf wall. (9) Jetty. (10) Daywork.

The headings and scope of the various sections will be determined largely by the type, character and extent of the works.

In the case of a large structural steelwork contract the sections would probably relate to the various buildings, bays, and other areas where steelwork is to be erected, i.e. be classified by location, rather than by the nature of the works. Similarly in the case of a large sewage disposal works contract, the sections would probably relate to the various component parts of the scheme such as outfall sewer, detritus chamber, pumping station, settling tanks, stormwater tanks, percolating filters, sludge digestion tanks, humus tanks, sludge drying beds, effluent pipe, access roads and ancillary works.

In each section the various billed items should be further subdivided into sub-sections covering the various classes of work. A useful guide in the choice of suitable sub-sections, where the work involved is fairly extensive, is found in *part IV* of the *Standard Method of Measurement of Civil Engineering Quantities*, which deals with the units and methods of measurement of civil engineering work. For example, in reinforced concrete work the majority of the billed items would probably be grouped under three main sub-sections; namely, concrete, shuttering and reinforcement.

It is pointed out in the *Standard Method of Measurement of Civil Engineering Quantities (part II)*, that different parts of civil engineering work may involve the use of the same permanent materials, but entail widely differing costs of construction. 'Permanent' materials relate to items used in the construction work, such as concrete, brickwork, pipework, etc., and which will not be removed at the end of the contract. In these circumstances it is advisable to give the contractor the opportunity of entering different rates for work of the same nature but carried out under different conditions.

For instance, reinforced concrete of the same mix to be laid in the base of a pump sump, in a floor slab at ground level, or in the tank base to a water tower, are all similar forms of construction but carried out under entirely different conditions, resulting in considerably different costs, and must accordingly be entered as separate items in the bill of quantities. Similarly a one-brick wall in a manhole below ground, in a pumphouse above ground level or in the upper section of a tall brick chimney, all entail widely different costs of construction, and it is essential that each item should be separately billed in order that the contractor may insert different prices against each section of brickwork.

Care must be taken to ensure that this subdivision into items does not reach unnecessarily high proportions yet, at the same time, is sufficient to differentiate between the various classes of work involved.

Provisional Quantities and Sums

Provisional quantities of work are often incorporated in a civil engineering bill of quantities, to cover work which is quite separate and distinct from the definite quantities of work listed in the bill of quantities and based entirely on the works detailed on the contract drawings. For instance, provisional quantities of excavation and concrete may be included, to cover the extra depth of foundations or making good 'soft spots' which are encountered in a road formation. These additional items, or variations to the original quantities, could not have been foreseen when the bill of quantities was being prepared, and so the only solution available is to make an estimate of the possible extent of these additional works and to enter them in the bill of quantities as provisional.

In addition, general provisional sums are also frequently included in bills of quantities to cover contingencies and additional works generally which may arise during the construction of the works due to site conditions or changes in design. Provisional sums of this type are expended at the direction of the engineer, with the work measured, as executed, and valued at the rates contained in the priced bill of quantities. Where these rates are not applicable, then the work will be valued in accordance with the method laid down in the conditions of contract, such as by reference to the current schedules of dayworks carried out incidental to contract work, issued by the Federation of Civil Engineering Contractors, or a daywork schedule incorporated in the bill of quantities.

A general provisional sum or contingencies item in a bill of quantities, might read as follows:

'Include the general provisional sum of £*1500* (One thousand five hundred pounds), to be dealt with in accordance with clause 58(3) of the General Conditions of Contract.'

Further provisional sums may be included to cover certain specific work, such as supplying progress photographs, but the same principles apply.

Prime Cost Items

The term 'prime cost' is defined in the *Standard Method of Measurement of Civil Engineering Quantities* as 'the net sum entered in the bill of quantities by the engineer as the sum provided to cover the cost of, or to be paid by the contractor to merchants or others for, specific articles of materials to be supplied or work to be done, after deducting all trade discounts and any discount for cash in excess of $2\frac{1}{2}$ per cent., or such other amount as may be given in the conditions of contract'. Hence the 'prime cost' sum includes a cash discount of $2\frac{1}{2}$ per cent. which may or may not be payable to the contractor. (See *General Conditions of Contract* clause 58(5).)

The term 'prime cost' is often abbreviated to 'P.C.' in the bill of quantities. From this definition it would appear that the term 'prime cost' applies to both materials supplied and work executed, and it also applies whether the cost is to be met direct by the employer or the contractor. This is at variance with the *General Conditions of Contract*, clause 58, whereby the term 'prime cost' only covers goods or materials supplied (sub-clause 2), and work carried out by a nominated sub-contractor, or the main contractor under certain conditions, is covered by a 'provisional sum'.

When prime cost items are included in civil engineering bills of quantities for materials, the contractor is to be given the opportunity to insert separate prices for the following items, associated with the prime cost item:

(a) Profit on the prime cost sum applied in the form of a percentage.
(b) Packing, carriage and delivery of the materials to the site (where these services are not included in the prime cost sum), unloading, unpacking, fixing, returning empties and other incidental expenses and charges, applied in the form of a fixed sum.

The *Standard Method of Measurement of Civil Engineering Quantities* advocates the use of a subsidiary bill with three items in the description column, covering the prime cost, percentage profit and fixed charge. The total cost of these three items is then carried to the rate column or pricing column.

Two examples of typical prime cost items relating to fittings or components in a civil engineering contract follow. The descriptions of these items are kept as brief as possible, largely limiting the information given to that needed to identify the materials and components. The contractor is referred to the specification for more detailed information.

Item No.	*Description*		*Qty.*	*Unit*	*Rate*	£
450	*Access Covers*	£				
	(a) Provide the P.C. sum of £*180*. (One hundred and eighty pounds) for 10 No. steel medium weight recessed covers and frames, size 1350 × 600 mm, with one set of jack screw operating keys, delivered to the site.	180·00				
	(b) *Add* for profit per cent. on £180.					
	(c) *Take delivery and fix only* 10 No. steel multiple access covers and frames, size 1350 × 600 mm including bedding frame and filling recessed cover and hollow frame with concrete as specified. *Take delivery* of one set of operating keys.					
	Note: Total of sums for items (a), (b) and (c) carried to rate column.					

Item No.	Description		Qty.	Unit	Rate	£
451	*Screens to Water Intake*	£				
	(a) Provide the P.C. sum of £8000 (Eight thousand pounds) for coarse bar screens and frames to water intake, delivered to the site.	8000·00				
	(b) *Add* for profit per cent. on £8000.					
	(c) Allow for taking delivery of the bar screens and frames, transporting on site and fixing in water intake, including the services of a diver and all necessary equipment.					

Where work is to be carried out by specialist firms as sub-contractors, a prime cost item will be included in the bill of quantities and the contractor must be given the opportunity of pricing any attendance or other services which he will be required to provide, in addition to the provision of the prime cost sum and the contractor's profit thereon. The following example represents the type of entry that could appear in the bill of quantities, using once again the subsidiary bill in the description column.

Item No.	Description		Qty.	Unit	Rate	£
452	*Handrailing to Concrete Staircases and Landings to Pump Chambers*	£				
	(a) Provide the P.C. sum of *£450* (Four hundred and fifty					

	pounds) for tubular handrailing to 3 No. reinforced concrete staircases.	450·00				
	(b) *Add* for profit, per cent. on £450.					
	(c) Allow for all necessary attendance upon the sub-contractor, including hoisting and slinging the materials to the required levels and providing all other facilities for the specialist's operatives fixing the following (mortices and other associated contractor's work measured elsewhere):					
	320 lin m: 32 mm bore bent and wreathed wrot iron tubing.					
	120 No. : Forged steel double ball pattern standards, 825 mm high.					

Schedules of Basic Prices

Where the 'Variation of Prices (Labour and Materials) Clause' is incorporated in a civil engineering contract, the contractor is permitted to claim any increased costs of labour, materials and consumable stores which occur after the date of the tender, in respect of materials subsequently used on the works covered by the contract. Many civil engineering contracts, particularly the larger ones with long contract periods, incorporate the price variation clause.

Where the price variation clause operates it is usual to include a schedule of basic rates at the end of the bill of quantities, wherein the contractor may enter the basic prices of materials and usually labour also, upon which his tender has been computed. The normal practice is for the main items of materials, consumable stores, fuel or power to be listed in the schedule of basic rates, when the bill of quantities is being prepared. The contractor will, in addition, be permitted to enter any other materials in respect of which he may subsequently wish the price variation clause to operate. It is often stated that all prices entered in the schedule are to exclude all discounts.

The basic prices which the contractor inserts in the schedule must relate to materials which comply in all respects with the specification, as the only adjustments that will be permitted are variations in the price of such materials which occurred subsequent to the date of the tender. The amount by which the cost of satisfactory materials exceeds that of alternative materials which may have been submitted for approval, but whose use on the job has not been permitted, cannot rank for consideration under the price variation clause.

A typical schedule of basic rates covering a road and siteworks contract follows:

SCHEDULE OF BASIC RATES OF LABOUR AND PRICES OF MATERIALS ON WHICH THE TENDER IS BASED

Item	*Unit*	*Price*
Labour		£
Craftsman	hour	
Labourer	hour	
Materials (delivered to site, exclusive of all discounts)		
Cement	Mg	
Sand	cu m	
Aggregate	cu m	
Reinforcing rods: 25 mm dia and over	Mg	
Ditto 20 mm dia—plus rate	Mg	
Ditto 16 mm dia— ditto	Mg	
Ditto 12 mm dia— ditto	Mg	
Ditto 6 mm dia— ditto	Mg	
Timber for shuttering	cu m	
125 × 250 mm precast concrete kerbs (straight)	lin m	
Ditto (curved on plan)	lin m	
Precast concrete paving slabs, 50 mm thick	sq m	
Ashes for sub-base	cu m	

Tarmacadam for base course	cu m		
Ditto, single course	cu m		
Ditto, wearing course	cu m		
B.S. salt-glazed ware pipes	per cent. addition on standard list prices		
Precast concrete gulley pots, 450 mm diameter, and 900 mm deep, with 150 mm trapped outlet and rodding eye	Each		
Cast iron heavy duty road gulley gratings and frames, (weighing 100 kg per set)	Set		
Cast iron heavy duty manhole covers and frames, (weighing 200 kg per set)	Set		
Wrot iron step irons	Each		
Southwater engineering bricks, No. 2	1000		
The contractor is to add below any further materials, with their prices, in respect of which he wishes the price variation clause to operate			

Temporary Works

The cost of temporary works is, as a general rule, to be covered by the various rates entered in a civil engineering bill of quantities. This general principle is particularly applicable to the following classes of temporary work:

(a) For servicing the works as a whole; for example, gantries, temporary tracks, structures connected with concrete-mixing plant, blockyard equipment, and workyard sites, where the latter is not made available free of cost under the terms of the contract.

(b) Temporary work which is needed for the formation and construction of permanent work detailed in various items in the bill of quantities. A typical example of this type of temporary work is trench timbering, which is necessary to support the sides of the trench prior to completion of the permanent work and the back-filling of the trench. No specific item is included in the bill of quantities to cover the trench timbering, and so the contractor has to estimate the amount of timbering that is likely to be needed and to allow for the cost of the labour and use of timber involved in the appropriate excavation rates.

It is usual to include a clause in the Preliminaries Bill indicating that the billed rates are, generally, to include the cost of all necessary temporary works.

When contractors tendering for a job all have a considerable volume of work in hand, they may tend to give inadequate consideration to the probable cost of providing the necessary temporary works. Thus a design evolved to use only limited temporary work may, by chance, be priced on a similar basis to a job requiring considerable quantities of temporary work. Some engineers feel that innovations are on occasions dealt with in this way. If this is so, the danger of stagnation in design is apparent.

Nevertheless, it is most desirable, as is pointed out in the *Standard Method of Measurement of Civil Engineering Quantities*, to provide special items in the bill of quantities to cover temporary works, of which the cost is reasonably constant and does not depend on the quantity of permanent works. An example of this class of temporary work is the construction of a cofferdam to allow the permanent work to be executed under dry conditions.

Other examples of temporary works which should be billed as special items in the bill of quantities are those where the cost of the temporary works is disproportionately high in relation to the cost of the associated permanent work, such as the provision of housing for employees and the construction of shafts and adits in tunnel work, which will not be required after the completion of the permanent work.

Where special billed items for temporary works cover the provision, maintenance and removal of these works, the descriptions of the items shall include details of the proportions of the payments and the times when they will be made to the contractor, in respect of the temporary works.

The following gives details of a special billed item to cover temporary works:

Item No.	*Description*	*Qty.*	*Unit*	*Rate*	£
	The following in Temporary Works covering Alterations to 375 mm diameter Intake Pipe				
100	Allow for the construction and maintenance of an interlocking steel sheet piled cofferdam, for taking all responsibility in connection		Item		

	therewith, and for removing ing on completion, all as specified. (75 per cent. of the cost is to be paid when the cofferdam has been constructed and the remaining 25 per cent. on completion of the alterations to the intake pipe and removal of the cofferdam.)					
101	Allow for pumping out the cofferdam and for keeping all works within it free from water, for the period required by the Engineer. (Proportionate payments are to be made throughout the period for which the cofferdam is required.)		Item			

Daywork

The term 'daywork' is defined in the *Standard Method of Measurement of Civil Engineering Quantities* as the 'method of valuing work on the basis of the time spent by the workmen, the materials used and the plant employed'. Circumstances often arise on a civil engineering contract where it is impracticable to value work at the billed rates and the only satisfactory method of evaluation of the work is on a daywork basis. For this reason most civil engineering bills of quantities incorporate a daywork schedule which provides the basis for the valuation of any work which the engineer directs to be executed as daywork. This class of work is often additional work which is uncertain in extent.

The *Standard Method of Measurement of Civil Engineering Quantities* details the following three methods for the valuation of work carried out on a daywork basis:

'(a) By a daywork schedule prepared in such a way as to enable entry in detail of separate rates for the respective classes of labour, materials supplied and the hire of plant; such rates to cover overhead charges and profit, site supervision and staff, insurances and holidays with pay, use and maintenance of small hand tools and appliances (but not the sharpening of tools), non-mechanical plant and equipment, such as ladders, trestles, stages, bankers, scaffolding, temporary track, wagons, skips and all similar items, unless these are set up or used exclusively for daywork, and in the case of rates for mechanically operated plant coming under the heading of 'plant', consumable stores, fuel and maintenance. When travelling allowances or travelling costs (transport of men by contractor's transport), lodging allowances and any other emoluments and allowances payable to the workmen at the date of submission of the tender are included, it should be so stated in the preamble.

'(b) By using (in whole or in part) the current schedules of dayworks carried out incidental to contract work issued by the Federation of Civil Engineering Contractors.

'(c) By adapting the current schedules of dayworks carried out incidental to contract work, issued by the Federation of Civil Engineering Contractors, in such a way as to enable entry of percentages for labour and materials differing from those given in the schedules of dayworks, and in the case of plant, percentages varying the hire rates given in the schedule of dayworks.'

Whichever of the three methods is adopted, the *Standard Method of Measurement of Civil Engineering Quantities* states that the following matters are to be incorporated in a preamble to the dayworks schedule:

'(i) The time of gangers or charge hands, working with their gangs, is to be paid for under the appropriate items, but the time of foremen and walking gangers is not to be included, but is to be covered by site supervision and staff.

'(ii) Overtime, when chargeable under the contract, is to be paid for in the same proportion as is paid to the workmen—thus, if a man works one hour overtime for which he is paid for $1\frac{1}{2}$ hours, then the contractor is to be paid for $1\frac{1}{2}$ hours for the man.

'(iii) The rates for plant are only to apply to plant which the contractor has available on the site.

'(iv) The rates for materials are to cover delivery at the usual points at which materials are received on the site, and not distribution to the individual sites where daywork is in progress, the cost of such distribution being chargeable in addition.

'(v) The daywork rates are to cover the use of such contractor's wagons and temporary tracks as are already in position on the site of the work to be done by daywork, unless such wagons and tracks are used exclusively for daywork, when they are to be paid for.

'(vi) The cost of watching and lighting specially necessitated by daywork is to be paid for separately.'

These last six provisions which it is recommended should be entered in all daywork schedules, do much to prevent any anomalies arising and in clarifying the process of valuation of the daywork. It is quite common practice to enter provisional quantities or sums against each item in the daywork schedule, and when priced, the total so obtained is carried to the summary in the bill of quantities, as a contingencies item. For example, on a large civil engineering contract a total net daywork figure of £25000 might be split conveniently between £15000 for labour, £5000 for materials and £5000 for plant.

Schedules of Dayworks carried out incidental to Contract Work

These schedules, issued by the Federation of Civil Engineering Contractors, do not cover daywork which is ordered to be carried out after the contract works have been substantially completed or for contracts carried out wholly on a daywork basis. In these cases the rates are to be agreed between the employer and the contractor.

These schedules are sub-divided into three sections as given below:

(1) *Labour.* A specified percentage is added to the net amount of the wages paid to workmen and gangers. 'Net amount of wages' is defined as 'wages (including travelling time and payments in respect of time lost due to inclement weather) paid to workmen and gangers at plain-time rates and/or at overtime rates in accordance with the rates prescribed by the Working Rule Agreement of the Civil Engineering Construction Conciliation Board for Great Britain, or other appropriate wage-fixing authority and, where no rates are prescribed by a wage-fixing body, the actual wage paid to the workman concerned.'

The percentage addition only provides for:

(a) National insurances.
(b) Third party and employer's liability insurances.
(c) Holidays with pay.
(d) Site supervision and staff—including agent, general foreman, timekeeper and clerks.
(e) Small tools—such as picks, shovels, barrows, trowels, ladders, hand saws, buckets, trestles, hammers, chisels and all items of a like nature.
(f) Head office charges and profit.

Travelling expenses and subsistence allowances paid to workmen and gangers are chargeable net in addition.

(2) *Materials.* A specified percentage is added to the cost of the materials delivered to the site. The cost of materials is defined as the invoiced price of materials delivered to the site, without deduction of any cash discounts not exceeding $2\frac{1}{2}$ per cent.

The cost of internal haulage of the materials on the site is to be paid for in addition at the appropriate daywork rates for labour, lorry hire, etc.

(3) *Plant.* Either hourly, daily or nightly hire rates are given for a comprehensive list of items of plant which are to cover the cost of the use

of the contractor's own plant, where already on the site, exclusive of driver and attendants, but inclusive of fuel and consumable stores.

This list of plant includes bar bending and shearing machines, compressors and breakers, cranes, scotch derricks, diving gear, dumpers, dump trucks, excavators, hoists, lifting and jacking gear, lorries, concrete mixers, offices and store sheds, paint spraying machines, piling plant, portable pumps, pumping equipment, concrete pumps, railway equipment, mechanical rammers, rollers, shuttering, tractors, scrapers, trenchers, winches, etc.

Daywork Schedules Generally

As an alternative to the use of the Schedules of Dayworks issued by the Federation of Civil Engineering Contractors, a daywork schedule on the lines indicated in the *Standard Method of Measurement of Civil Engineering Quantities* can be, and frequently is, incorporated in a bill of quantities.

The labour rates used will generally be those inserted in the schedule of basic rates. With regard to overtime working, it is often provided that in the event of the engineer directing overtime to be worked on daywork, the employer shall reimburse the contractor, the net value of the difference between the wages payable for such overtime working and the wages that would have accrued during the same period at ordinary time rates, but the percentage inserted by the contractor, to be added to the basic labour costs, shall be added only to the wages that would have accrued at ordinary time rates during the period for which overtime was worked.

With regard to materials the contractor will be requested to insert the percentage addition that he will require to the basic prices for the materials, as inserted in the schedule of basic prices, or if not included in the basic list, at the net price paid by the contractor for the materials delivered to the site, as substantiated by the supplier's invoices.

The daywork schedule provisions for plant will normally refer to the rates laid down for contractors' own plant in the 'Schedules of Dayworks carried out incidental to contract work' issued by the Federation of Civil Engineering Contractors, and the contractor is requested to state the percentage addition or deduction to these rates that he will require. Provision is usually made for payment to be secured for the actual hours worked only, with no allowance made for standing time and that the minimum hire periods shall be the periods stated in the Schedule.

It may also provide that in the event of plant being brought to the site on the written instructions of the Engineer and used only for daywork, the cost of haulage to and from the site will be paid to the contractor net. Furthermore, that the plant hire rates shall apply to the first thousand hours hire of any one type of plant used on daywork, with all subsequent hours of use paid for at two-thirds of these rates.

It will be seen that there are many variations of the form of daywork schedule which can be incorporated in a civil engineering bill of quantities, and various combinations may be employed using parts of the schedules of dayworks issued by the Federation of Civil Engineering Contractors. There is much to be gained by standardising the daywork schedule as far as possible and the bodies responsible for the preparation of the two documents which we have been considering, have made great strides in this direction.

IV – General Rules Covering the Preparation of Bills of Quantities for Civil Engineering Work

PREAMBLES

PREAMBLES are introductory clauses inserted at the commencement of bills of quantities containing any necessary instructions, references to obligations imposed on the contractor under the terms of the contract and any matters which affect the contractor in pricing the bills and which ought to be drawn to his notice. Their main purpose is to help contractors when tendering for jobs by making the task of pricing the bills of quantities as straightforward as possible.

Clause 21 of the *Standard Method of Measurement of Civil Engineering Quantities* states that the following directions should be given to firms tendering for works of civil engineering construction, and these will normally be incorporated in the main preamble to the bill of quantities:

'(a) Attention is directed to the form of contract, the conditions of contract, the specification and the drawings, and these documents are to be read in conjunction with the bill of quantities.

'(b) The bill of quantities has been drawn up in accordance with the *Standard Method of Measurement of Civil Engineering Quantities* published by the Institution of Civil Engineers.

'(c) The prices and rates to be inserted in the bill of quantities are to be the full inclusive value of the work described under the several items, including all costs and expenses which may be required in and for the construction of the work described, together with all general risks, liabilities and obligations set forth or implied in the documents on which the tender is to be based; where special risks, liabilities and obligations cannot be dealt with as above, then the price thereof is to be separately stated in the item or items provided for the purpose.

'(d) A price or rate is to be entered against each item in the bill of quantities, whether quantities are stated or not. Items against which no price is entered are to be considered as covered by the other prices or rates in the bill.

'(e) Any special methods of measurement used are stated at the head of or in the text of the bill of quantities for the trades or items affected. All other items are measured net in accordance with the drawings, and no allowance has been made for waste.

'(f) General directions and descriptions of work and material given in the specification are not necessarily repeated in the bill of quantities. Reference is to be made to the specification for this information.'

These directions cover matters of the greatest importance to the contractor and particular attention is drawn to the fact that, under these directions, all rates entered in the bill of quantities are to be all-in comprehensive rates, all items are measured net with no allowance for waste and that where no price is entered against an item in the bill of quantities then the item in question is deemed to be covered by other rates or prices in the bill. The contractor is accordingly precluded from making claims for extras under any of these heads and must bear this in mind when building up his unit rates for the billed items.

Preamble clauses are frequently inserted at the head of each individual or sectional bill to cover general and financial aspects of the particular section of work, and which have an important bearing on the pricing of items in the bill.

PRELIMINARIES BILL

A 'Preliminaries Bill' is sometimes incorporated in a civil engineering bill of quantities. This bill details the general obligations of the contractor under the terms of the contract and temporary works to be provided, and gives him the opportunity to price them, if he so wishes.

Under clauses 8 and 9 of the *Standard Method of Measurement of Civil Engineering Quantities*, general obligations as provided for in the conditions of contract and the cost of temporary works are, as a general rule, to be covered by the billed rates, and there is normally no need for a separate 'Preliminaries Bill' as encountered in building work.

TAKING-OFF QUANTITIES

(a) *Generally*

Clause 23 of the *Standard Method of Measurement of Civil Engineering Quantities* gives general guidance as to the way in which the 'taking-off' of dimensions should proceed. In 'taking-off' the quantities for insertion in the bill of quantities, consideration must be given to the order of measurement which is followed in the final measurement of the work. It is suggested that the quantities should, as far as practicable, be those which would result if the contract drawings were to be regarded as the record drawings or details of work as actually carried out. In this way a more logical sequence in the order of 'taking-off' will be developed and greater accuracy in dimensions is almost bound to follow.

It is most important that all work whose quantity cannot be determined with a reasonable degree of accuracy should be labelled 'provisional', and items of this kind should be kept separate from items which contain definite quantities. In this way the contractor is made aware of the uncertain nature of the quantity entered and that there is a possibility that the item might not materialise.

The *Standard Method of Measurement of Civil Engineering Quantities* requires all dimensions and mathematical calculations to be entered on separate sheets of dimension paper or in dimension books. These entries are to be carefully made so that they can be readily checked by another person without any possible chance of confusion arising.

(b) *Dimension Paper*

The normal ruling of 'dimension paper' on which the dimensions scaled or taken direct from drawings are entered, is indicated below. This ruling conforms to the requirements of B.S.3327—*Stationery for Quantity Surveying.*

1	2	3	4	1	2	3	4

Each dimension sheet is split into two identically ruled parts, each consisting of four columns. The purpose of each column will now be indicated for the benefit of those readers who are unfamiliar with the use of this type of paper.

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

Column 2 is termed the 'dimension column' in which the actual dimensions, as scaled or taken direct from the drawings, are entered. There may be one, two or three lines of dimensions in an item depending upon whether it is lineal, square or cubic.

Column 3 is termed the 'squaring column' in which the length, area or volume obtained by multiplying together the figures in columns 1 and 2 is recorded, ready for transfer to the abstract or bill.

Column 4 is known as the 'description column' in which the written description of each item is entered. The right-hand side of this wider column is frequently used to accommodate preliminary calculations and other basic information needed in building-up the dimensions and references to the location of the work and is referred to as 'waste'.

In the worked examples that follow in succeeding chapters the reader will notice that one set of columns only is used on each dimension sheet with the remainder used for explanatory notes, but in practice both sets of columns will be used for 'taking-off'.

(c) *Spacing of Items*

It is essential that ample space 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 subsequently inserted, without cramping up the dimensions unduly. The cramping of dimensions is a common failing amongst examination candidates and does cause loss of marks.

(d) *Waste*

The use of the right-hand side of the description column for preliminary calculations, build-up of lengths, explanatory notes, etc., should not be overlooked. All steps that have been taken in arriving at dimensions, no matter how elementary or trivial they may appear, should be entered in the waste section of the description column. Following this procedure will do much to prevent doubts and misunderstandings concerning dimensions arising at some future date.

(e) *Order of Dimensions*

A constant order of entering dimensions must be maintained throughout, i.e. (i) length, (ii) breadth or width, and (iii) depth or height. In this way there can be no doubt as to the shape of the item being measured. When measuring a cubic item of concrete—10 m long, 5 m wide and 0·50 m deep, the entry in the dimension column would be as follows:

	10·00 5·00 0·50		Conc. class 'A' in machine bed.

It will be noted that dimensions are usually recorded in metres to two places of decimals with a dot between the metres and fractions and a line drawn across the dimension column under each set of figures.

(f) *Timesing*

If there were three such items, then this dimension would be multiplied by three in the timesing column as shown below:

3/	10·00 5·00 0·50		Conc. class 'A' in machine bed.

If it was subsequently found that a fourth bed was to be provided, then a further one can be added in the timesing column by the process known as 'dotting on', as indicated below:

3 1· /	10·00 5·00 0·50		Conc. class 'A' in machine bed.

It is pointed out in the *Standard Method of Measurement of Civil Engineering Quantities* that where there are a number of units of the same item, all multiplying factors are to appear in the timesing column. Taking, for instance, 30 rows of piles with 4 piles in each row, the entry on the dimension sheet would be:

30/ 4/	0·30 0·30 10·00		R.C. (Quality 'B') 300 × 300 mm piles, in 9 to 12 m lens.

(g) *Abbreviations*

Many of the words entered in the description column are abbreviated in order to save space and time spent in entering the items by highly skilled technical staff. Many abbreviations have become almost standard and are of general application and for this reason a list of the more common abbreviations is given in Appendix I at the end of this book. A considerable number of abbreviations are obtained by merely shortening the particular words, such as the use of 'shuttg.' in place of 'shuttering', and 'rad.' for 'radius'.

(h) *Grouping of Dimensions*

Where more than one set of dimensions relates to the same description, the dimensions should be suitably bracketed in order that this shall be made perfectly clear. The following example illustrates this point:

2/	148·00		125 × 250 mm precast granite conc. half battered kerb, b. & j. in c.m. (1:3)
2/	246·00		
	132·00		
	56·00		

Where the same dimensions apply to more than one item, the best procedure is to segregate each of the separate descriptions by an '&' sign as illustrated below:

$\frac{22}{7}$/	3·00		Additional excavn. in tunnel for overbreak.
	1·00		&
			Pressure grout ard. outside of tunnel lining in ct.

(j) *Deductions*

After measuring an item of construction it is sometimes necessary to deduct for voids or openings in the main area or volume. This is normally performed by following the main item by a deduction item as shown in the following example:

8/	1·80		Conc. (class 'B') in m.h. cover slab, 150 mm th.
	1·35		
8/	0·60		*Ddt.* ditto
	0·45		(opgs.)

(k) *Figured Dimensions*

When 'taking-off' it is most desirable to use figured dimensions on the drawings in preference to scaling, as the drawings are almost invariably in the form of prints, which are not always true-to-scale. It is sometimes necessary to build-up overall dimensions from a series of figured dimensions and this work is best set down in 'waste', on the right-hand side of the description column.

(l) *Numbering and Titles of Dimension Sheets*

Each dimension sheet should be suitably headed with the title and section of the job at the head of each sheet and with each sheet numbered consecutively at the bottom. Some prefer to number each set of columns on each dimension sheet separately. The entering of page numbers on each dimension sheet ensures the early discovery of a missing sheet.

At the top of the first dimension sheet for each main section of the work should be entered a list of the drawings from which the measurements have been taken, with the precise drawing number of each contract drawing carefully recorded. A typical example of such a list follows:

NORTH CREAKE OUTFALL SEWER SHEET NO. 1

Drawings

NC/SEW/1/0A	(Layout Plan)
NC/SEW/1/5A	(Sewer Sections)
NC/SEW/1/6B	(Sewer Sections)
NC/SEW/1/7B	(Sewer Sections)
NC/SEW/1/12A	(Manhole Details)

The importance of listing the contract drawings, from which the dimensions have been obtained, in this way, is that in the event of changes being made to the work as originally planned resulting in the issue of amended drawings, it will be clearly seen that these changes occurred after the bill of quantities was prepared and that variations to the quantities can be expected.

It is good practice to punch all dimension sheets at their top left-hand corner and to fasten them together with treasury tabs.

(m) *Abstracting*

When the items on the dimension sheets after squaring cannot conveniently be transferred direct to the appropriate section of the bill, it will be necessary to group them in an abstract, where they will be suitably classified and reduced to the recognised units of measurement preparatory to transfer to the bill. The various phases of abstracting are described and illustrated in chapter 17.

ARRANGEMENT OF BILL OF QUANTITIES

(a) *Ruling of Bill of Quantities*

In order that a uniform method of setting out the information in a civil engineering bill of quantities shall be employed, the *Standard Method* *of Measurement of Civil Engineering Quantities* recommends that the rulings laid down in the British Standard Specification *Stationery for Quantity Surveying* (B.S. 3327) should be adopted.

This British Standard lays down two forms of ruling, namely, left hand billing and right hand billing, for use with either single or double bills (with one or two sets of pricing columns). The most commonly used form of bill ruling for civil engineering work is the single bill (right-hand billing), and this is now being used to a considerable extent for building work. This form of ruling is illustrated below:

1	2	3	4	5	6

No. of column	*Use of column*	*Width*
		mm
1	Item No.	19
2	Description	107
3	Quantity	18
4	Unit	18
5	Rate	13
6	£	36 (nominal)

This form of ruling has distinct advantages over 'left-hand billing', in that the quantity, unit, rate and pricing columns are all adjacent to one another which greatly assists in pricing and checking priced bills of quantities.

The double billing paper with two sets of pricing columns, is mainly used for Bills of Variations, one set of columns being used for omissions and the other set for additions.

(b) *Numbering of Items*

The *Standard Method of Measurement of Civil Engineering Quantities* states that billed items are to be numbered consecutively for convenience of reference. It is the usual practice in civil engineering work to number all the billed items to be priced consecutively right through the bill of quantities, commencing with one at the first item and running through to possibly several thousand on the last item on a very large contract. In building work the most usual practice is to letter the items alphabetically on each page to avoid the use of large numbers. In this system the third item on page 20 of the bill of quantities would be referred to as item 20/C (page 20 item C).

The *Standard Method* further adds that clauses containing descriptive matter only are not to be numbered. This is a good procedure as it means that only those items which are numbered need be priced by the contractor. The following example illustrates this point.

Item	*Description*	*Qty.*	*Unit*	*Rate*	£
	CAST IRON SHAFT RINGS				
	Fix only				
	comprising sorting, transporting on site, assembling and placing in position, including the use of all necessary jointing material. Cast iron shaft lining rings consist of 10 No. ordinary plates, 2 No. T plates and 1 No. key piece, each forming a 7·00 m internal diameter vertical shaft section 600 mm high, with a weight of 5·80 Mg per unit ring or section.				
182	In rings inside cofferdam sheeting (In 30 No. rings).	174	Mg		
183	In rings in ground below foot of cofferdam. (In 18 No. rings).	105	Mg		

(c) *Entering Quantities in the Bill*

Where quantities are rounded off before being transferred to the bill, it is recommended in the *Standard Method* that this shall be done on a 'give and take' basis, so that the quantities in the bill represent as accurately as possible the work shown on the drawings. Obviously the inclusion of many items with small fractional quantities, which slows down the pricing of the bill, is rather unnecessary. On the other hand it is also bad policy to weight all the quantities by making them all up to the next highest full unit.

Quantities are normally to be entered as single units such as megagrammes or metres. One of the main aims in the preparation of civil engineering bills of quantities is to eliminate numerous subdivisions and small units.

Where fractional quantities cannot be avoided, they are to be expressed in decimals and not in fractions. The *Standard Method of Measurement of Civil Engineering Quantities* states that the use of fractional quantities is to be avoided unless the omission of the fraction affects the total amount of the item by more than, say £1. The use, or otherwise, of fractional quantities will accordingly need to be considered for the more costly items of construction. Fractional quantities for low priced items, such as expansion joints on roads, can be discounted from the outset.

(d) *Units of Measurement*

The words used in describing work of one, two or three dimensions shall be linear, square and cube respectively. These words precede the unit of measurement; examples being linear metres, square metres and cubic metres.

The following abbreviations are recommended for the various units employed:

cu (cubic)	m (metres)	Mg (megagramme)
sq (square)	mm (millimetres)	kg (kilogramme)
lin (linear)		

Where alternative units of measurement are permitted in the *Standard Method of Measurement of Civil Engineering Quantities*, such as concrete in roof and floor slabs, not exceeding 300 mm in thickness, which can be measured in square metres or cubic metres, the unit selected is to be used throughout each section of the bill of quantities and preferably throughout the bill as a whole. The use of different units gives rise to inconsistency and may result in errors in pricing by the contractor.

COMPREHENSIVE MEASUREMENT FOR REPETITION WORK

Clause 29 of the *Standard Method of Measurement of Civil Engineering Quantities* points out that it may be convenient to cover composite work, when of a uniform type of construction, by a single item, even though several classes of materials and workmanship are involved. Typical examples are retaining walls, tunnel work and pipe lines measured by the linear metre of length or manholes and valve chambers, which are enumerated.

In each case a subsidiary bill should be included in the description column or in an appendix, listing in the recognised units the quantities of the component materials and workmanship required to make up the unit of length or number of a group. In this way the rates for the component parts in addition to the rate for the composite unit of length or enumerated item may be entered in the bill of quantities.

The use of the subsidiary bill will assist the contractor in building up his price for the composite item and, when priced, will help the engineer in checking the billed rates and in building up new rates for varied work. Enumerated items occasionally appear in bills of quantities covering manholes and valve chambers without the inclusion of a subsidiary bill and this generally means that the contractor has to take-off approximate quantities before he can price the billed item and this is obviously most unsatisfactory. Either the manhole or valve chamber should be measured in detail or when covered by an enumerated item should be accompanied by a subsidiary bill, giving details of the component items of the average manhole or valve chamber.

This method is very well suited for the measurement of tunnel work, where there will probably be a uniform type of construction over a considerable length. Furthermore, it simplifies the engineer's task in taking-off the quantities and the contractor's job of pricing these items in the bill of quantities. In the case of sewers, apart from changes in pipe size, which necessitate separate items, one also experiences the difficulty of continually varying depths of excavation for the sewer trench. It is recommended that the average, minimum and maximum depths of excavation, measured from ground level to invert level, should be given in the billed description of the item.

Where concrete beds, haunchings and surrounds are provided to sections of the work, these will need to be covered by an item in the subsidiary bill, stating the average volume of concrete to be provided throughout the length of sewer per linear metre in beds, haunchings and surrounds, as appropriate.

An example will now be given covering the measurement of tunnel work on the comprehensive system with a subsidiary bill, using double billing paper (right-hand billing). This particular ruling of paper has two sets of pricing columns, so that the first set of columns can accommodate the prices for the items in the subsidiary bill and the comprehensive billed rate for the main item will be entered in the second set of pricing columns.

2·50 m Internal Diameter, Tunnel in Cast Iron Tubbing

Item	*Description*	*Qty.*	*Unit*	*Rate*	£	*Rate*	£
1.	2·50 m internal diameter, shield driven, tunnel constructed in cast iron segments, in accordance with the drawings and specification, from access shaft No. 3 westwards to access shaft No. 4	335	lin m				
	Subsidiary Bill giving Quantities of one linear yard of Tunnel						
A.	Excavate in sand in free air for tunnel, including the disposal of the excavated soil. Prices are to include for the cost of the shield and all other necessary equipment.	7·07	cu m				
B.	Additional excavation as necessary for overbreak.	9·43	sq m				
C.	Pressure grout around outside of tunnel lining in cement.	9·43	sq m				
D.	Erect and fix cast iron lining in tunnel (bolts measured separately).	1	lin m				
E.	Cast iron tubbing, as specified.	2·29	Mg				
F.	Steel in 20 mm diameter bolts, with nuts and washers, fixed complete.	0·08	Mg				
	carried forward			£			

Item	*Description*	*Qty.*	*Unit*	*Rate*	£	*Rate*	£
	brought forward			£			
G.	Machining to faces of circumferential and longitudinal flanges 100 mm wide.	50	lin m				
H.	Caulking joints between circumferential and longitudinal flanges in rust cement.	25	lin m				
I.	Screwed 32 mm diameter wrot iron plugs, including tapping of grout holes.	12·6	no.				
	Cost per linear metre.			£			
	(This cost becomes the comprehensive rate for item No. 1).						

V – Measurement of Site Investigation and Site Clearance Work

CLAUSES 30 to 38, inclusive of the *Standard Method of Measurement of Civil Engineering Quantities*, which lay down the basic principles for the measurement of these classes of work, have been quoted in full for ease of reference by the reader. In addition explanatory notes have been inserted against the clauses from the *Standard Method*, which it is hoped will be of assistance in the interpretation of the various clauses.

This will be followed by worked examples covering the 'taking-off' of quantities of site clearance work.

CLAUSES FROM THE *S.M.M. of C.E.Q.*	EXPLANATORY NOTES

SITE INVESTIGATION

30. *Application of Section*

Site investigation is to be understood to include test pits, penetration tests, boring in soil, and rock boring.

This section covers all methods of boring and testing soils, when investigating sites, normally carried out preparatory to the design of civil engineering projects.

31. *Units of Measurement for Site Investigation*

The units of measurement for site investigation are to be:

Bringing the plant to the site, erecting, dismantling and removing
. . . Lump sum

Moving the plant from each position to the next including, if necessary, dismantling and re-erecting
. . . Number

It is necessary to give the number of separate positions in which the boring or testing equipment will have to be set up on the site.

CLAUSES FROM THE *S.M.M. of C.E.Q.*	EXPLANATORY NOTES
Sinking test pits, carrying out penetration tests or borings including the provision of 'disturbed' samples ... Linear metre of depth	(a) Various stages of depth are separately classified for pits and borings—see clauses 32, 33 and 34. (b) 'Disturbed' samples are samples of soil taken from the loose excavated material at various stages as distinct from 'undisturbed' samples which are normally extracted from the soil in the form of a solid core and are placed in airtight tubes.
Removal of obstructions including plant and gang ... Hour	The obstructions to be removed might include remains of buildings, areas of concrete, thick undergrowth, etc. The work involved in their removal is to be measured on a daywork basis, by evaluating the time expended by plant and labour (with a minimum of three men in a gang).
Undisturbed samples ... Number	
32. *Method of Measurement and Classification of Items for Test Pits*	
The required minimum plan area of the test pits is to be stated. Separate items are to be provided for pits which do not exceed 1·50 m in depth, for those which exceed 1·50 m but do not exceed 3 m in depth, and so on in steps of 1·50 m.	(a) It is essential that the minimum plan area of test pits is given as the cost of the work will vary considerably with the plan area. Test pits with a small plan area are relatively difficult and costly to excavate as the working space is so confined. (b) The 1·50 m stages of depth are similar to those adopted for the measurement of pipe trench excavation. (See clause 40.)

Excavation above ground water level should be separated from excavation below ground water level, with due consideration being given to the effect of tidal water on the ground water level.

Separate items are to be provided for timbering.

Specific items should be provided for pumping, if required, as described in clause 41.

Separate items are to be provided for penetration tests in addition to items for test pits or borings.

Information on how long the test pits are to remain open should be given.

Any matters affecting cost are to be expressly mentioned. Separate items for timbering and pumping, if required, are a departure from normal practice as the excavation rates usually include these operations. Where a pumping item is given, it is to be on the basis of supplying and/or installing and dismantling pumps of specified capacity (per pump), for pumps working (per hour) and for pumps standing by (per hour).

The length of time for which test pits are to remain open will also have an important bearing on cost, as it may well determine whether or not timbering will be required.

33. *Method of Measurement and Classification of Items for Boring in Soil*

Separate items are to be provided for preliminary or reconnaissance borings and for final borings.

In the case of final borings the minimum diameter of casing and minimum diameter and length of undisturbed samples are to be stated.

Separate items are to be provided for boring within a depth of 10 m, boring between 10 m and 15 m, and so on in depths of 5 m. The boring rate is to include for the provision of disturbed samples of all strata in airtight bottles. The rates for undisturbed samples are to cover the use of sampling tubes, delivery to the specified laboratory and detention there for a reasonable period.

The various stages into which boring in soil is to be classified deserves special note, together with the fact that boring rates are to cover the cost of providing 'disturbed' samples.

The rate for the removal of obstructions is to include supply and use of plant and the attendant squad (minimum three men).

CLAUSES FROM THE *S.M.M. of C.E.Q.*

EXPLANATORY NOTES

34. *Method of Measurement and Classification of Items for Boring in Rock*

Separate items are to be provided for boring within a depth of 10 m, for boring between 10 m and 20 m, and so on in depths of 10 m. The rates for boring are to cover the extraction of complete cores.

Boring in rock is separately classified in much larger stages of depth.

SITE CLEARANCE

35. *Application of Section*

Site clearance is to be understood to mean the removal of superficial obstructions. Demolition or the breaking up of old structures if they are contained in the excavation is to be dealt with as described in clause 42. For stripping turf see clause 40.

Site clearance is concerned with the removal of obstructions on the surface of the ground.

Breaking up of sections of concrete, brickwork and masonry, as part of excavation work, is measured in cubic metres as 'extra over' the excavation. This unit of measurement could equally well apply to similar 'breaking-up' work carried out during site clearance operations and not connected with general excavation work.

Stripping turf is measured by the square metre, as 'extra over' excavation.

36. *Units of Measurement for Site Clearance*

Bushes, undergrowth, small trees less than 300 mm girth, tree stumps less than 100 mm diameter, hedges, fences, rubbish and debris (the area of the site being stated).

. . . Lump sum or per hectare

Bushes, undergrowth, small trees and tree stumps, rubbish and debris are generally covered by giving the area involved in hectares.

The contractor is required to

In certain cases it may be desirable to measure hedges and fences by the linear metre.

Trees ... Number

Tree stumps ... Number

Demolition of buildings, the overall cubic contents above ground level being stated.

... Lump sum

Demolition of steelwork, the approximate weight of steel being stated.

... Lump sum

Demolition of pipe lines and similar structures including their supports, the size being stated.

... Linear metre

visit the site before submitting his tender when the actual site conditions will be closely examined.

It is generally good practice to measure hedges and fences which are to be removed, by the linear metre wherever practicable.

Larger trees and tree stumps are to be separately enumerated in accordance with the classifications and method of measurement (1 m above ground level for trees and at ground level for stumps), given in clause 37.

With buildings to be demolished, the cubic content above ground level should be indicated and a description of the type of construction.

37. *Method of Measurement of Trees and Tree Stumps*

Separate items are to be provided for trees which exceed 300 mm girth but do not exceed 600 mm girth, for those which exceed 600 mm and do not exceed 900 mm girth, and so on in steps of 300 mm, measured at a height of 1 m above ground level.

Separate items are to be provided for tree stumps which exceed 100 mm diameter but do not exceed 200 mm diameter, for those which exceed 200 mm but do not exceed 300 mm diameter measured at ground level, and so on in steps of 100 mm.

38. *Disposal and Recovery*

The manner of disposal of materials is to be stated for each item and where the materials become the property of

It is most important to clearly define the method of disposal of demolished materials—whether

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the contractor a separate item is to be given in which the contractor is to state the credit value (if any) he is prepared to allow for these materials. The total credit value is to be carried to the end of the relative section of the bill of quantities by way of a deduction from the total.

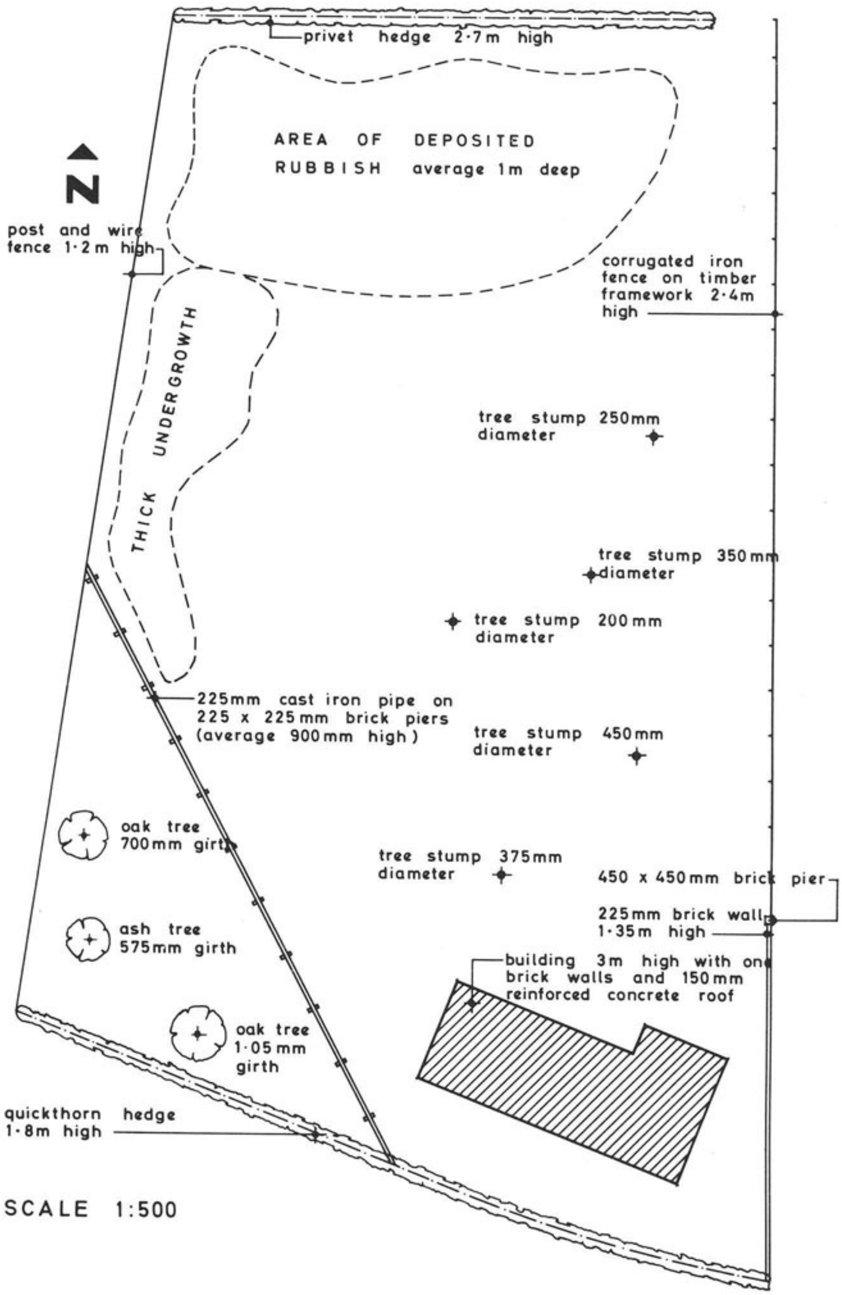
EXPLANATORY NOTES

they are to remain the property of the employer and, if so, the place to which they are to be carted, or if they are to become the property of the contractor, in which case the contractor must be able to enter in the bill of quantities the credit value which he is prepared to allow. Doubt on these matters often gives rise to arguments on the job over comparatively trivial items.

	SITE CLEARANCE	EXAMPLE I
31.00 14.00	Remove rubbish av. 1m dp., from site.	The overall dimensions have been obtained on a give-and-take basis, which is considered sufficiently accurate for this purpose. The area will be reduced to hectares prior to billing
25.00 7.00	Cut down thick undergrwth, grub up roots & remove from site.	Ditto.
35.50	Cut down privet hedge, approx. 2.7m hi. grub up roots, remove from site & fill in voids wi. excavtd. matl.	The cutting down of hedges is best measured in linear metres. It is advisable to state the type and height of hedge as this can affect the cost of the work.
53.00	Cut down quickthn. hedge, approx. 1.8m hi. do.	
1	Cut down tree, ex. 300mm & n.e. 600mm gth., grub up roots, remove from site & fill in void wi. excvtd. matl.	Felling of trees enumerated in 300mm stages of girth.
1	Ditto. ex. 600mm & n.e. 900mm gth., do.	Note: items such as the taking down of hoardings and notice signs and removal of gates will be enumerated items.
1	Ditto. ex. 900mm & n.e. 1200mm gth., do.	

SITE CLEARANCE

DRAWING NO. 1



SCALE 1:500

SITE CLEARANCE (Contd.)

	1		Remove tree stump, ex. 100mm & n.e. 200mm dia., grub up roots, remove from site & fill in void wi. excvtd. matl.	Removal of tree stumps enumerated in 100mm stages of diameter.
	1		Ditto., ex. 200mm & n.e. 300mm dia., do.	Note abbreviated method of repeating similar items and use of words "ditto" and "do."
	2		Ditto., ex. 300mm & n.e. 400mm dia., do.	
	1		Ditto., ex. 400mm & n.e. 500mm dia., do.	
	67·00		Take down post & wire fence, 1·2m hi., & remove from site.	Taking down fences is best measured in linear metres. This fence is in such bad condition that it is not considered necessary for the contractor to allow a credit item for the materials involved.
	59·50		Take down corrugated iron fence, 2·4m hi., on 75 x 75mm tbr. frmwk., wi. posts at 3m ccs., & remove from site.	
	1		The Cr. is to give the credit value which he is prepd. to allow. for the matls. arisg. from the last item	A considerable amount of salvageable material is involved with this fence and a credit item has accordingly been included.

SITE CLEARANCE (Contd.)

	Dimensions		Description	Notes
	23·75 0·23 1·35		Take down & remove one-bk. bdy. wall & adg. pier.	Note order of dimensions:- 1) Length. 2) Thickness. 3) Height.
	0·45 0·45 1·50		(pier.	Removal of brickwork is best measured in cubic metres.
	45·00		Take down & remove 225mm c.i. pipe, strpd. to & incl. 225 x 225mm bk. piers, av. 900mm hi. at 4m ccs.	The pipe supports are described and included in the lineal item.
			bldg. – main area. 18·500 7·000 126·000 3·500 129·500 Add. projn. 6·000 2·000 12·000 Total area 129·5 12·0 141·5 m^2 3 Total Vol. 424·5 m^3	The cubic contents can conveniently be calculated in "waste", each step being suitably annotated.
	1		Demolish bldg. wi one-bk. walls & 150mm R.C. roof; the overall cubic contents above ground level being 425 cu. m. & remove from site.	Buildings to be demolished are enumerated with the overall cubic contents above ground level given in the description.

FURTHER EXAMPLE OF SITE CLEARANCE WORK.

DEMOLITION OF TIMBER JETTY. EXAMPLE II

	Item		Demolish xtg. frd. & bolted tbr. jetty, size 96·7m x 12·8m & tee head size 43·4m x 11·0m on plan, wi deck level at 7·620 above O.D. & 3·810 above M.H.W.S.T. The jetty is made up of 64no. 300 x 300mm & 38no. 400 x 400mm tbr. piles driven into the sea bed wi. 300 x 150mm diagonal cross brcg., 300 x 300mm & 300 x 450 mm walgs. & 300 x 150mm & 300 x 300mm brrs. supportg. 1830 sq. m of· 100 mm th. tbr. deckg., 4no. bollards size 1050 x 300mm on plan, 8no. 200 x 100mm r.s.js, 600mm lg., & 1no. tbr. staircase risg. 3·80m from the lower staging, 1·50m wide wi. 13no. 300 x 75mm steps & 150 x 300mm stringers.	The Contractor will insert a lump sum against this comprehensive demolition item A detailed description covering all the main components parts of the jetty should be given in the billed item to enable the Contractor to build up a realistic price for the work.
			Demolish small tbr. frd. & sheeted hut, size 1·80m x 3·65m x 2·13m hi.	

DEMOLITION OF TIMBER JETTY (Contd.)

			Clear all matls. & debris from the site & withdraw all the piles, incl. any broken piles from the sea bed.	
	Item		Allow the full credit value of all matls. resultg. from the demolitn. of the jetty, which are to become the property of the Cr.	The credit value of the materials arising from the demolition of the jetty will be considerable and the Contractor must be given the opportunity to make due allowance for this.

VI – Measurement of Excavation, Dredging and Filling and Geotechnical Processes

CLAUSES 39 to 51 of the *Standard Method of Measurement of Civil Engineering Quantities* cover the measurement of these classes of work. It is a lengthy section and is now quoted in full with accompanying explanatory notes. This will be followed by a typical dredging bill and a worked example covering the 'taking-off' of quantities of excavation and filling work.

Further details of excavation measurement will be given in worked examples covering other types of civil engineering work, which follow in later chapters.

CLAUSES FROM THE *S.M.M. of C.E.Q.*

EXPLANATORY NOTES

EXCAVATION, DREDGING AND FILLING

39. *Classification of Items of Excavation*

Separate items are to be provided for excavation differing in character, purpose or method of execution. (For disposal of excavated material, see Clause 46.) Thus it is necessary to distinguish between excavation which, although carried out for the same purpose, differs in different situations of the work, in the depth to which it is to be taken, or in the strata or material to be excavated. For example, the following classes of excavation are among those which are to be represented by separate items:

Stripping turf (if carried out as a separate operation).
Top-soil (if to be re-used).
Removing and reinstating roads and other paved surfaces.
Shallow surface excavation.
Excavation in bulk in the open.
Cuttings, as for roads and railways.

It will be noted that excavation for different purposes, often involving differing methods of execution and the use of a variety of types of plant are to be kept separate. This gives emphasis to one of the most important factors governing the preparation of civil engineering bills of quantities, namely, that where items of work give rise to differing costs of construction then they shall be separately listed in the bill of quantities. In this way the contractor may attach different prices to each separate item of work. The list of separate classes of excavation contained in clause 39 should be carefully noted.

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Trenches (for drains, pipes and the like).
Trenches (other than for drains, pipes and the like).
Pits, pier-holes, etc.
Dumpling excavation between trenches.
Excavation in underpinning.
Excavation in tunnels and headings.

The various classes of excavation are to be sub-divided, as necessary, so that opportunity may be given for fixing different prices in the several classes for:

Excavation in soft material, and excavation in hard material or rock. (See clause 45.)
Excavation in free air, and excavation in compressed air.
Excavation above high water, excavation between tides and excavation below low water, the levels of demarcation being stated.

40. *Methods of Measurement and Units of Excavation*

The quantities of excavation, except where otherwise mentioned hereunder, are to be the net cubic content, in cubic metres, of the voids to be formed by the removal of the materials excavated in accordance with the specification and drawings. No allowance is to be made for bulking.

Stripping Turf

The unit of measurement for stripping turf, where carried out as a separate operation, is to be the square metre measured extra over excavation.

EXPLANATORY NOTES

Excavation in different materials and under different conditions of working are each to be entered separately in the bill of quantities. Again widely differing costs are involved and the contractor must be given the opportunity to separately price the different items.

All excavation quantities are to be measured net, with no allowance made for the bulking which occurs on excavation and which varies with different soils. The contractor will need to make the necessary allowances, when assessing his rates for excavation and disposal.

Where turf is separately stripped it is measured 'extra over' normal excavation in square metres. Thus the excavation quantities include the volume occupied by the turf.

Top Soil

The unit of measurement for excavating top soil, if it is to be re-used, is to be the square metre, measured extra over excavation. The depth of the top soil to be removed is to be stated.

It will be noted that the excavation of top soil is only separately measured as an 'extra over' excavation item when the top soil is to be re-used. Where the top soil is not to be re-used for any purpose then no separate billed item is required. In all cases the general excavation item will include the volume of the top soil.

Removing and Reinstating Roads

The unit of measurement for removing and reinstating roads and other paved surfaces in connection with trenches for drains, pipes and the like is to be the linear metre, and for other classes of excavation the square metre, measured extra over excavation in both cases.

Note the different unit of measurement used for the removal and reinstatement of paved surfaces over trenches and general areas respectively.

Trenches (for drains, pipes and the like)

Trench excavation for drains, pipes and the like is to be measured in linear metres without the width of trench being stated, but the diameter of the pipes or the overall width of the concrete protection, if any, are to be given. The average depth, in metres, calculated by dividing the area of excavation as shown on the longitudinal section by the length, is to be stated.

Separate items are to be provided for lengths of trench which do not exceed a maximum of 1·50 m in depth, for those which exceed 1·50 m and do not exceed 3 m in depth, and so on in steps of 1·50 m up to 6 m, measured in each case from the surface of the ground to be excavated.

For deep trenches, separate items

Trenches to accommodate sewers, drains, watermains and pipes generally are measured by the linear metre, stating the internal diameter of the pipe or the overall width of concrete bed, haunch or surround. In no case is it necessary to state the width of the trench to be excavated, as this must be left to the contractor to decide and is influenced to some extent by the method to be adopted and the type of plant, if any, to be used.

The method of determining the average depth of the trench and the stages of depth into which trench excavation is subdivided deserve special attention.

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are to be provided for trenches which do not exceed 6 m in depth, for those which exceed 6 m and do not exceed 9 m in depth, and so on in steps of 3 m, measured in each case from the surface of the ground to be excavated.

Provisional items may be provided for excavation, e.g. in pockets ordered to be taken out below the specified depth, the unit of measurement being the cubic metre, and the depth from the surface is to be stated.

It may be necessary to provide for the removal and reinstatement of field drains.

Trenches (other than for drains, pipes and the like) and Pits, Pier-holes, etc.

The quantities of excavation in trenches, pits, pier-holes, etc., are to be based on the horizontal area of the bottom of the wall or other structures to be built, multiplied by the mean depth from the surface, suitable allowance being made in the case of back battered walls. The unit of measurement is to be the cubic metre.

Separate items are to be provided for trenches, etc., which do not exceed 3 m in depth, for those which do not exceed 6 m in depth, and so on in steps of 3 m, measured in each case from the surface of the ground to be excavated.

It may be necessary to provide a separate item to cover the cost of any additional excavation which may be

EXPLANATORY NOTES

It is stated that the trench depths are to be measured from the surface of the ground in each case, but it is often necessary to lay sewers under roads in a site development contract, when it is usual to excavate down to road formation in the first instance and to subsequently excavate the sewer trenches below this level. In this case the trench depths measured on the site should be taken from road formation, and not ground level, as the contractor cannot reasonably expect to be paid twice for the excavation work above road formation on the line of the sewer trench.

Excavation of trenches for wall foundations, pits, pier-holes, etc., is measured in cubic metres. It will also be noted that the stages of depth of excavation vary from those to be used for pipe trenches, with 3 m steps adopted throughout.

It is often necessary to allow for additional excavation for working space, timbering, etc., required beyond the net width of the structure (whether for working space, timbering or other temporary work) and for any consequent refilling, the measurement to be the sum of the areas in square metres of the sides of the excavation.

in this class of work, and the unit of measurement is the square metre, with the measurements taken on the perimeter of the net excavation area required for the structure. Typical examples are manholes and underground tanks.

Tunnels

The quantities of tunnel excavation are to be based on the net cross-sectional area necessary for the specified thickness of lining. The unit of measurement is to be the cubic metre.

In addition, a separate item is to be provided to cover the cost of any additional excavation for overbreak and of building up and making good the voids, to be measured by the square metre of the outer surface of the specified lining, no thickness being stated.

Excavation for tunnel linings is taken in cubic metres, measured to the outside of the lining. Any excavation beyond the lining for overbreak and the building up and making good of voids is taken in square metres measured on the outer surface of the lining.

41. *Temporary and General Works for Excavation*

Subject to the provisions of clause 9, separate items are not to be provided for temporary and general works incidental to excavation. The cost of these works is to be allowed for in the rates for excavation, for example:

(a) Timbering for trenches, and for upholding and maintaining excavation generally.
(b) Temporary sheet piling to sides of excavation, except for items included in clause 9.
(c) Trimming bottoms of excavation to receive concrete, and keeping the surfaces of excavation in condition. (But see clause 105.)

Apart from the exceptions listed in clause 9, it is usual for the billed excavation rates to cover the cost of temporary timbering and sheet piling to trenches and other excavations, trimming bottoms of excavations and keeping excavations clear of water.

It will be noted that separate items are to be provided for temporary timbering and sheet piling to be *left in* position by order of the engineer, as this work does, in fact, become part of the permanent construction.

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(d) Keeping excavation clear of water by pumping, baling or otherwise (except where separately provided for as mentioned hereunder).

Items are to be provided for temporary timbering and temporary sheet piling left in by order of the engineer. The unit of measurement for timber is to be the cubic metre, and for steel sheeting the square metre as described in clause 87.

While pumping should usually be borne upon the rates generally, where there is exceptional uncertainty as to the amount of pumping to be expected, or where exceptionally high rates for excavation would result if the pumping were borne upon those rates, it may be advisable to exclude the cost of pumping from the rates for excavation, and provide specific items for supplying and/or installing and dismantling pumps of specified capacity (per pump), for pumps working (per hour), and for pumps standing by (per hour).

42. *Breaking up old Structures*

The unit of measurement for the breaking up of brickwork, concrete, masonry and the like encountered in excavation is to be the cubic metre, and the work is to be measured extra over the excavation in which it is contained.

Separate items provided for breaking up old structures should follow the item for excavation in which the old structures occur.

EXPLANATORY NOTES

The conditions under which separate pumping items are provided and the form which they take are worthy of note.

The unit of measurement for breaking up concrete, brickwork and masonry, to be carried out as part of excavation work, is the cubic metre, measured as 'extra over' excavation. Thus the volume occupied by the concrete, etc., will not be deducted when measuring the volume of general excavation. The rate to be inserted by the contractor will be the additional cost per cubic metre of breaking-up concrete, etc., over and above the cost of normal excavation work per cubic metre.

43. *Unit and Method of Measurement for Dredging*

The unit of measurement for dredging is to be the cubic metre.

Dredging may be measured from soundings, or by hopper measurements, depending on the circumstances. It should be stated in the bill which method has been adopted.

When measured from soundings, the quantities of dredging are to be calculated by taking the net cubic contents of the voids formed, i.e. measured *in situ*, such quantities being computed by comparing the soundings and levels taken before and after dredging. The limits of tolerance, if any, are to be stated. Only material removed from above the specified level or from above the lower limit of tolerance, as the case may be, is to be included in the measurement.

The two different methods of measurement of dredging should be noted, and it is important that the bill of quantities should state quite clearly which method is being employed.

With the soundings method in particular, it is customary to lay down limits of tolerance, often 300 mm below the specified dredged levels, below which no dredging work will be paid for.

44. *Silting*

Where the contractor is to be responsible for any silting over the dredged area during the period of maintenance, attention is to be specially directed to the fact that this responsibility is to be covered by the rates.

Under some contracts the contractor has to include in his dredging rates for the removal of silt which accumulates over the dredged area during the maintenance period.

45. *Definition of Excavation in Soft and in Hard*

If the strata to be excavated or dredged include both soft material and hard material or rock, then a definition of hard material or rock, drawn up to suit the anticipated local geological

The need to define 'soft' and 'hard' material when they will both be encountered in the excavation work should be noted and also the reference to the

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formation, is to be given. Incidental boulders occurring within the limits of the soft material, if greater than a specified volume, are to rank as hard material or rock; and those of smaller dimensions, as soft material. The assumptions on which the quantities have been divided should be disclosed to firms tendering, but any guarantee that they are correct may be specifically disclaimed.

46. *Disposal of Excavated and Dredged Material*

Where the disposal of excavated and dredged material (other than a comparatively small amount required for back filling) is within the control of the contractor, or where a single place for its disposal is defined by the contract, the cost of such disposal is to be covered by the excavation and dredging rates and it should be so stated in the description of the item.

When the contract provides for more than one place of deposit, the estimated quantity for each place of deposit is to be given and separate items are to be provided for each such place.

The cost of forming the embankments for railways, roads, and other works consisting of an alternation of cuttings and embankments is to be covered by the rates for the excavation of the cuttings or other excavation from which the material is obtained. The quantities and location of each cutting and embankment are normally to be set out in the form of a table.

EXPLANATORY NOTES

local geological formation.

No materials which can be excavated by the use of pick and shovel will normally be regarded as 'rock', nor boulders of 0·30 cu m or under in size.

In the majority of cases the excavation items include the disposal of the excavated material. The principal exceptions to this general rule are where the place of disposal is outside the control of the contractor or where there is more than one disposal point for the excavated material.

In the latter case combined excavation and disposal items can still be used provided that separate items are included for each disposal point.

It will be further noted that in the case of roads, railways and similar projects, where a series of cuttings and embankments are involved along the route, often using the excavated material to form the embankments, then combined excavation and fill rates can conveniently be employed. The use of tables showing the haulage distances and quantities involved in each cutting and embankment is extremely helpful (mass-haul diagrams).

47. *Unit and Method of Measurement for Filling*

When the cost of filling is not included in the excavation rates in accordance with the preceding clause, the unit of measurement of filling is to be the cubic metre. The measurements are to be taken to the outlines and levels shown upon the drawings or specified.

Where a specified extra height and/or width is ordered in a bank for long term settlement the item should state whether the measurement will or will not include such addition to the net drawing dimension.

Where the amount of filling required to be done exceeds the amount available from excavation, separate items are to be provided for the deficit. If the additional filling is obtained from borrow-pits on or near the site of the work it is to be measured in the borrow-pits as excavation. If imported material (not from borrow-pits) is used it may be preferable to measure the actual volume to be filled.

When the quantity of filling entered in a bill of quantities includes allowance for displacement of soft ground, wave action or other source of waste, the quantity, as calculated from the sections above original ground level, is to be stated, the allowance for displacement, wave action or other source of waste being given separately, with an indication as to the method adopted in estimating this quantity.

The various rules for the measurement of filling, where it is not included in the excavation rates, deserve special study. In general, the filling is measured in cubic metres for the total volume to be filled as measured from the drawings, without allowance for consolidation. Where all or part of the filling material is to be obtained from borrow-pits, it is generally best measured in the borrow-pits as excavation.

Note the recommendations relating to allowances for displacement of soft ground, wave action, etc., and for filling on marshy ground.

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Warranty as to the accuracy of the assumptions made should be expressly excluded.

Measurements on marshy ground may be determined by wagon loads or by the use of marker plates, provided that the contractor makes the best use of the material.

Back filling is to be covered by the excavation rates except where special selection is required, in which case separate items are to be provided.

48. *Trimming, Soiling and Sowing*

The unit of measurement for trimming and for soiling and sowing of surfaces, where paid for separately, is to be the square metre, and the thickness of soiling and rate of sowing are to be stated.

Surfaces on the slope, as in the case of railway cuttings and embankments, are to be measured separately from surfaces on the level.

49. *Pitching*

The unit of measurement for pitched slopes is to be the square metre, and the thickness of the pitching is to be stated.

EXPLANATORY NOTES

Superficial items are normally taken to cover trimming and soiling and sowing of surfaces, distinguishing between level and sloping surfaces.

This occurs on river banks, railway cuttings, etc.

GEOTECHNICAL PROCESSES

50. *Application of Section*

Geotechnical processes are to be understood to mean the processes by which the properties of weak rocks and soils are altered *in situ* with the object of increasing their mechanical strength or reducing their permeability.

Specialised work where each method must be separately considered for purposes of measurement.

51. *Method of Measurement and Classification of Items for Geotechnical Processes*

Owing to the specialised nature of the works to which geotechnical processes are generally applied, no one set of units of measurement can be recommended for general use. Separate items should, however, be provided for the transport of plant to and from the site.

In the case of specialised methods of pumping, such as ground water lowering, specific items should be provided for the plant working (per hour) and standing by (per hour).

In certain cases a convenient unit of measurement for injection process is the cubic metre of material treated or quantity of material injected.

A typical bill covering dredging work now follows:

EXAMPLE III

Item	*Description*	*Qty.*	*Unit*	*Rate*	£
	BILL NO. 2 DREDGING The dredging rates shall include for dredging to the areas and levels shown on contract drawings Nos. 1 and 2 and to the limit of tolerance given in the specification with suitable dredging equipment, and for finishing off the bottoms and side slopes of the dredged areas to even surfaces in accordance with the drawings. The rates are to include for dredging in silt, sand, gravel or other soft material				

Item	*Description*	*Qty.*	*Unit*	*Rate*	£
	and for the disposal of the dredged material in a position to be approved by the River Authority.				
	The payments for dredging will be assessed on the number of barge loads of material removed.				
84	Allow for taking soundings before dredging and on completion of the work and for preparing a complete survey from these soundings, to verify the accuracy of the dredging work.		Item		
85	Excavate in river bed using normal dredging equipment and dispose of the dredged material, as described.	64,500	cu m		
	To Summary			£	

MEASUREMENT OF EXCAVATION AND FILLING

Various methods can be used to calculate the volume of excavation and/or filling required as part of civil engineering works. The method used is often largely determined by the type of work involved. Accuracy and speed of operation are the main factors to consider when selecting the method of approach.

When calculating the volumes of excavation and filling for cuttings and embankments to accommodate roads and railway tracks, Simpson's rule can often be used to advantage and a simple example follows to illustrate this point.

Using Simpson's rule the area at intermediate even cross sections (Nos. 2, 4, 6, etc.) are each multiplied by 4, the areas at intermediate uneven cross sections (Nos. 3, 5, 7, etc.) are each multiplied by 2 and the end cross sections taken once only. The sum of these areas is multiplied by 1/3 of the distance between the cross sections to give the total volume. To use this formula it is essential that the cross sections are taken at the same fixed distance apart and that there is an odd number of cross sections (even number of spaces between cross sections).

For instance, taking a cutting to be excavated for a road, 300 m in length and 40 m in width, to an even gradient, with mean depths calculated at 50 m intervals as indicated below and side slopes 2 to 1

Cross section	1	2	3	4	5	6	7
Mean depth (m)	4	10	16	20	18	12	6

The width at the top of the cutting can be found by taking the width at the base, i.e. 40 m and adding 2/2/ the depth to give the horizontal spread of the banks (the width of each bank being twice the depth with a side slope of 2 to 1).

Cross Section	*Depth (m)*	*Width at Top of Cutting (m)*	*Mean Width (m)*	*Weighting*
1	4	40+4/4 = 56	$\frac{56+40}{2} = 48$	1
2	10	40+4/10 = 80	$\frac{80+40}{2} = 60$	4
3	16	40+4/16 = 104	$\frac{104+40}{2} = 72$	2
4	20	40+4/20 = 120	$\frac{120+40}{2} = 80$	4
5	18	40+4/18 = 112	$\frac{112+40}{2} = 76$	2
6	12	40+4/12 = 88	$\frac{88+40}{2} = 64$	4
7	6	40+4/6 = 64	$\frac{64+40}{2} = 52$	1

The dimensions can now be entered on dimension paper in the following way:

EXCAVATION AND FILLING

(cutting for road)

	48·00			
	4·00		Exc. in cuttg.,	(c.s.1.
4/			cart aw. av.	
	60·00		distance of	
	10·00		100m & dep. in	(c.s.2
			300mm	
2/	72·00		consolidated	
	16·00		layers as fillg.	(c.s.3
4/	80·00			
	20·00		cube x 1/3/50·00	(c.s.4
2/	76·00			
	18·00			(c.s.5
4/	64·00			
	12·00			(c.s.6
	52·00			
	6·00			(c.s.7

To avoid a great deal of laborious and unnecessary labour in squaring, all dimensions have been entered as superficial items, to be subsequently cubed by multiplying the sum of the areas by 1/3 of the length between the cross section.

(total weighting is 18 and the number of 50m long sections of excavation is 6, so that 6/18 or 1/3 of the distance of 50m must be the timesing factor required.)

In simpler cases involving three cross sections only, the prismoidal formula may be used, whereby:

$$\text{Volume} = \frac{1}{6} \times \begin{matrix}\text{total}\\ \text{length}\end{matrix} \times \left\{ \begin{matrix}\text{area of}\\ \text{first section}\end{matrix} + \begin{matrix}\text{4 times area of}\\ \text{middle section}\end{matrix} + \begin{matrix}\text{area of last}\\ \text{section}\end{matrix} \right\}$$

EXAMPLE IV (Drawing No. 2)

This example covers the measurement of the excavation and filling required to an area 72 m × 36 m with surrounding banks with side slopes of $2\frac{1}{2}$ to 1. The whole of the area, excluding banks, is to be stripped of surface soil which will mainly be used for soiling the banks to a depth of 150 mm.

The 150·000 contour line is first plotted on the plan as this represents the demarcation line between the excavation and filling. Intermediate points on the contour line are found by interpolating between known spot or ground levels. For instance, taking the two levels in the bottom left-hand corner, (S.W.), the difference between the two adjacent spot levels is 150·860 − 149·285 = 1·575 metres, and the distance of the 150·000 level point from the edge of the area

$$= \frac{0{\cdot}715}{1{\cdot}575} \times 12{\cdot}000 = 5{\cdot}450 \text{ metres.}$$

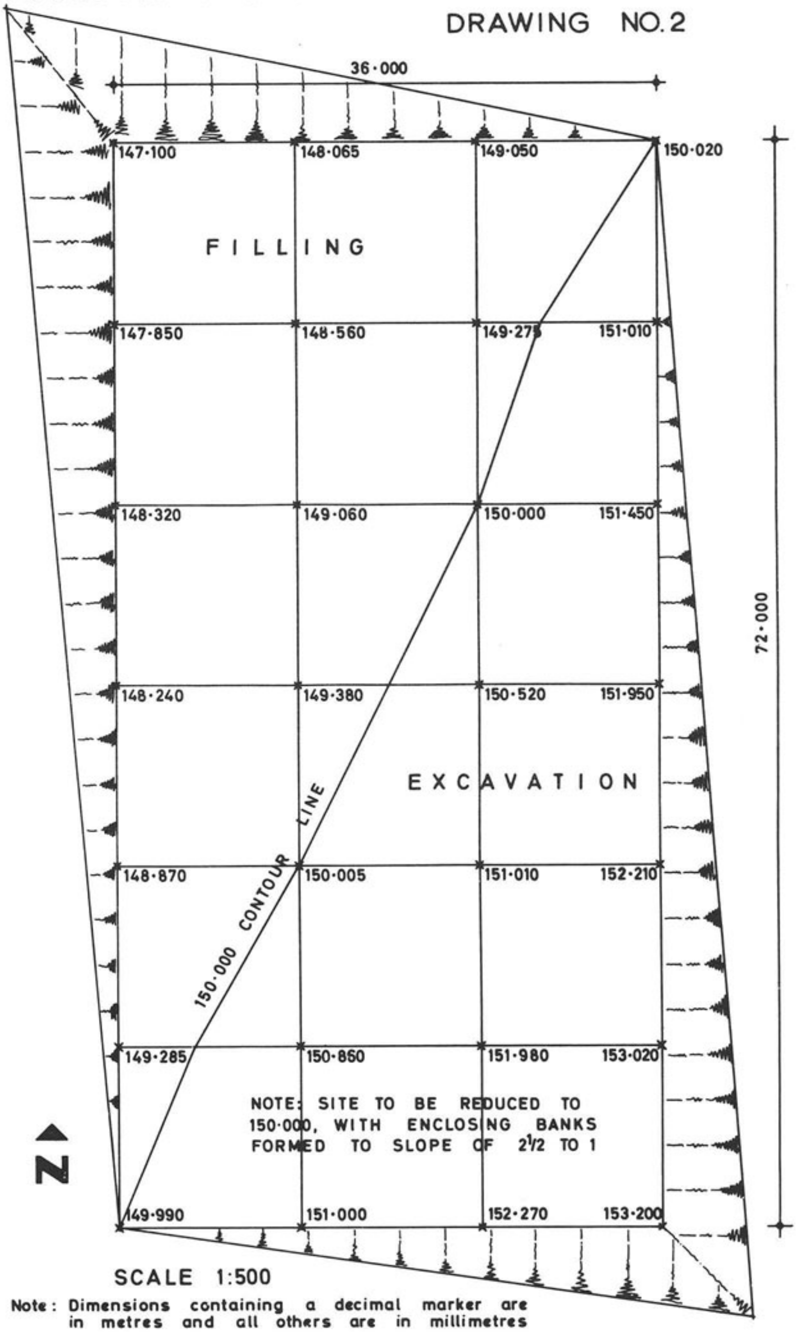
The method of working adopted for this example is to calculate the volumes of excavation and fill in the main area (i.e. 72 m × 36 m) from calculated average depths and to follow with the volumes of the banks. This is the simplest and quickest method although there are many alternative processes. The average depths of excavation and fill are most conveniently found by suitably weighting the depth at each point on the grid of levels, according to the area that it affects. Generally, this involves taking the depths at the extreme corners of the area once, intermediate points on the boundary twice and all other intermediate points four times. The sum of the weighted depths is divided by the total number of weightings (number of squares × 4) to give the average weighted depth for the whole area.

An alternative is to calculate the cross sectional area on each grid line, including the section of adjacent bank, and to weight the areas in accordance with Simpson's rule. The banks at the end of each area would have to be added to the volumes of excavation and fill respectively.

Schedules of depths and the dimensions of excavation and fill now follow.

EXCAVATION AND FILLING

DRAWING NO. 2



SCALE 1:500

Note: Dimensions containing a decimal marker are in metres and all others are in millimetres

EXCAVATION AND FILLING. EXAMPLE IV

AVERAGE DEPTH OF EXCAVATION TO MAIN AREA (EXCLUDING BANKS).

GROUND LEVEL	DEPTH OF EXCAVATN.	WEIGHTING	WEIGHTED DEPTH OF EXCAVATN.	COMMENTS
150·020	0·150	1	0·150	150mm surface strip.
151·010	1·010	1	1·010	To weight this twice would give excessively high excavation quantities
150·000	0·150	3	0·450	150mm surface strip - affects 3 squares.
151·450	1·450	2	2·900	
150·520	0·520	3	1·560	
151·950	1·950	2	3·900	
150·005	0·150	3	0·450	150mm surface strip
151·010	1·010	4	4·040	
152·210	2·210	2	4·420	
150·860	0·860	3	2·580	
151·980	1·980	4	7·920	
153·020	3·020	2	6·040	
149·990	0·150	1	0·150	150mm surface strip
151·000	1·000	2	2·000	
152·270	2·270	2	4·540	
153·200	3·200	1	3·200	
		36	45·310	
	Average depth of excavation		1·258	

Note: The contour line is virtually coincident with the corners of intermediate squares.
The total weighting of 36 is equivalent to 9 complete squares with 4 effective levels to each.

EXCAVATION AND FILLING. (Contd.)

AVERAGE DEPTH OF FILLING TO MAIN AREA (EXCLUDING BANKS)

GROUND LEVEL	DEPTH OF FILL	WEIGHTING	WEIGHTED DEPTH OF FILL	COMMENTS
147·100	2·900	1	2·900	
148·065	1·935	2	3·870	
149·050	0·950	2	1·900	
150·020	–	1	–	negligible quantity.
147·850	2·150	2	4·300	
148·560	1·440	4	5·760	
149·275	0·725	3	2·175	
148·320	1·680	2	3·360	
149·060	0·940	4	3·760	
150·000	–	3	–	
148·240	1·760	2	3·520	
149·380	0·620	3	1·860	
148·870	1·130	2	2·260	
150·005	–	3	–	negligible quantity.
149·285	0·715	1	0·715	
149·990	0·010	1	0·010	
		36	36·390	
	Average depth of fill		1·011	
	Add replacement of surface soil.		0·150	Much more convenient to add the additional 150mm at the end, rather than adding it to each individual depth.
	Average total depth of fill.		1·161	

EXCAVATION AND FILLING (Contd.)

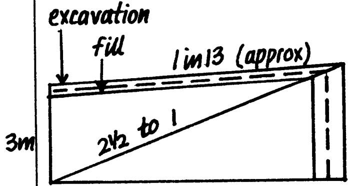
			Excavn. (main area)	
½/	72·00 36·00 1·26		Exc. to red. levels n.e. 3m dp. & remove from site.	Total volume of excavation to main area, using average depth previously calculated. Dimensions are recorded to the nearest 10 millimetres. Note that excavation and disposal of the excavated soil are combined in the same item.
½/	72·00 36·00		E.o. last for exc. top soil av. 150mm dp., & dep. for re-use in soilg. banks.	Where the top soil is to be re-used, a superficial "extra over" general excavation item is required.
			Fill (main area)	
½/	72·00 36·00 1·16		Ddt. Exc. to red. levels n.e. 3m dp. & remove from site. &	
½/	81·00 2·00 0·08		Add Exc. to red levels & transport av. dist. of 50m & dep. in 300mm consolidated layers as fillg. (surf. strip on (excavn. area.	Adjusted mean diagonal length taken here. Strip 2m wide, average depth 75mm, on right-hand side of contour line.

EXCAVATION AND FILLING (Contd.)

½/	72·00 36·00		Exc. top soil only, av. 150mm dp., transport av. dist. of 80m & dep. in spoil heaps.	This superficial item covers the stripping of vegetable soil over the area to be filled. This cannot feasibly be measured as "extra over" general excavation, as there is no general excavation to be performed over this area, and shallow surface excavation cannot be regarded as excavation to reduce levels.

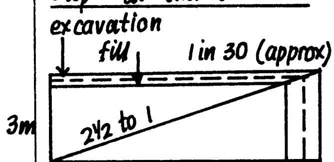
Banks

Slope at side of area.



add for	8·700	9·600
additional len.	1·000	1·000
	9·700	10·600
	exc.	fill
av. width	5·300	4·850
av. height.	1·950	1·800

Slope at end of area.



	7·900	8·500
	exc.	fill
av. width	4·250	3·950
av. height	1·650	1·500

Sections have been drawn with the approximate slope of the natural ground shown, in order to obtain the correct overall dimensions of the bank. It has been assumed that the top of the bank will finish against a straight line running from one end to the other, as the fall of the ground is fairly constant.

EXCAVATION AND FILLING (Contd.)

			Excavn. to banks	
½/	81.00 5.30 1.95		Exc. to red. levels n.e 3m dp. & remove from site. (side.	Additional length of bank to the side of the area (9m) is added to pick up the overlap of the banks at the high corner. The average width and height are taken in each case.
½/	36.00 4.25 1.65		(end.	
			Fill to banks	
½/	81.00 4.85 1.80		Ddt. ditto. & Add. Exc. to red levels & transport av-dist. of 50m & dep. in 300mm consolid'td. layers as fillg. (side.	
½/	36.00 3.95 1.50		(end.	
			Bank slopes	
½/	81.00 10.36		L. trimming bank to slope of 2½ to 1.	Average width of slope taken in each case.
½/	36.00 9.15		& Soilg. banks 150mm dp., wi. soil from spoil heaps, & apply fertiliser & seed at the rate of 0.05kg/sq.m, all as specified.	Not required to separate slopes to cuttings from those to embankments. S.M.M. of C.E.Q., clause 48 requires rate of sowing to be stated, although this would invariably be given in the specification.
½/	81.00 9.45			
½/	36.00 8.50			

VII – Measurement of Concrete Work

(including shuttering and reinforcement)

CLAUSES 52 to 63 of the *Standard Method of Measurement of Civil Engineering Quantities* cover the measurement of this class of work. It is another lengthy section and is quoted in full with accompanying explanatory notes. This will be followed by three worked examples covering the 'taking-off' of quantities of mass, reinforced and prestressed concrete.

CLAUSES FROM THE *S.M.M. of C.E.Q.* — EXPLANATORY NOTES

CONCRETE

52. *Application of Section*

The section applies to concrete work generally, but excludes concrete piles (see clause 79). The following are explanations of certain terms used in the section:

Reinforced concrete is to be understood to mean concrete reinforced with steel bar or rod and/or fabric reinforcement.

Prestressed concrete is to be understood to mean concrete upon which an initial internal distribution of stress has been imposed in such a way that a more favourable state of stress is achieved when the working loads are applied.

Note the definitions of 'reinforced concrete' and 'prestressed concrete'. 'Mass concrete' contains no steel reinforcement at all.

The measurement of concrete piles will be dealt with in Chapter X.

53. *Classification of Items for Concrete Construction*

Separate items are to be provided where differing methods of construction are involved in different parts of the work. Thus it is necessary to distinguish between the following classes of concrete:

Mass concrete placed *in situ.*
Reinforced concrete placed *in situ.*

The different methods of classifying concrete and associated work should be carefully studied, as these all involve separate items in the bill of quantities.

Prestressed concrete placed *in situ*.
Precast concrete (mass, reinforced or prestressed).

For each of the above classes of *in situ* concrete construction an item shall be provided for the concrete itself (see clause 54), and it shall include the mixing, placing and compaction of the concrete. In addition, separate items shall be provided for:

Shuttering (see clause 57).
Facework (see clause 58).
Steel (see clauses 59 and 60).
Tensioning prestressed concrete (see clauses 61 and 62).
Fixing ironwork (see clause 63).

The items for precast concrete shall be subdivided as shown in clause 55. The rates for precast concrete are to cover the cost of moulds.

In all classes of concrete separate items are to be provided for:

(1) Different qualities of concrete.
(2) Structural elements such as columns, beams, slabs, framework and panels.
(3) Concrete 300 mm thick or under, indicating the thickness and whether vertical, sloping or horizontal.
(4) Concrete deposited under water or between tides, the levels of demarcation being stated.
(5) Generally where the cost of depositing concrete or fixing precast work is affected by its position in the work.

Note the separate items to be provided within each class of concrete (mass, reinforced, prestressed, etc.) according to the quality of concrete and the use to which it is to be put. The term 'different qualities of concrete' covers different types of cement or aggregate, different mixes, and different sizes and gradings of aggregate.

Item (5) is particularly important and sometimes passes unnoticed. For example concrete laid in an upper floor slab in a high building will cost more than concrete of the same quality provided in the ground floor slab, due to greater handling costs, etc., and separate billed items are therefore required. Concrete laid in very

CLAUSES FROM THE *S.M.M. of C.E.Q.*

EXPLANATORY NOTES

small quantities is more expensive than when provided in much larger volumes and should accordingly, be kept separate. Similarly, with concrete placed at varying levels in relation to tides in sea and river works.

54. *Methods of Measurement and Units of Measurement of Concrete placed 'in situ'*

No deductions in the measurement of concrete are to be made for small cavities, chamfers, nosings, bolt-holes, rails, joists, reinforcement or the like.

The voids in concrete for chamfers, chases, joists, reinforcement and the like are quite small and do not justify deduction from the total volume of *in situ* concrete, as the resultant saving in cost would be very small indeed.

The units are to be:

Mass concrete ... Cubic metre

Reinforced concrete, Prestressed concrete ... Cubic metre

Concrete in slabs, floors and roofs not exceeding 300 mm in thickness, the thickness being stated ... Square metre or cubic metre

It will be noted that *in situ* concrete in slabs, roofs and floors, not exceeding 300 mm in thickness, may be measured in square metres or cubic metres with the thickness stated. It generally helps the estimator if they are measured in square metres.

55. *Classification of Items and Units of Measurement of Precast Concrete*

The units of measurement for precast concrete are to be:

Beams, columns, copings, altars, steps, kerbs, dressings and the like ... Linear metre or cubic metre or number

Quoins, etc., may either be measured as extra over or by number, the overall sizes being stated in each case.

Slabs, as in the case of pavings and

A variety of units of measurement are given for the main items of precast concrete work. The actual unit of measurement be to used will be largely determined by the type and size of unit under consideration.

It will be noted that concrete blockwork for quay walls, etc., is to be measured in cubic metres, landings, the thickness of the slab being stated. ... Square metre

The unit of measurement for concrete blockwork for quay walls, docks, breakwaters and the like is to be the cubic metre, and the size and approximate weight of the blocks are to be stated.

Concrete blockwork is to be measured as set in the work, the volume of the joint being included in the measurement.

Separate items are to be provided for the two classes of material in a composite wall formed partly of blockwork and partly of *in situ* concrete.

A separate item is to be provided for joggles and dowels measured as 'extra over' blockwork.

The rates for precast concrete are to cover the cost of moulds.

including the width of one joint in each direction, with any concrete backing separately measured. Where a comparatively thin facing of precast concrete blocks is to be provided to a concrete wall, then these would be measured in square metres as 'extra over' the concrete, in accordance with clause 58(c). Joggles and dowels are taken as a separate item as 'extra over' blockwork.

56. *Classification of Items and Units and Measurement of Precast Prestressed Concrete*

The units of measurement for precast prestressed concrete are to be:

(*A*) (i) Factory made precast members pre-tensioned, supplied and delivered, including steel
... Linear metre or cubic metre or number

(*A*) (ii) Site made precast members, pre-tensioned (steel to be measured separately) ... Linear metre or cubic metre or number

(*B*) Precast members to be post-tensioned, supplied and delivered
... Linear metre or cubic metre or number

(*C*) Assembly and post-tensioning of item (*B*) (steel to be measured separately) ... Number of assemblies

The method of classification and units of measurement to be used for precast prestressed concrete deserve special study, as this class of concrete is now being used to an increasing extent. It will be noted that, in the case of the enumerated assembly and erection items, the cross sections and lengths of the units concerned are to be given.

The introduction of generally accepted definitions for 'post-tensioning' and 'pre-tensioning' at this stage might prove useful to some readers.

'Post-tensioning' is a method of

CLAUSES FROM THE *S.M.M. of C.E.Q.*

(*D*) Erection of members of items (*A*) and assemblies item (*C*)

. . . Number

The rates for assembly and erection are to include the cost of jointing. Separate items are to be provided for units of differing cross-sections and lengths, the cross-sections and lengths being stated. The costs of moulds and concrete are to be included in the rates for members.

57. *Classification of Items, Methods of Measurement and Units of Measurement of Shuttering for 'in situ' Concrete*

The term 'shuttering' is to be taken to include centering, formwork and the like. The rates for shuttering are to cover the cost of all parts in contact with the concrete and the necessary bearers, struts and other supports.

Shuttering is to be measured as the area of the finished structure which requires to be supported during the deposition of the concrete. The cost of the shuttering required to form the construction joints, skew-backs, stunt-ends, steppings, bonding chases and the like, which may be necessary to uphold the concrete during the operations of deposition and setting, is to be covered by the rate for the concrete and no measurement of shuttering is to be taken in these cases.

Separate items are to be provided for rough and wrought shuttering and for shuttering to vertical, horizontal, battered, curved, arched, domical and other types of work. All shuttering of 300 mm in width or under and all

EXPLANATORY NOTES

prestressing in which tendons are tensioned after the concrete has hardened.

'Pre-tensioning' is a method of prestressing in which tendons are tensioned before the concrete is placed.

A 'tendon' is a stretched element used in a concrete member of a structure to impart prestress to the concrete and is normally of steel.

Bearers, struts and other supports to formwork are not separately measured, but are included in with the superficial item of shuttering measured on the face in contact with the concrete. The unit of measurement to be used for shuttering work generally is not specifically stated, but the square metre is normally used in practice, except where the width of the shuttering does not exceed 300 mm when it is measured by the linear metre.

Separate items are to be provided for rough or sawn and wrot or planed shuttering and for shuttering in different planes, such as horizontal, vertical, battered, curved, etc.

One further important provision in clause 57 relates to the measurement of shuttering to certain structures, such as fillets or splays over 50 mm wide on the splay are to be measured separately by the linear metre, the width being stated. In general, the items of shuttering should immediately follow the items of concrete to which they relate.

Separate items are to be provided for forming holes for pipes and the like and measured by number; no deduction is to be made from the measurements of shuttering in respect of such holes.

Where the cross-section of the concrete is reasonably uniform throughout the length of the proposed structure, or where the area of shuttering is constant in relation to the cubic content of the concrete to be supported (as, for example, in tunnels, retaining walls and the like), separate items need not be provided for the shuttering, the cost of this work being covered by the rate for the concrete. In these cases the description attached to the item of concrete is to make it clear that allowance for shuttering is to be made in the rate for the concrete.

tunnels, culverts and retaining walls, where the area of shuttering is constant in relation to the volume of the concrete. In these circumstances the shuttering can be included in the appropriate concrete items.

58. *Classification of Items and Unit of Measurement for Facework*

The unit of measurement for facework is to be the square metre measured extra over the concrete.

Separate items are to be provided in the following cases for exposed faces:

(a) Where a finish different from that obtained by the ordinary methods of depositing concrete against shuttering is required.

(b) Where a superior quality of concrete is to be used for the facework, the thickness of the face concrete being stated.

Clause 58 lays down the various methods of construction which involve the separate measurement of facework. In all cases the facework is measured in square metres as 'extra over' the concrete, and the concrete is, accordingly, measured for the full volume of the work, up to the exposed face and including the facework.

CLAUSES FROM THE *S.M.M. of C.E.Q.*

(c) Where a facing of brickwork or stonework is adopted, the average thickness of the brickwork or stonework being stated.

59. *Units of Measurement for Steel*

The units of measurement for steel are to be:

Rounds, rails or other steel sections introduced into mass concrete ... Megagramme

Bar or rod reinforcement ... Megagramme

Fabric reinforcement ... Square metre

Steel wire or cable for prestressing on site ... Megagramme or linear metre

60. *Classification of Items and Method of Measurement for Steel*

Bar or rod reinforcement and steel wire or cable for prestressed concrete are to be measured according to the weight as calculated from the drawings or specified, the basis of the calculated weights being that steel weighs 0·785 kg per sq cm of normal cross-sectional area per linear metre, no allowance being made for waste or rolling margin.

Wire or other material required for binding or supporting the reinforcement is not to be measured, but its cost, as well as that of bending, hooking and all other work in providing and fixing the reinforcement as shown on the drawings or specified, is to be covered by the rates for the bars or rods.

Where special supports are required to top reinforcement, they should be shown on the drawings and measured separately.

EXPLANATORY NOTES

Steel reinforcement to concrete is measured by weight, in megagrammes, except in the case of fabric reinforcement, which is measured by the square metre, with the weight per square metre stated in the description.

Clause 60 fully details the method of measurement of reinforcing steel bars, rods, wires and cables.

The steel reinforcement rates are to include for all bending, hooking and fixing of the rods or bars and provision of tying wire, and no allowance is to be made for waste or rolling margin. Rods or bars serving a similar purpose and of 25 mm diameter or side and upwards can be grouped together in a single item. Separate items are, however, to be provided for rods and bars 12 m in length or over, taken in 1·50 m stages, i.e. exceeding 12 m and not exceeding 13·50 m, exceeding 13·50 m and not exceeding 15 m, etc.

The weights of bars or rods of differing sizes, but otherwise of the same description in regard to their position in the work, the labour involved and the fixing, may be added together and given as one item, except that for rods or bars less than 25 mm in diameter or side, separate items are to be given for each size.

Separate items are to be provided for bars or rods 12 m in length and upwards, in steps of 1·50 m.

Fabric reinforcement is to be measured as the area of work covered, the weight in kg per square metre of fabric being stated.

Allowance for the extra material at laps, for cutting the fabric to the sizes required, and for bending, binding and waste, is to be made in the rates. The amount of lap is to be stated.

Separate items are to be provided for steel wire for prestressing of differing cross-section, and for cables of differing construction, the length and form of construction being stated. The rates for the wire or cables are to include all waste.

Billed descriptions of reinforcement must always distinguish between circular reinforcing members and those of square section. The latter members are now being increasingly used because of their better bonding characteristics with the concrete. In the examples that follow the term 'rod' has been used to cover round reinforcement to tie up with this clause, although in practice the term 'bar' is now used extensively to cover both round and square reinforcement.

61. *Classification of Items and Units of Measurement for Post-Tensioning on Site*

The separate items and units of measurement are to be:

Forming holes including, where necessary, ducts, casings, sheathing or chases ... Linear metre
Anchorages, including fixing ... Number
Tensioning ... Number of wires or cables
Grouting of cables ... Linear metre

Note the item for measuring the formation of ducts, etc., in members to be post-tensioned on the site as this is extremely expensive work.

Where proprietary forms of anchorage are used, the anchoring procedure must be carried out strictly in accordance with the manufacturer's instructions and recommendations.

CLAUSES FROM THE *S.M.M. of C.E.Q.*

Pneumatic mortar (the thickness being stated) ... Square metre

Bringing plant for tensioning to the site and removing it ... Lump sum

Separate items are to be provided for post-tensioning and pre-tensioning and for longitudinal and transverse tensioning.

62. *Units of Measurement for Pre-tensioning on Site*

The units of measurement are to be:

Tensioning, including the temporary and permanent anchorages ... Number of wires or cables

63. *Classification of Items and Units of Measurement for Fixing Ironwork in Concrete*

Separate items are to be provided for any additional work in the deposition, formation and shuttering of the concrete which is incidental to the fixing of iron and steel. The units of measurement are to be:

Bedding or grouting of base plates ... Square metre

Mortices for bolts, and grouting ... Number

Separate items are to be provided for mortices for bolts which do not exceed 100 mm in depth, for those which do not exceed 200 mm in depth, and so on in steps of 100 mm up to 300 mm, thereafter in steps of 300 mm.

EXPLANATORY NOTES

The normal form of tensioning apparatus consists of hydraulic jacks, although weights and/or levers are sometimes used.

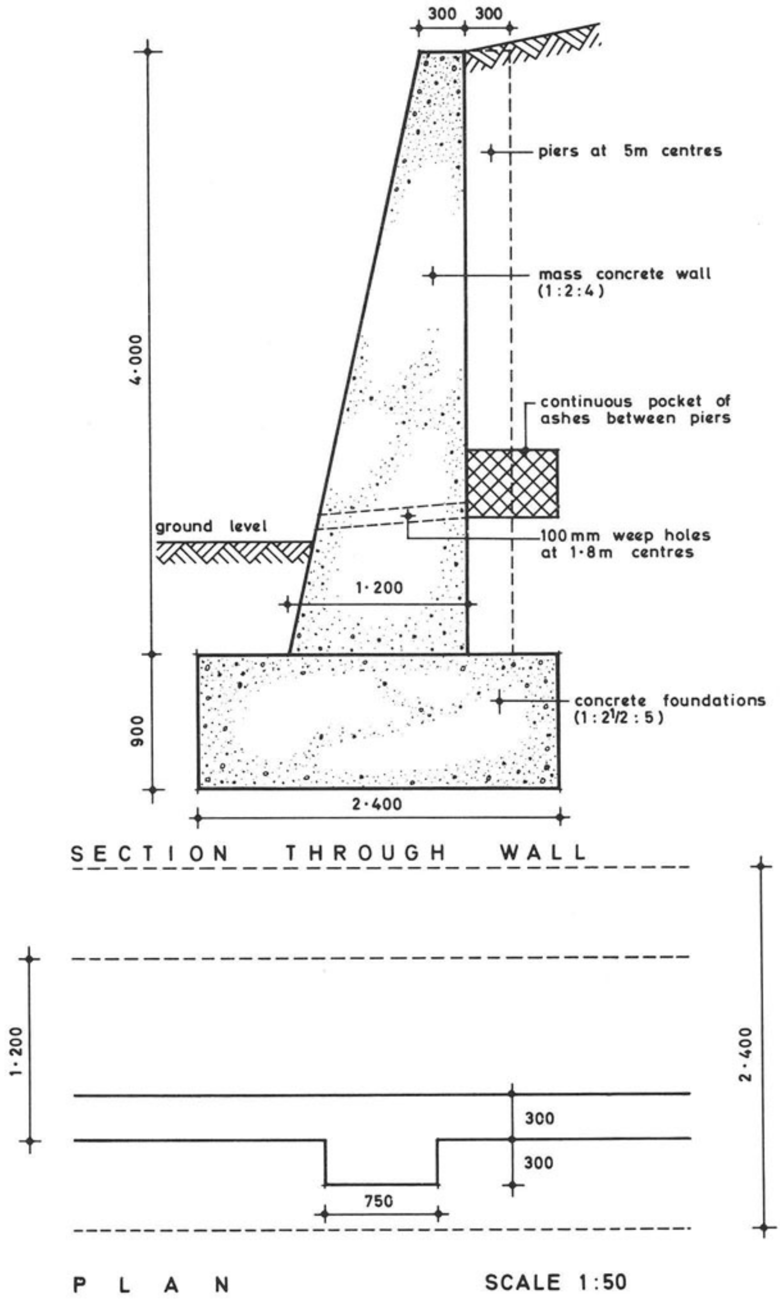
Note the stages into which the formation of mortices in concrete for bolts and including the grouting of the bolts are to be classified, as separate enumerated items.

MASS CONCRETE RETAINING WALL. EXAMPLE V

For the purpose of this example a 30 m length of wall has been taken and the excavation dimensions have been omitted.				Note: the principles adopted in this example would apply equally well to the measurement of reservoirs, settling tanks, bridge abutments, etc. built in concrete.
	30·00 2·40 0·90		Conc. (1 : 2½ : 5) in ret. wall fdn.	Always give the class or mix or strength of concrete and the use to which the concrete will be put when it affects the price.
			piers 5) 30 6+1 1·200 300 2) 1·500 750	Note the extensive use of abbreviations and the standard order of dimensions, ie, length, breadth and height.
	30·00 0·75 4·00		Conc. (1:2:4) in ret. wall, av. 750 mm th. & attached piers.	Piers taken at both ends of retaining wall. The thickness of the wall determines the amount of tamping or vibrating that has to be carried out for a given volume of concrete - this affects the price and the thickness should be stated in the description of the item.
7/	0·75 0·30 4·00		(piers.	
2/	30·00 0·90		Sawn vert. shuttg. to sides of fdn. (Provsnl.)	This has been taken as a "provisional" item as it is not absolutely clear from the drawing just how much shuttering will be required.

MASS CONCRETE RETAINING WALL

DRAWING NO. 3



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MASS CONCRETE RETAINING WALL (Contd.)

	30·00 4·10		Wrot battered shuttg. to face of ret. wall & E.o. conc. for finishg. battered surf. of wall to a smooth fin. in accordance wi. the specfn. less piers 7/750 30·000 5·250 24·750	Wrot shuttering has been taken for the full height of the wall, as it would probably be difficult to use sawn shuttering for the bottom section below ground only and it will avoid any snags arising from variations in the finished ground level. Note longer length on sloping face (scaled from drawing).
	24·75 4·00		Sawn shuttg. to vert. face of ret. wall.	
7/	0·75 4·00		Ditto. to face of attached piers.	The shuttering to the face of the piers has been kept separate from that to the wall face, as the narrower width will almost certainly result in a higher unit cost.
7/2/	4·00		Sawn vert. shuttg. 300mm wide to sides of attchd. piers	This item is measured as a lineal item, as it does not exceed 300mm wide. Alternatively, the provision of all shuttering can be included in the concrete rates.

MASS CONCRETE RETAINING WALL (Contd.)

			1·8)30 17	
17/	1		Provide & b.i. 100mm dia. clayware land drain pipes, 1m lg. on rake, thro. mass conc. wall, incl. circ. cuttg. to shuttg. at both ends and all nec. tempy. supports	
	24·75		Provide continuous pocket of ashes behind wall, between piers, in line wi. weep holes, approx. 450 x 600mm in section.	Note: If expansion jointing was required between the various sections of wall, the non-extruding expansion jointing for the full cross-sectional area would normally be measured in square metres, with the strip of sealing compound on the outer face of the wall taken as a lineal item.

REINFORCED CONCRETE PUMPING CHAMBER

			Excavn.
			175 3·500 750 4·425 *Less* 350 4·075
	3·40 3·00 4·08		*Exc. for pumpg. chbr., n.e. 6m dp. & remove from site.*
			3·400 3·000 2/6·400 12·800
	12·80 4·08		*Allow for any additnl. excavn. reqd. to provide workg. space, etc. for the constn. of the pumpg. chbr. (mesd. as sum of areas of sides of excavn.)*
			Conc. & Shuttg.
			750 75 675
	2·80 2·40 0·68		*R. Conc. (1:2:4) in base to pumpg. chbr.*
			600 900 150 1·650
	1·65 1·20 0·23		*Ddt ditto.* *(area ard.* *(plant fdn.*

EXAMPLE VI

Excavation for pits, etc. is measured the total depth, but taken in 3m stages in the description. It is not considered necessary to separate the top soil for subsequent re-use, due to the small quantity involved. If extremely wet ground is likely an item for "extra-over" excavation for de-watering by well-point pumping system might be taken.

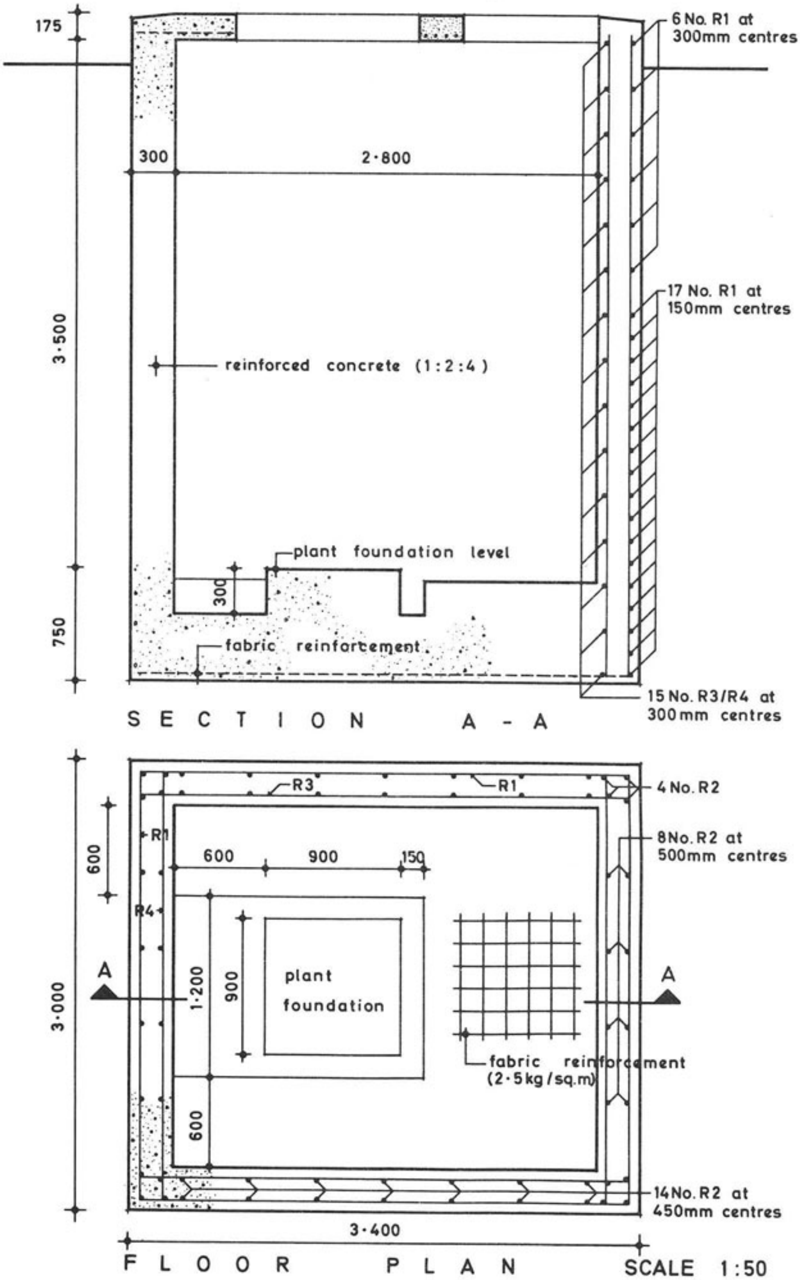
In accordance with clause 40 of the Standard Method of Measurement of Civil Engineering Quantities.

Note: The principles of measurement adopted in this example would be equally applicable to reinforced concrete reservoirs, settling tanks, cooling towers, culverts, etc.

Concrete in bases kept separate from that in walls. Concrete laid under differing conditions involves different costs and so requires separate billed items.

Note the use of the word "reinforced" in the description to cover the cost of the additional labour in tamping concrete around reinforcement.

PUMPING CHAMBER DRAWING NO. 4

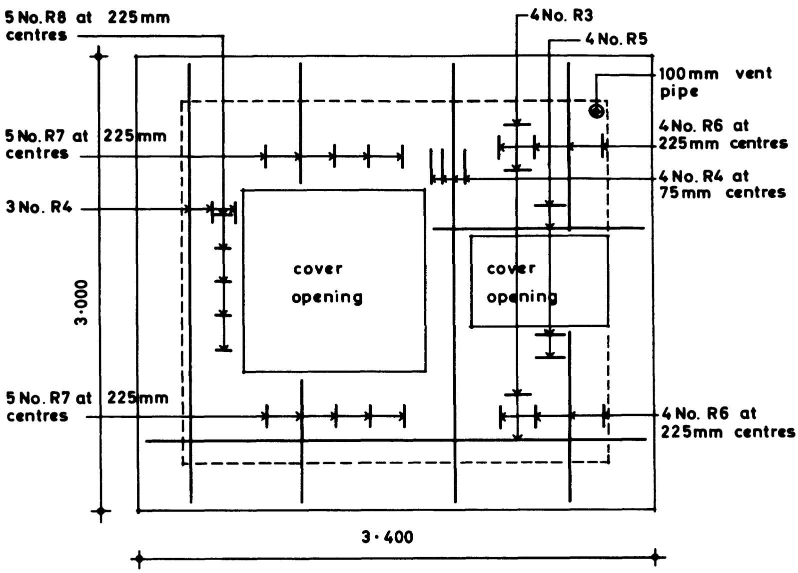


PUMPING CHAMBER DRAWING NO.5

BAR SCHEDULE

Note: All bars are 12mm diameter

BAR REFERENCE	SHAPE OF BAR	LENGTH	TOTAL NUMBER
R 1	L SHAPED 1·650 1·800	3·450	92
R 2	STRAIGHT (in two lengths)	2·500	120
R 3	STRAIGHT	3·300	34
R 4	STRAIGHT	2·900	37
R 5	STRAIGHT	1·400	4
R 6	STRAIGHT	1·100	8
R 7	STRAIGHT	800	10
R 8	STRAIGHT	600	5



ROOF PLAN SCALE 1:50

REINFORCED CONCRETE PUMPING CHAMBER (Contd.)

	0·90 0·90 0·30		R. Conc. (1:2:4) in s.q. in plant fdn. in base of pumpg. chbr. 2/1·650 3·300 1·200 4·500	Concrete in small quantities kept separate from the larger items, as costs are likely to be higher.
	4·50		Wrot. vert. shuttg., 225mm hi., to sides of sump in base of pumpg. chbr.	Shuttering, not exceeding 300mm in width, is measured in linear metres.
4/	0·90		Wrot. vert. shuttg. 300mm hi., to sides of plant fdn. in base of pumpg. chbr. 3·400 3·000 less 2/40 80 80 3·320 2·920	The cost of shuttering is high and shuttering in different locations and serving different functions must be kept separate, as widely varying costs are involved.
	3·32 2·92		Steel fabric reinft., weighg not less than 2·50kg/sq.m in base of pumpg. chbr., wi 150mm laps at jts.	40mm cover has been allowed to the reinforcement on all edges. Fabric reinforcement is measured the area actually covered in square metres. (See S.M.M. clauses 59 & 60)
	2·80 2·40		Fin hor. surf. of conc., in s.q., to a smooth fin. in accordance wi. the specfn.	
	4·50 0·23 3·60 0·30		E.o. conc. for fin. vert. surfs. in n.w. to ditto.	See S.M.M. clause 58.

REINFORCED CONCRETE PUMPING CHAMBER (Contd.)

			3·500 750 4·250	
			2·800 2·400 2/ 5·200 10·400 add corners 4/300 1·200 11·600	Note method of building-up the girth of the chamber wall, measured on its centre line, by taking the internal perimeter and adding the thickness of the wall for each corner.
	11·60 0·30 4·25		R. conc. (1:2:4) in walls to pumpg. chbr., 300mm th.	
			11·600 add 4/300 1·200 12·800 Less part above g.l. 4·250 225 4·025	Note build-up of external girth of pumping station. Alternatively, the external dimensions of the chamber could be taken:- 3·400 3·000 2/ 6·400 12·800
	12·80 4·03		Sawn shuttg. to vert. face of walls to pumpg. chbr. (Ext.	
	12·80		Wrot. vert. shuttg. to ditto., 225mm hi.	Taking smooth face of concrete to 75mm below ground level - is a lineal item as it does not exceed 300mm in width.
			3·500 75 3·575	
			11·600 less 1·200 10·400	

REINFORCED CONCRETE PUMPING CHAMBER (Contd.)

	Dimensions		Description	Notes
	10·40 3·58 1·20 0·23		Wrot. vert. shuttg. to face of walls to pumpg. chbr. (Int. (side of sump	Note that the items of shuttering follow the concreting items to which they relate and this procedure will be followed in the finished bill.
	12·80 0·23 10·40 3·58 1·20 0·23		E.o. conc. for fin. vert. surfs to a smooth fin. in accordance wi. the specfn. (Ext. (Int. (Sump.	
	3·40 3·00		R. conc. (1:2:4) in cover slab to pumpg. chbr., 175mm av. th., wi. upper surf. to falls & E.o. conc. for fin. upper surf. of cover slab to a smooth fin. in accordance wi. the specfn.	
	1·20 1·20 0·90 0·60		Ddt both last. (cover (opgs	The concrete is adjusted for all openings, other than for pipes and similar small apertures.
	2·80 2·40		Wrot shuttg. to soff. of cover slab to pumpg. chbr. (3·58m above base to chbr) (opg. datd.) & E.o. conc. for fin. soff. of cover slab to smooth fin. a.b.	Height above base is given as this determines the length of struts required and has an important bearing on cost. Alternatively the height could be given in 1·50m stages when exceeding 3·50m as in the building method.

REINFORCED CONCRETE PUMPING CHAMBER (Contd.)

	Dimensions		Description
	1·20 1·20 0·90 0·60		Ddt. last 2 items (cover opgs.
			1·200 1·200 2/2·400 = 4·800 900 600 2/1·500 = 3·000
	4·80 3·00		Wrot shuttg. to edges of opgs. in cover slab 175mm hi.
	12·80		Wrot. shuttg. to edges of cover slab, 150mm hi.
	4·80 0·18 3·00 0·18 12·80 0·15		E.o. conc. for fin. vert. surfs. in n.w. to a smooth fin. a.b.
	1		Form hole in 175mm R. conc. cover slab for 100mm pipe, incl. circ. boxg.

In practice the shuttering would probably be erected over the whole area of the soffit of the cover slab, including the openings. Furthermore, if shuttering is deducted for the area of the openings, then the question of cutting the shuttering around the opening arises. The S.M.M. gives no guidance as to cutting. The alternative is to make no adjustment for the opening (See Example IX). The cover slab would be constructed later than the walls, after the plant has been installed – hence the need for the separate 150mm strip of shuttering to the edge of the cover slab.

REINFORCED CONCRETE PUMPING CHAMBER (Contd.)

			Reinft.	
			R3 R4	
			34 37	
			less rods in cover slab. 4 7	
			30 30	
92/	3·45		12mm ϕ m.s. rods in walls to pumpg. chbr.	(R1.
120/	2·50			(R2.
30/	3·30			(R3.
30/	2·90			(R4.
4/	3·30		12mm ditto in cover slab to do.	(R3.
7/	2·90			(R4.
4/	1·40			(R5.
8/	1·10			(R6
10/	0·80			(R7
5/	0·60			(R8

Reinforcement in different positions in the work is kept separate due to the varying costs involved.
Check the bar bending schedule against the drawings before extracting the quantities from it. If no schedule is supplied then it will usually be necessary to prepare one.
40mm cover is provided to the reinforcement, unless otherwise specified and the normal allowance for hooked ends is an addition of 12 times the diameter of the rod for each hooked end.
The total length of rod will be weighted up, usually on abstract sheets and billed in megagrammes.
The cost of forming bends, hooks, etc. is to be covered by the rates for the reinforcement.
Note: the term "rod" has been used for the purpose of this example to cover round bars to tie up with clause 60 of the S.M.M. of C.E.Q.
In practice the term "bar" is now frequently applied to both round and square bars.

PRESTRESSED CONCRETE BEAMS – 15 No.

(Site - made precast post - tensioned)

EXAMPLE VII

The beams are to be precast and post - tensioned on the site.

Prices for the precast beams are to cover all moulds, m.s. reinforcement and anchorage recesses (formation of ducts are m/s.)

Typical preamble clauses are included to give the complete picture.

The forming of ducts, to accommodate the prestressing cables or bars, is a very expensive item and requires separate measurement.

Supply of Beams

Reinft.

"U" bars (12mm)

2/800	1.600
	500
	2.100

2/4/2.100 = 16.800

16.800 x 0.888kg = 14.9kg.

Calculation of weight of secondary reinforcement in a single beam in straight bars, stirrups, links, 'U' bars and spiral reinforcement.

Ends of 'U' bars left projecting to form key for insitu concrete cast on end of beam after stressing.

stirrups (10mm)

	900
	600
2/	1.500
	3.000
less cover 4/2/40	320
	2.680
add laps 2/75	150
	2.830

No.

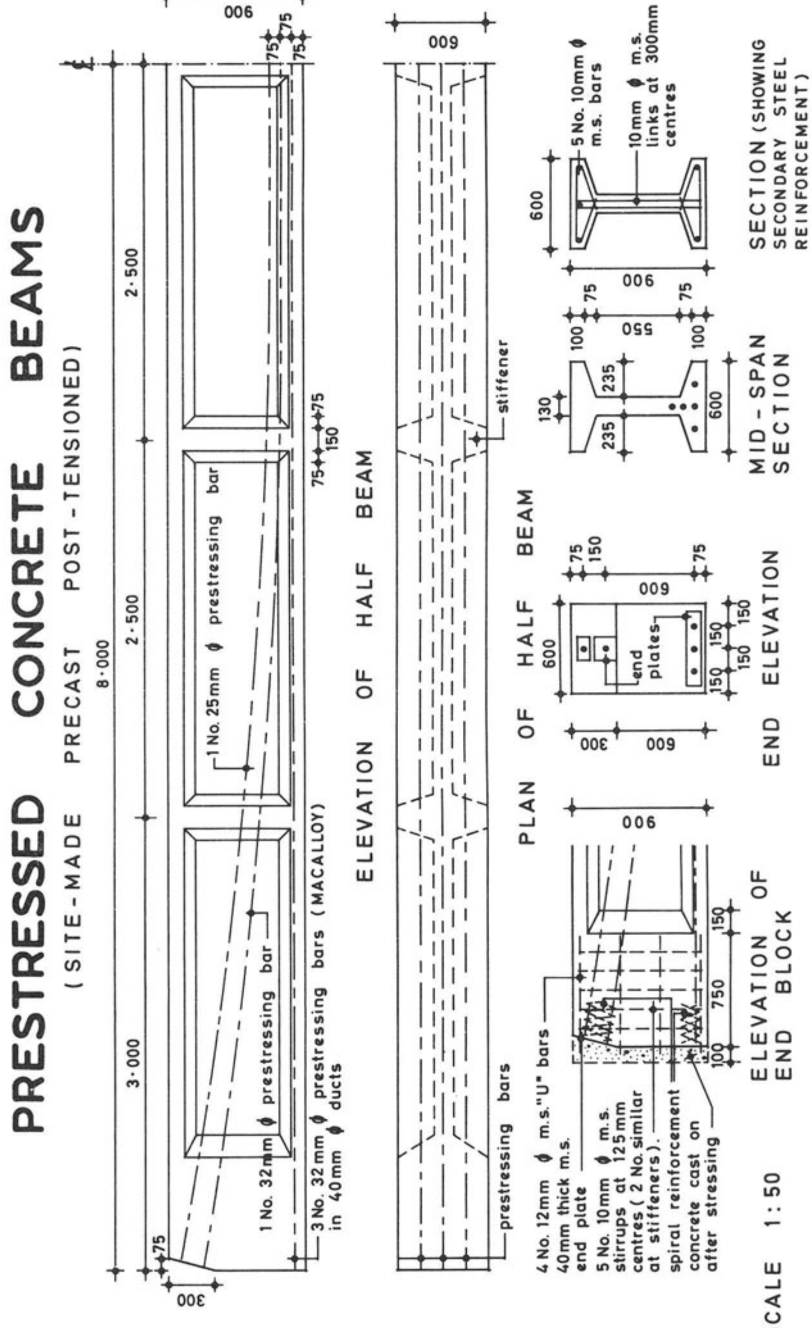
Ends 2/5	= 10
stiffeners 5/2	= 10
	20

20/2.830 = 56.600

56.600 x 0.616kg = 34.9kg

Note: the beams covered by this example would be suitable for use as bridge beams, covering the main spans.

DRAWING NO. 6


PRESTRESSED CONCRETE BEAMS
(SITE-MADE PRECAST POST-TENSIONED)
8·000
3·000
2·500
2·500
900
300
75
150
1 No. 32mm ϕ prestressing bar
1 No. 25mm ϕ prestressing bar
3 No. 32mm ϕ prestressing bars (MACALLOY) in 40mm ϕ ducts
ELEVATION OF HALF BEAM
600
stiffener
prestressing bars
PLAN OF HALF BEAM
4 No. 12mm ϕ m.s."U" bars
40mm thick m.s. end plate
5 No. 10mm ϕ m.s. stirrups at 125mm centres (2 No. similar at stiffeners).
spiral reinforcement
concrete cast on after stressing
750
100
ELEVATION OF END BLOCK
end plates
END ELEVATION
130
235
550
100
MID-SPAN SECTION
5 No. 10mm ϕ m.s. bars
10mm ϕ m.s. links at 300mm centres
SECTION (SHOWING SECONDARY STEEL REINFORCEMENT)
SCALE 1:50

PRESTRESSED CONCRETE BEAMS (Contd.)

Links (10mm)

		820 (ht.)
len.	2/300	600 (width)
	2/350	700 (bend) (&c.)
		2·120

len. of beam	16·000
less ends 2/750	1·500
300)	14·500
	49

49/2/2·120 = 207·760

207·760 x 0·616kg = 128kg.

Some of the links are often extended above the top surface of the beam to act as shear connectors.

strt. bars (10mm)

	16·000
less cover 2/40	80
	15·920

5/15·920 = 79·600

79·600 x 0·616kg = 49·2kg.

spiral reinft. (8mm)

allowing 5 turns
- 150mm dia.

len. of each turn :-

$\pi D = \frac{22}{7} \times 150 = 471$

total len:

2/5/5/471 = 23·550

23·550 x 0·395kg = 9·3kg

PRE	STRES	SED	CONCRETE BEAMS	(Contd.)
15/	1		Supply precast conc. beam, all as specd. in accord. wi. workg dwgs. each 16m in length x 600 x 900mm dp., wi. 2no. end blocks, 750mm lg., recessed for anchorages, & 5no. stiffeners, incl. 15kg of 12mm ϕ 'U' bars, 35kg of 10mm ϕ stirrups, 128kg of 10mm ϕ links, 50 kg of 10mm ϕ strt. bars, 9½kg of 8mm ϕ spiral reinft. & 5cu. m of conc.	Clause 56 of the S.M.M. of C.E.Q., states that precast prestressed members may be measured in linear metres, cubic metres or by number. For the purpose of this example the precast units have been enumerated, as it seemed the only really satisfactory way having regard to the form of construction. These beams have been taken as precast on site and post-tensioned, in order to give practice in the measurement of post-tensioned work, in accordance with clause 61 of the S.M.M. of C.E.Q. Some Contractors might prefer the beams to be precast and tensioned at a manufacturer's works, in which case the formation of ducts, fixing of anchorages, tensioning, prestressing cables or bars and grouting would all be included in the enumerated item covering the precast concrete beams.

PRESTRESSED CONCRETE BEAMS (Contd.)

15/	2		Supply & fix anchorage for 1 No. 25mm ϕ prestressg. bar in accord. wi. manufacturer's details. & Ditto. for 1 No. 32mm ϕ p. bar, do. & Ditto. for 3 No. 32mm ϕ p. bars, do.	The details of the anchorages required will vary with the prestressing system being used. In the Lea-McCall system end plates are usually cast into the concrete and finish flush with the face of the concrete. Another system uses precast concrete cones.
15/5/	16.00		Form 40mm ϕ duct to take prestressg. bar (m/s.)	Measured in linear metres. (See S.M.M. of C.E.Q., clause 61). In some cases the prestressing bars or cables are fixed into the concrete as it is placed and sheathed to prevent adhesion between the steel and the concrete. The sheathing, often of light-gauge steel conduit or lead-coated flexible tubing, will be described and measured in linear metres.
15/	2		Supply & fix liftg. hook, as specd.	

PRESTRESSED CONCRETE BEAMS (Contd.)

15/4/	16·00		Supply & deliver 32mm ϕ high tensile prestressg. bar.	Measured by the megragramme or linear metre (See S.M.M. of C.E.Q., clause 59).
15/	16·00		Ditto., 25mm ϕ do.	With many prestressing systems, a considerable number of wires are used to form prestressing cables but the method of measurement is the same. The price for the prestressing bars or cables includes all waste (See S.M.M. of C.E.Q., clause 60).
			<u>Post Tensiong.</u>	
	Item		Allow for bringing the tensiong. plant on to the site & removg. on completn.	Lump sum item (See S.M.M. of C.E.Q., clause 61).
15/4/	1		Fix & post tension 32mm ϕ prestressg. bar, longit. (16m between anchorages).	Number of wires, cables or bars enumerated. Transverse prestressing has been omitted from this example, but where provided, it would be measured similarly to the longitudinal prestressing bars or cables, but classified as transverse tensioning (See S.M.M. of C.E.Q., clause 61).
15/	1		Ditto., 25mm ϕ do.	

PRESTRESSED CONCRETE BEAMS (Contd.)

15/4/	16·00		Groutg. of 32mm ϕ prestressg. bar wi. c.m.	Measured in linear metres.
15/	16·00		Ditto. 25mm ϕ do.	
15/2/	1		Conc. class 'B', to end of precast beam, 600 x 900 x av. 120mm th., after stressg., incl. all nec. shutterg.	Best enumerated, including the use of shuttering.
15/	1		Hoist & erect stressed precast beam, 16m lg. x 600 x 900mm dp., ov'll., weighg. approx. 12 Mg, about 5m above g.l.	See S.M.M. of C.E.Q., clause 56. It is necessary to include the approximate weight in the description.
	Item		Allow for testg. 1 No. prestressed beam before erection, all as specd.	

VIII – Measurement of Brickwork

CLAUSES 64 to 69 of the *Standard Method of Measurement of Civil Engineering Quantities* lay down the principles to be followed in the measurement of this class of work. This section is now quoted in full accompanied by explanatory notes and this will be followed by two worked examples, covering the measurement of a tall brick chimney shaft and a deep brick manhole.

CLAUSES FROM THE *S.M.M. of C.E.Q.*	EXPLANATORY NOTES

BRICKWORK

64. *Units of Measurement for Brickwork*

The units of measurement are to be:

General brickwork, up to and including 700 mm in thickness, the thickness being stated ... Square metre

General brickwork, exceeding 700 mm in thickness ... Cubic metre

Plinths, corbels, bull-noses, chases and rabbets, measured extra over general brickwork ... Linear metre

Brick copings ... Linear metre

The normal unit for the measurement of brickwork is the square metre, stating the thickness of the brickwork in the description of the item. In no case is it reduced to one brick thick. When the brickwork exceeds 700 mm or three bricks thick the unit of measurement becomes the cubic metre. It will be appreciated that brickwork does not often exceed 700 mm in thickness in practice.

Plinths, corbels, over-sailing courses, chases, rebates and the like are measured by the linear metre, as 'extra over' general brickwork, giving the sectional dimensions in the description. No deduction of general brickwork is made for these features.

The term 'rabbet', or 'rebate' as it is more commonly expressed nowadays, refers to a rectangular recess formed along the edge of brickwork, usually to receive joinery or stone dressings. A 'chase' is a channel or groove formed or cut in the brickwork, as required to take the edge of a suspended concrete slab.

The measurement of concrete and clay walling blocks would be governed by the same rules as apply to the measurement of brickwork.

65. *Classification of Items for Brickwork*

Separate items are to be provided for all brickwork differing in value from the normal owing to its position in the work, to the necessity for providing centering, or to the shapes and contours to which it is to be built, such as:

Walls with battered faces.
Walls circular on plan. It should be stated if purpose-made bricks are required.
Manholes, wells and pits.
Chimney shafts.
Arches.
Linings of sewers and tunnels, differentiating between straight and curved work.
For brickwork used as facing to mass concrete, see clause 58(c).
Separate items should be provided for metal reinforcing and ties.

This section deserves careful study as it covers matters of the greatest importance which are, on occasions, overlooked. The cost of constructing brickwork on civil engineering projects is often influenced to a considerable extent by the position and nature of the brickwork. It will be immediately apparent that brickwork constructed in the confined space at the bottom of a deep manhole, where the rate of output becomes much reduced, will be far more costly than brickwork constructed at ground level.

Similarly, circular brickwork on the upper sections of a tall chimney shaft, involving the hoisting of materials, payment of height money and slower rate of working due to the more complicated work, will result in much higher costs of construction.

Brickwork constructed under these differing conditions must, accordingly, be kept separate with an adequate description, in order that the contractor may enter a realistic price against each item of work.

66. *Method of Measurement for Brickwork*

Brickwork is to be measured as the net quantity shown on the drawings or specified, no allowance being made for cutting and

The contractor is to allow for normal cutting and waste when building-up his brickwork rates, as the quantities billed will be the net

CLAUSES FROM THE *S.M.M. of C.E.Q.*

EXPLANATORY NOTES

waste. The measurement of walls circular in plan and less than 700 mm in thickness is to be taken on the mean radius of the wall.

quantities as obtained from the drawings.

67. *Mortar for Brickwork*

Brickwork is to be described as built 'in lime mortar' or 'in cement mortar', etc., as the case may be, and the proportions of the mortar are to be stated.

The type and proportions of the mortar to be used must be stated in each case. This has an important bearing on cost, not only by virtue of the varying costs of the constituent materials but also the different weights and relative ease of working.

It must also be remembered that certain mortars are unsuitable for use in particular locations, such as lime mortar below ground level and cement mortar in tall chimney shafts.

68. *Rates to be Inclusive*

The cost of rough or fair cutting in brickwork to arches, skew-backs and inverts, cutting and fitting to masonry or concrete, moulds, templates and centering, and also of all labour necessary for the completion of the work shown on the drawings or specified, is to be covered by the rates of brickwork.

It will be noted that incidental brickwork labours such as rough and fair cutting, cutting and fitting of brickwork to masonry or concrete, the use of centering to arches, etc., are not separately measured, but have to be covered by the contractor when building-up his brickwork rates. As a general rule the total cost of these items forms only a very small proportion of the cost of the general measured brickwork items in civil engineering work, and their separate measurement is not therefore justified.

69. *Unit and Method of Measurement for Facing*

Fair-faced work, facings of special quality or selected bricks, and pointing, where required,

The use of facings and fair-faced work are separately measured in square metres as 'extra over' the cost of are to be measured by the square metre as extra over the cost of ordinary brickwork, the description of the facing-brick and the nature of the pointing being stated. The thickness of the facework or the nature of the bond is to be stated.

Facings to arches, where required, are to be measured in the same manner, the area being given by the sum of the faces and exposed soffit of the arch.

ordinary brickwork. This item covers the extra cost of the materials used, over and above those employed in ordinary or common brickwork, and the additional labour cost in handling the more expensive materials and pointing the joints to the exposed faces of the brickwork.

The description of the facing item must include everything that affects the price, i.e. the type or price and thickness of bricks and type of mortar, the bond of brickwork and the nature of the pointing. The bond to be used determines the number of facing bricks required per square metre of brickwork, e.g. there are 76 facing bricks per square metre in Flemish bond and 86 in English bond.

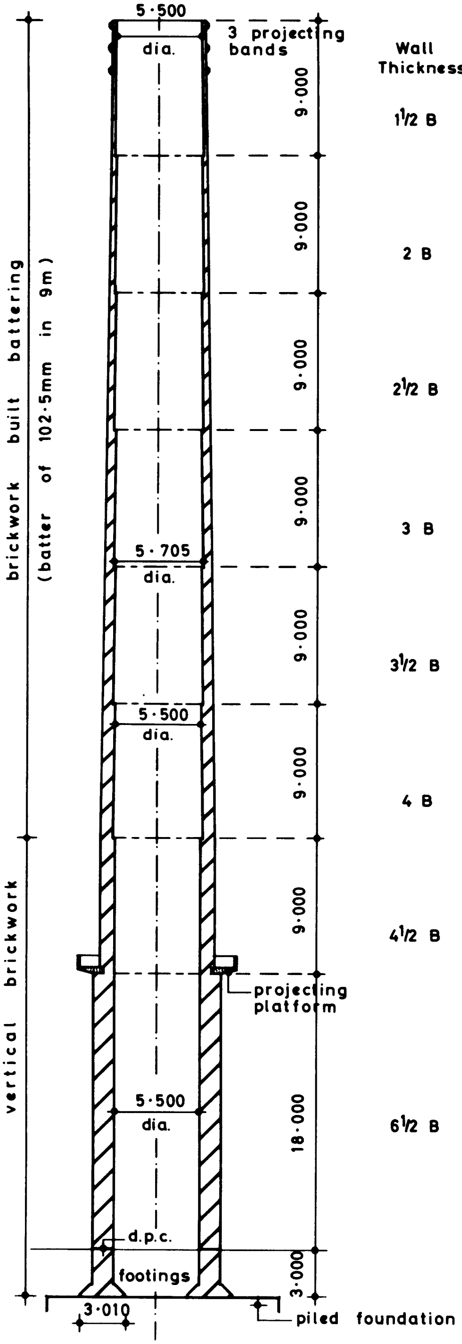
In civil engineering work 'fair-faced' work frequently occurs, where engineering bricks are being used throughout the thickness of the wall, as in the construction of manholes and bridge abutments.

In these cases there is no additional cost of facing brick and the item covers solely the extra labour and material required for pointing the exposed face of the brickwork. It is, accordingly, unnecessary to state the bond in the billed description of this work.

Note that the measurement of the superficial area of faced arches includes the area of the exposed soffit or underside of the arch.

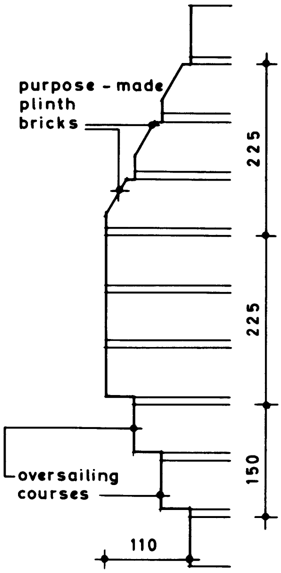
DRAWING NO. 7

TALL BRICK CHIMNEY SHAFT



SECTION

SCALE 1:500



DETAILS OF PROJECTING BAND
SCALE 1:10

TALL	BRICK		CHIMNEY SHAFT	EXAMPLE VIII
			(81m high above d.p.c)	
	Brickwork only measured.			Commence by measuring at the base and then work up the chimney shaft, taking ordinary or common brickwork first and then following with facings. Average out the thickness of the footings and measure in cubic metres, as the thickness exceeds 700mm (13 courses in all).
			Top course of ftgs. 1·505 Bott. cos. of ftgs. 3·010 2) 4·515 av. thickness 2·258	
			Intl. dia. 5·500 2/½/wall thickness = 2/½/ 1·398 1·398 mean dia. 6·898 mean rad. 3·449	
22/7/	6·90 2·26 0·98		Cube bwk. in eng. bks. in c.m. (1 : 3) in Eng. bond, c.o.p. to a mean rad. of 3·449, to base of chy. shaft.	It is unnecessary to specifically mention that this brickwork is in footings. Note: brickwork is classified according to the nature of the work, such as retaining walls, bridge abutments, etc.
			less top of ftgs to fdn. level. 3·000 975 2·025	
22/7/	6·90 1·40 2·03		Ditto. (up to d.p.c.	The brickwork below d.p.c. level will be in cement mortar, but above d.p.c. will probably be in lime mortar to give flexibility and must accordingly be kept separate.
22/7/	6·90 1·40		Hor. d.p.c. of 2 cos. of slates, as specd., c.o.p. to a mean rad. of 3·449.	

TALL BRICK CHIMNEY SHAFT. (Contd.)

			above d.p.c.	
22/7/	6·90 1·40 18·00		Cube bwk. in eng. bks. in l.m. (1:3) in Eng. bond, c.o.p. to mean rad. of 3·449 in chy. shaft (0–18m above g.l.)	Give height stages in the billed descriptions as the cost of the brickwork will increase considerably with rises in height.
			Intl. dia. 5·500 add 2/½/968 968 mean dia. 6·468 mean rad. 3·234	Then continue taking-off" the ordinary or common brickwork up the chimney shaft stage by stage.
22/7/	6·47 0·97 9·00		Ditto., to mean rad. of 3·234 in do. (18–27m above g.l)	
			mean intl. dia. 5·602 (at 31·5m) 2/½/860 860 mean dia. 6·462 mean rad. 3·231	From this stage onwards the brickwork is built battering and it must be stated in the description of the item as it involves further additional expense.
22/7/	6·46 0·86 9·00		Ditto., built battering (102·5mm in 9·0m), to mean rad. of 3·231 in do. (27–36m above g.l.)	

TALL BRICK CHIMNEY SHAFT (Contd.)

			Mean intl. dia. 5·602 2/½/ 753 753 mean dia. 6·355 mean rad. 3·178	
22/7/	6·36 0·75 9·00		Cube bwk. in eng. bks. in l.m. (1:3), in Eng. bond, built battering, c.o.p. to mean rad. of 3·178 in chy. shaft. (36 – 45m above g.l.)	
			5·602 645 2)6·247 3·124	
22/7/	6·25 9·00		Bwk. 645mm th. in do. to mean rad. of 3·124 in do. (45 – 54m above g.l.)	The thickness of the brickwork has now been reduced below 700mm and this item becomes a superficial one in accordance with clause 64 of the S.M.M. of C.E.Q.
			5·602 538 2)6·140 3·070	Alternatively the thickness of the brickwork could be expressed by number of bricks (e.g. a 215mm wall is a one-brick wall).
22/7/	6·14 9·00		Ditto. 538mm th., in do., to mean rad. of 3·070 in do. (54 – 63m above g.l.)	
			5·602 430 2)6·032	

TALL BRICK CHIMNEY SHAFT (Contd.)

22/7/	6.03 9.00		Bwk., 430mm th., in eng. bks. in l.m. (1:3) in Eng. bond, built battering, c.o.p. to mean rad. of 3.016 in chy shaft. (63 – 72m above g.l.)	Alternatively this could be described as 430mm brick wall.
			5.602 323 2) 5.925 2.963	
22/7/	5.93 9.00		Ditto., 323mm th. in do., to mean rad. of 2.963 in do. (72 – 81m above g.l.)	
			<u>Facewk.</u>	
			Intl. dia. 5.500 <u>add</u> 2 x wall thickness = 2/1.398 2.796 extl. dia. 8.296 extl. rad. 4.148	

TALL BRICK CHIMNEY SHAFT (Contd.)

			up to d.p.c.
			below g.l. 75
			g.l. to d.p.c. 150
			225
22/7/	8·30		E. o. ord. bwk. in eng. bks. for fcg. wi. red. fcg. bks. (p.c. £20 per 1,000) & ptg. wi. neat flush jts. to extl. face of circ. chy. shaft, wi. an extl. rad of 4·148 in Eng. bond in c.m. (1:3).
	0·23		
22/7/	8·30		Ditto. in g.m. (1:1:6) (0 – 18m above g.l.)
	18·00		
			5·500
			2/968 1·936
			7·436
			3·718
22/7/	7·44		Ditto. wi. extl. rad. of 3·718 in do. (18 – 27m above g.l.)
	9·00		
			mean intl. dia. 5·602
			2/860 1·720
			mean extl. dia. 7·322
			mean extl. rad. 3·661

Follow the measurement of ordinary brickwork with that of facings, measured as "extra-over" the ordinary brickwork taken on the outside face of the chimney shaft, commencing 75mm below ground level and working upwards in the same stages as for the ordinary brickwork.

The type of brick, bond, mortar and method of pointing is to be given in the description of the facings.

Keep the work below d.p.c. in cement mortar and that above d.p.c. in gauged mortar separate. (measured in square metres).

TALL BRICK CHIMNEY SHAFT (Contd.)

22/7/	7·32 9·00		E. o. ord. bwk. in eng. bks. for fcg. a.b. to extl. face of circ. chy. shaft, built battering, wi. mean extl. rad. of 3·661 in g.m. (1:1:6) (27 – 36m above g.l.) 5·602 2/753 1·506 2)7·108 3·554	
22/7/	7·11 9·00		Ditto., do., wi. mean extl. rad. of 3·554 in do. (36 – 45m above g.l.) 5·602 2/645 1·290 2)6·892 3·446	Note use of words "ditto" and "do" to reduce lengths of descriptions, after the first item on a sheet, as and when similar items arise. The first "do" in the accompanying item refers to "built battering."
22/7/	6·89 9·00		Ditto., do. wi. mean extl. rad. of 3·446 in do. (45 – 54m above g.l.) 5·602 2/538 1·076 2)6·678 3.339	
22/7/	3·34 9·00		Ditto., do. wi. mean extl. rad. of 3·339 in do. (54 – 63m above g.l.)	

TALL BRICK CHIMNEY SHAFT (Contd.)

			5·602 2/430 860 2)6·462 3·231
22/7/	6.46 9.00		E. o. ord. bwk. in eng. bks. for fcg. a.b. to extl. face of circ. chy. shaft, built battering, wi. mean extl. rad. of 3·231 in g.m (1:1:6) (63-72m above g.l.)
			5·602 2/323 646 2)6 248 3·124
22/7/	5·60 9·00		Ditto., do., wi. mean extl. rad. of 3·124 in do. (72-81m above g.l.)
			6·248 2/55 110 2)6·358 3·179

TALL BRICK CHIMNEY SHAFT. (Contd.)

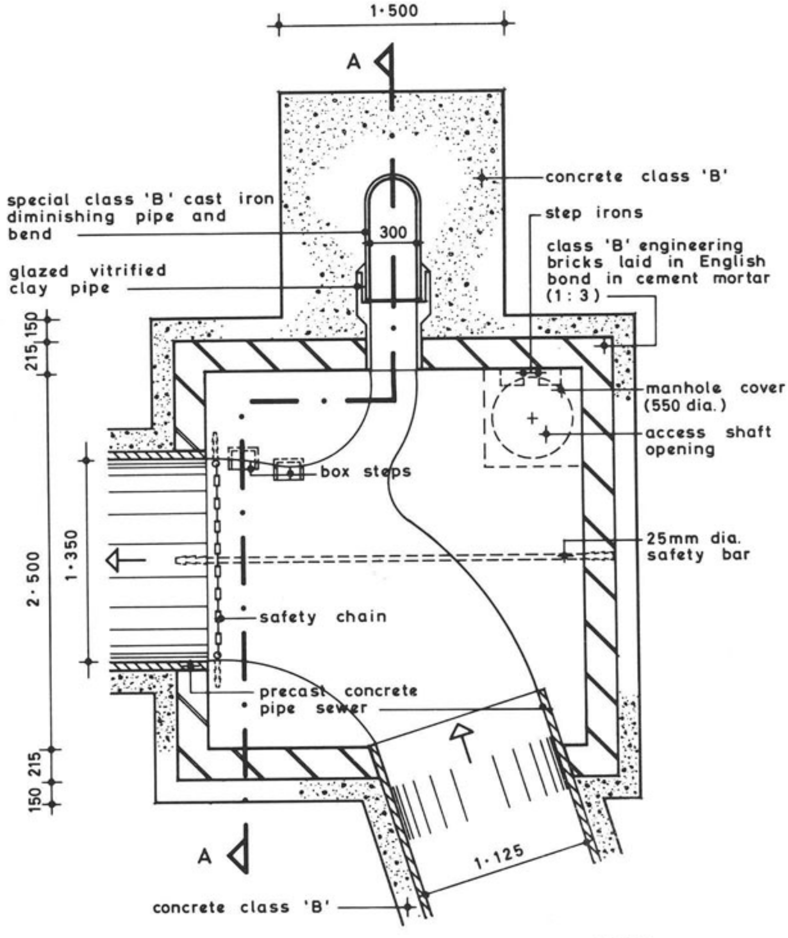
22/7/3/3/	6.36		E.o. fcgs. for p.m. tapd. plinth bks., (p.c. £2.80 per 100) in proj. bands to chy. shaft c.o.p. to mean extl. rad. of 3.179 (78 – 81m above g.l.)	Next proceed to measure the three projecting bands at the top of the shaft and any other additional features. Special plinth bricks are measured as "extra-over" facings in lineal metres.
			6.248 2/110 220 2)6.468 3.234	
22/7/3/	6.47		E.o. gen. bwk. for bldg. 2 proj. cos. of bwk. wi. total proj. of 110mm, c.o.p. to extl. rad. of 3.234 in bands to chy. shaft. (78 – 81m above g.l.)	Projecting courses are measured as "extra-over" general brickwork in linear metres, covering the additional labour and material involved. (S.M.M. clause 64)
			6.248 2/55 110 2)6.358 3.179	In practice these measurements would be followed by the adjustment of brickwork for the inspection platform, flues and test pipes, and the building in of step irons, reinforcing steel bands, etc.
22/7/3/	6.36		E.o. gen. bwk. for bldg. 3 os'lg cos., c.o.p. to mean rad. of 3.179 in bands to chy. shaft, incl. ptg. 3 retns, wi. total proj. of 110mm. (78 – 81m above g.l.)	

DEEP BRICK MANHOLE — EXAMPLE IX

			Excavn.	
			walls 2/215 — 2·500, 430	
			conc. 2/150 — 300	
			3·230	
			Depth g.l. to top of base — 6·685	
			base — 225	
			6·910	
	3·23 3·22 6·91		Exc. for m.h. n.e. 9m dp., backfill & remove surplus excavtd. matl.	Note that the excavation for manholes, pits, etc., is not measured in separate 3m stages. (S.M.M. of C.E.Q., clause 40).
	1·50 1·50 6·91		(backdrop.	
			3·230 3·230 2/6·460 12·920 add backdrop 2/1·500 — 3·000 15·920	The excavation rates are to include the cost of timbering and keeping the excavations free from water. (S.M.M. of C.E.Q., clause 41).
	15·92 6·91		E. o. gen. excavn. for any additnl. excavn. & backfill that may be required for workg. space, timbg. or other tempy. work. (sum of area of sides of net excavatn mesd.)	Very desirable to include this item when dealing with this class of work.

DEEP BRICK MANHOLE

DRAWING NO. 8



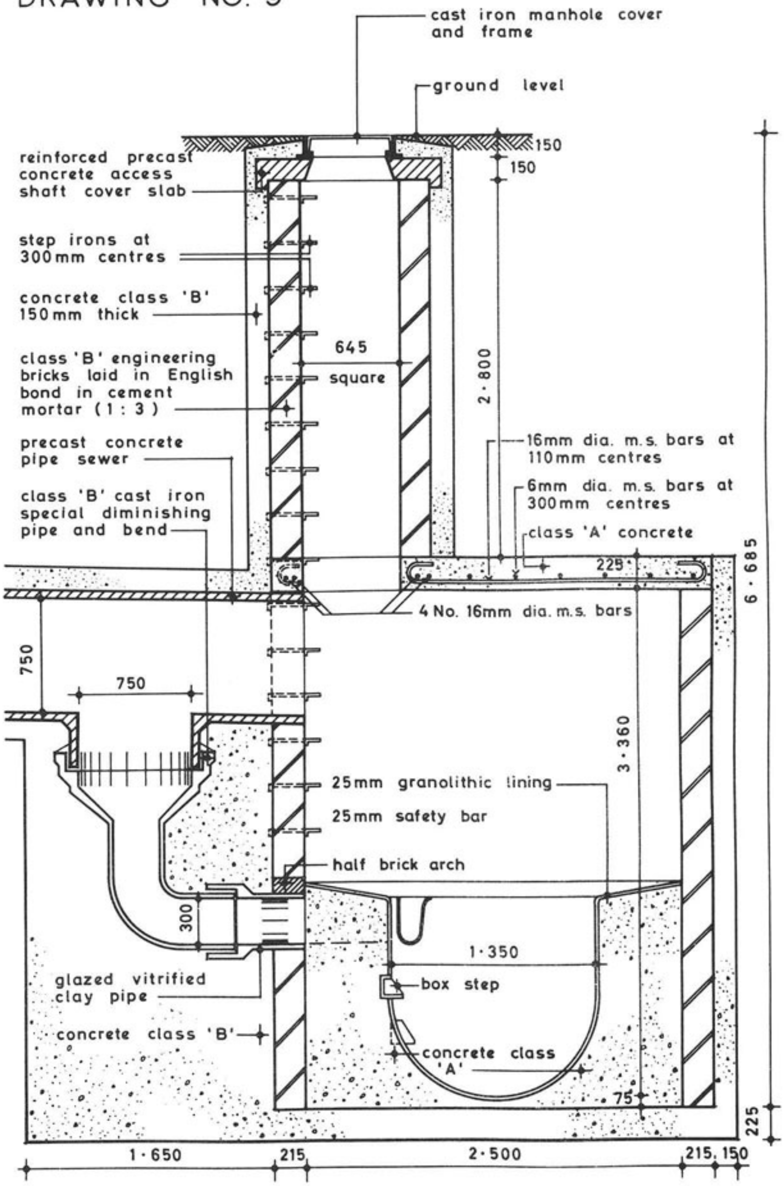
NOTE
⟶ indicates direction of flow

P L A N

SCALE 1:50

DEEP BRICK MANHOLE

DRAWING NO. 9



S E C T I O N A - A

SCALE 1:50

			DEEP BRICK MANHOLE (Contd.)	
			Conc.	
	3·23 3·23		Conc. class 'B' in base to m.h., 225mm th.	Best measured in square metres (See S.M.M. of C.E.Q., clause 54.).
	1·50 0·15		Ddt. ditto. (surrd. to backdrop.	
	1·65 1·50 2·60		Conc. class 'B' in surrd. to backdrop.	The concrete surround to the 750mm dia. sewer has been left to be taken when measuring the sewer between manholes.
			2·500 2·500 2/ 5·000 10·000 add walls 4/2/215 1·720 conc. backg. 4/150 600 12·320 height. 225 3·360 75 3·660	Note method adopted for obtaining the perimeter length or girth of concrete backing, measured on its centre line.
	12·32 0·15 3·66		Conc. class 'B' in vert. backg., 150mm th., to bk. walls of m.h. chbr.	Measured in cubic metres.
			750mm pipe 750 2/60 120 extl. dia. 870 1125mm pipe 1·125 2/75 150 extl. dia. 1·275 1350mm pipe 1·350 2/85 170 extl. dia. 1·520	Thickness of pipe added to internal diameter to give external diameter in each case.

DEEP BRICK MANHOLE (Contd.)

	1.50		*Ddt.* Conc. class (backdrop	
	0.15		'B' in vert. backg.,	
	2.38		150mm th.	
22/7 /	0.44			
	0.44			
	0.15		(750mm pipe.	
22/7 /	0.64			
	0.64		(1125mm pipe.	
	0.15			
22/7 /	0.76			
	0.76		(1350mm pipe.	
	0.15			
			645	
			645	
			2/ 1.290	
			2.580	
			add walls 4/2/215 1.720	
			conc. backg. 4/150 600	
			4.900	
			height 2.800	
			150	
			2.950	
				It is not considered necessary to make adjustment for the smaller thickness of concrete around the access shaft cover slab.
	4.90		Conc. class 'B' in vert.	
	0.15		backg. 150mm th., to bk.	
	2.95		walls of m.h. access shaft.	
			Shutterg. 2.500	
			2.500	
			2/ 5.000	
			10.000	The measurement of shuttering generally follows the items of concrete to which it relates, and represents the face of the concrete to be supported.
			add walls 4/2/215 1.720	
			conc. backg. 4/2/150 1.200	
			12.920	
			height. 225	
			3.360	
			300	
			3.885	

DEEP BRICK MANHOLE (Contd.)

	12.92 3.89		Sawn vert. shutterg. to conc. surrd. to m.h. chbr. (provsln.) (sides to surrd.	The face of the concrete will not be exposed and a sawn finish to the shuttering will therefore be sufficient. This item is labelled provisional" as not all of the shuttering may be required.
2/	1.50 2.60		(to backdrop.	
	1		Form hole through sawn vert. shutterg. for 750mm dia. pipe.	No deduction of shuttering has been made for holes for pipes.
	1		Ditto. for 1125mm dia. pipe.	
	1		Ditto. for 1350mm dia. pipe.	
			645 645 2/1.290 2.580 add walls 4/2/215 1.720 conc. backg. 4/2/150 1.200 5.500	
	5.50 2.95		Sawn vert. shutterg. to conc. surrd. to m.h. access shaft.	
			Bwk 2.500 2.500 2/5.000 10.000 add corners 4/215 860 10.860	

DEEP BRICK MANHOLE (Contd)

			645 645 2/1·290 2·580 *add* corners 4/215 860 3·440 height. 3·360 75 3·435	
	10·86 3·44		One-bk. wall in class 'B' eng. bks. in Eng. bond in c.m. (1:3) in m.h. chbr.	It is desirable to keep the brickwork to the manhole chamber and the access shaft separate in order that the Contractor may insert different prices for the two classes of work, which are executed under different conditions
	3·44 2·80		Ditto. to m.h. access shaft.	
	1		Build in end of 300mm dia. pipe into one-bk wall & e.o. gen. bwk. for turng. arch over same in 1 No. h.b. ring, 215mm thick.	A separate enumerated item is needed to cover the cutting and fitting of the brickwork around the pipe and the forming of the brick arch over it, to prevent the pipe being fractured by the weight of the superimposed brickwork. It is not specifically mentioned in the S.M.M.
	1		Ditto., 1125mm dia. pipe into do. & do. (bwk. ddtd. for opg.)	
	1		Ditto., 1350mm dia. pipe into do. & do. (do.)	Brickwork is deducted for the larger pipes passing through brick walls and this is mentioned in the billed descriptions.
	1		Ditto., 750mm dia. pipe into do., but no arch. (do.)	

DEEP BRICK MANHOLE (Contd.)

22/7	0·44 0·44		Ddt. one bk. wall (750mm pipe.	
22/7	0·64 0·64		(1125mm pipe.	
22/7	0·76 0·76		(1350mm pipe.	
	10·00 2·00 2·58 2·80		E.o. cost of ord. bwk. for fin. intl. face to m.h. wi. a fair face, flush ptd.	"Extra over" item for facings or fair-faced work, measured in square metres on the actual face of the work. No fair face work is measured below the benching. The height of fair-faced brickwork above the benching level is increased to 2·000 to make allowance for the areas over pipes entering the manhole.
22/7	0·44 0·44		Ddt. ditto. (750mm pipe. 2·500 2/215 430 2·930 Cover Slab	
	2·93 2·93		R. conc. class 'A' in m.h. chbr. cover slab, 225mm th. (opg. ddtd.)	
	0·65 0·65		Ddt. ditto. (opg.	It is doubtful whether it is necessary to deduct the shuttering for the area of the opening as it will probably not be cut out on the job, and no deduction has been made in this example.
	2·50 2·50		Wrot. shutterg. to soff. of m.h. chbr. cover slab.	

DEEP BRICK MANHOLE (Contd.)

4/	0·65		Wrot. shutterg. to edges of opg. to conc. cover slab, 225mm wide.
4/	2·93		Sawn shutterg. to edges of cover slab, 225mm wide.
			2·930 less cover 2/40 80 2·850 add hkd. ends 2/192 384 3·234
			2·930 less cover 80 110)2·850 26+1
27/	3·23		16mm ϕ m.s. reinforcg. rods in cover slab.
4/	3·23		(transverse rods.
			110)645 6
6/	0·64		Ddt. ditto. (opg.
			2·930 less cover 2/40 80 2·850
			2·500 less opg. 645 1·855 add len. over wall 215 2·070 less cover 2/40 80 1·990

Shuttering 300mm wide or under is measured in linear metres. (See S.M.M. of C.E.Q., clause 57).

When calculating the length add 12 times the diameter of the reinforcing rod for each hooked end.

Divide the length of the slab by the spacing of the rods to give the number of spaces between them and add one to total to convert number of spaces into number of rods.

For the purpose of this example the term "rod" has been used to cover round rods or bars to tie up with the S.M.M. of C.E.Q. In practice the term "bar" is now used extensively to cover both round and square bars.

No hooked ends to distribution rods.

Shorter rods finishing against access shaft opening.

DEEP BRICK MANHOLE (Contd.)

6/	2·85		6mm ϕ m.s. reinforcg. rods in cover slab.	Number of rods obtained from Section A-A.
2/	1·99			
	2·50 2·50 1·45		Fine conc. class 'A' in m.h. benchg., incl. all lab. in shapg. to reqd. invts.	Include for all necessary labour in the description of the benching.
			1·350 1·125 2)2·475 1·238 add grano. ling. 2/25 50 mean dia. 2)1·288 mean rad. 0·644	
$\frac{1}{2}/\frac{22}{7}/$	2·00 0·64 0·64		Ddt. ditto.	Length scaled off drawing, measured on centre line of channel.
	2·00 0·64 0·65		(main channel.	It is not considered necessary to deduct for the 300mm branch connection.
	2·50 2·50		Finish benchg. in grano. (1:1½) to smooth face in small areas, incl. all rdd. or curved shapgs & arrises.	Measured in square metres.
2/	2·00 1·35		(sides of channel	
	1		Len. of 300mm dia. B.S. g.v.c. pipe in conn. to m.h., 650mm lg.	Best taken as an enumerated item for pricing purposes.

DEEP BRICK MANHOLE				(Contd.)
	1		Class 'B' c.i. special dim. pipe & bend (750 – 300mm dia.) as detailed dwg., in backdrop to m.h.	
22/7/	0·60 0·45 0·45		Ddt. conc. class 'B' in surrd. to (dim. pipe backdrop.	External radius taken in each case.
22/7/	1·50 0·17 0·17		(bend.	
			645 walls 2/215 430 o'hg. 2/75 150 1·225	
	1		Precast r. conc. access shaft cover slab 1225mm sq. o'll. & 200mm o'll. thickness, recessed for opg., all as specd.	
	1		C.i. heavy duty m.h. cover & fr. 550mm dia., weighg. not less than 200kg. & surrd. fr. wi. conc.	

DEEP BRICK MANHOLE (Contd.)

2/	1		C.i. boxstep, 225 x 150 x 125mm o'll. weighg. not less than 3·5kg. ea. & set in conc. benchg.	The weight is necessary to establish the price.
15/	1		Apprvd. patt. w.i. step iron weighg. not less than 1·75kg ea. & b.i. to one-bk. wall of m.h.	
	1		25mm dia. galvd. w.i. safety bar, 2·50m effective len., wi. ragbolt at ea. end & b.i. to one-bk. wall of m.h.	Labour in fixing included in the item.
	1		Galvd. w.i. safety chain, 1·50m lg., wi. hook & 2 no. 25mm dia. ragbolts, 225mm lg., b.i. conc. benchg. all as specd.	The description of this item is restricted to the essential features and the contractor is referred to the specification for any further details.

IX – Measurement of Masonry and Waterproofing

THESE TWO sections of work are covered in clauses 70 to 78 of the *Standard Method of Measurement of Civil Engineering Quantities*, which are now quoted in full together with explanatory notes. Worked examples will follow covering a stone-faced sea wall and the waterproofing and other constructional work in a pumphouse containing a pump well.

CLAUSES FROM THE *S.M.M. of C.E.Q.*	EXPLANATORY NOTES
	MASONRY
70. *Units of Measurement for Ashlar and Dressed Stone*	
The unit of measurement for ashlar and dressed stone is to be the cubic metre, except in the case of facework to concrete, where the unit of measurement is to be the square metre, the average thickness being stated. (See also clause 58(c).)	Ashlar and dressed stone, as distinct from rubble or mass masonry is measured in cubic metres, except where, as in the case of a sea wall, the stonework is constructed as a facing to concrete when it is measured in square metres as 'extra over' the concrete, stating the thickness. The concrete is not deducted for the volume of the wall occupied by stonework.
71. *Method of Measurement and Classification of Items for Ashlar and Dressed Stone*	
Where the measurement is in cubic metres, the quantities are to be ascertained by taking the cubic contents of the smallest rectangular figure that will enclose the stone when worked. The mortar joints of a completed masonry structure are to rank for measurement as masonry. No allowance is to be made for projecting nibs to take nipper	Note the rules relating to the cubic measurement of stone: (a) Irregular shaped stones are to be measured to the smallest rectangular cube from which they can be obtained. (b) Mortar joints are included in the volume of masonry, taking the width of one joint in each

CLAUSES FROM THE *S.M.M. of C.E.Q.*

points. The nature of the face dressing is to be stated. In the case of *in situ* dressing separate items are to be provided, the unit of measurement being the square metre.

Separate items are to be provided for stones which exceed 1 cubic metre in volume but do not exceed 1·25 cubic metres in volume and so on in steps of 0·25 cubic metres.

Separate items are to be provided for the different classes of masonry, such as copings, altars, voussoirs, steps and the like, and, under those heads, for stones differing in the amount of labour put upon them such as stones dressed circular on face and quoins to copings.

The cost of setting, joggle-jointing, grouting and pointing, as well as any timbering and centering, is to be covered by the rates for masonry.

Masonry is to be described as built 'in lime mortar' or 'in cement mortar', as the case may be, and the proportions of the mortar are to be stated.

EXPLANATORY NOTES

dimension or measuring to the centre lines of joints.

(c) The type of face dressing is included in the description of the stone, except where the dressing is carried out after the stone is placed in position, when it is separately measured in square feet.

(d) Separate items for large stones (exceeding 1 cu m) in stages of 0·25 cu m (exceeding 1 cu m and not exceeding 1·25 cu m and so on).

(e) Separate items for stones serving different functions and involving varying amounts of labour, as the price per cubic metre will vary in each case.

(f) All labours, except those relating to the provision of dowels and cramps, are included in the masonry rates.

(g) The type and mix of mortar must be stated as it affects the price.

The term 'coping', in clause 71, refers to the protective feature at the head of a wall, an 'altar' is a step forming the side wall of a graving dock and a 'voussoir' is a wedge-shaped arch stone.

72. *Dowels and Cramps*

Dowels and cramps, whether of metal, slate or other material, are to be measured separately by number, including the sinkings or mortices therefor, and running.

Note that enumerated dowel and cramp items include the forming of sinkings in the stone and running them in lead.

73. *Unit of Measurement for Rubble Masonry or Mass Masonry*

The unit of measurement for rubble masonry or mass masonry is to be the cubic metre.

Rubble masonry or mass masonry is to be described as built in 'lime mortar' or 'in cement mortar', as the case may be, the proportions of the mortar being stated.

Note the unit of measurement for random or mass masonry (roughly dressed stone often laid to irregular patterns with wide joints).

74. *Facework*

Where the facework of rubble masonry or mass masonry differs from the bulk, the facings are to be measured by the square metre as extra over the cost of rubble masonry or mass masonry, the description and thickness of the facework and the nature of the pointing stated.

Facework to rubble or mass masonry is measured in square metres as 'extra over' rubble masonry with a full description. The general item of rubble masonry includes the volume of the facework.

75. *Fixing Ironwork*

Separate items are to be provided for any additional work in masonry which is incidental to the fixing of iron and steel. The units of measurement are to be those set out for concrete in clause 63.

See clause 63 for the stages of depth relating to mortices for bolts.

WATERPROOFING

76. *Units of Measurement for Waterproofing*

The units of measurement for waterproofing are to be:

Asphalt ... Square metre
Waterproof sheeting ... Square metre
Rendering in ordinary or waterproofed cement mortar ... Square metre
Waterproof painting or coating ... Square metre
Angle fillets, skirtings, nibs, exposed

Waterproofing, including asphalt work, is generally measured in square metres. Note the exceptions, taken as lineal or enumerated items, particularly the item of lining to culverts, irrespective of width.

CLAUSES FROM THE *S.M.M. of C.E.Q.*

arrises, and strips less than 300 mm wide and lining to culverts
... Linear metre

Lining to small sumps ... Number

77. *Classification of Items for Waterproofing*

Separate items are to be provided for work on horizontal, inclined, vertical and curved surfaces.

The thickness of the finished work and the number of coats are to be stated. Where cement mortar rendering is used, the proportions of the mortar are also to be stated.

78. *Method of Measurement of Waterproofing*

Waterproofing is to be measured as the area covered, allowance being made in the rates for forming joints, for overlaps where sheeting or fabric embedded in asphalt is used, and for laying to falls. No deduction is to be made for the area occupied by gratings or down pipes. Mitres, angles and stops of skirtings and the like are to be covered by the rates for waterproofing.

EXPLANATORY NOTES

Waterproofing membranes in different planes are each kept separate due to the varying costs involved. Note that both the thickness and the number of coats must be given in the description.

The rates for the superficial items of waterproofing work are quite comprehensive, the only additional items being those listed in clause 76, as lineal or enumerated items.

STONE-FACED SEA WALL (60m length)

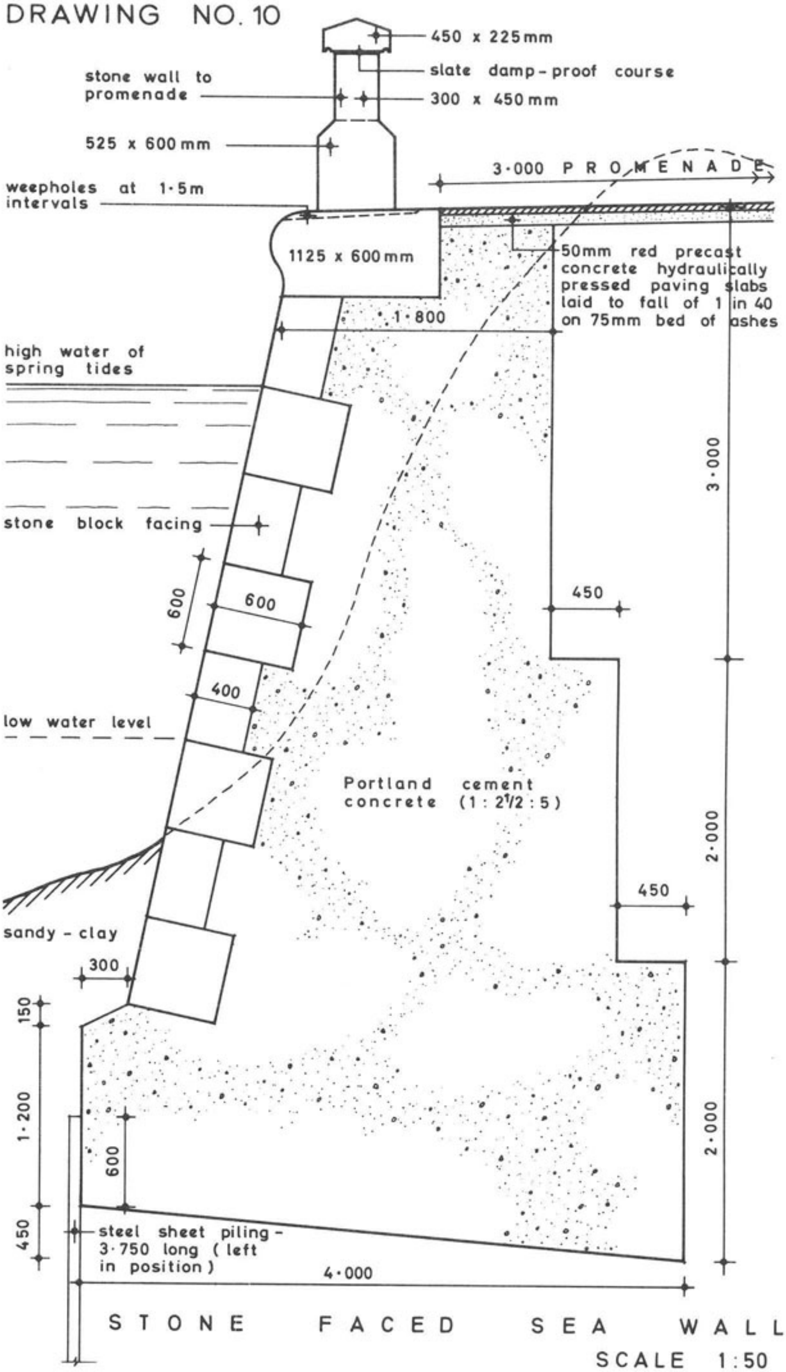
EXAMPLE X

Note: The dimensions in this example have been squared ready for transfer to the abstract in Chapter 17.

Dimensions	Squared	Description	Notes
		2·700 4·080 2)6·780 3·390	Note method of obtaining mean width by means of waste calculations or side casts.
60·00 3·39 0·90	182·8	Exc. below l.w.l. in sandy-clay for sea wall, n.e. 9m dp., backfill as nec., & remove excvtd. matl.	A give-and-take line is drawn on the sea face of the excavation to obtain the average width for the first section. The width of the second section includes the steel sheet piling.
60·00 4·08 2·40	588·0		
		770·8	
		1·600 2·700 2)4·300 2·150	The Contractor will need to cover the cost of all temporary works in his billed rates for excavation, concrete, etc. Alternatively, a special billed item could be included for temporary work, as described in Chapter 3.
60·00 2·15 2·35	303·3	Ditto., between tides n.e. 6m dp., do.	
		650 1·600 2)2·250 1·125	The excavation is measured in sections by reference to high and low water levels, stating the depth taken from the surface in each case in 3m stages.
60·00 1·13 1·55	105·2	Ditto., above h.w.l. n.e. 3m dp., do.	
		2·000 1·500 3·500	

(1)

DRAWING NO. 10



STONE FACED SEA WALL

SCALE 1:50

STONE - FACED SEA WALL (Contd.)

	60.00 2.20	132.0	E.o. gen. excavn. below l.w.l. for any additnl. excavn & backfill reqd. for timbg. or workg. space. (area of sides of excavn. measured). (sea face)	It is desirable to subdivide the additional excavation into sections in the same way as for the general excavation.
	60.00 3.50	210.0	(rear face)	
			342.0	Trimming the bottom of the excavation on the slope to receive the concrete at the base of the wall is deemed to be included in the excavation rates, in accordance with clause 41 of the S.M.M. of C.E.Q.
	60.00 2.35	140.9	Ditto. between tides for do.	
	60.00 1.55	92.9	Ditto. above h.w.l. for do.	
			Steel Sheet Piling	See S.M.M. of C.E.Q., clauses 87 and 88 and Chapter 10, for the measurement of this class of work.
	60.00 3.75	224.7	Supply, handle, pitch & drive Messrs. X No. 3 section steel sheet piling, at base of sea wall, wi. top fin. level 2.50m below l.w.l.	The length of piling is not stated in this case as it is less than 12m.
			Mass Concrete 2.850 3.150 2 | 6.000 3.000	
	60.00 3.00 1.50	270.0	Conc. (1 : 2½ : 5) below l.w.l. in sea wall.	The concrete is subdivided into sections in the same way as the excavation. It also includes the volume of the masonry which is measured as "extra over" the concrete.
	60.00 4.00 2.00	480.0	(2)	
			750.0	

STONE-FACED SEA WALL (Contd.)

			750·0	
½/	60·00		Ddt. conc. (1:2½:5) below L.W.L. in sea wall.	It is often easier to measure the total enclosing rectangle and then deduct the voids from it.
	4·00			
	0·35	84·0	(tapg. base.	
	60·00			
	0·35		(top of toe.	
	0·35	7·4	91·4	
			658·6	
	60·00		Do. vert. shutterg. to ditto.	Follow the concrete items with the supporting shuttering.
	3·50	210·0		It is assumed that no shuttering will be required on the face which is built up with masonry (the masonry serving as the formwork)
	60·00			
	1·20	72·0		
			282·0	
	60·00	60·0	Do. shuttg. to slopg. surf. of ditto., 350 mm wide.	This shuttering is forming a splay and should therefore be taken as a lineal item stating the width.
			1·900 2·300 2) 4·200 2·100	
			2·750 2·850 2) 5·600 2·800	
	60·00		Conc. (1:2½:5) between tides in sea wall.	
	2·10			
	1·82	229·2		
			1·820 520 2·340	
	60·00			
	2·80			
	0·52	87·4	(3)	
			316·6	

STONE-FACED SEA WALL (Contd.)

	60·00		Do. vert. shutterg. to	
	2·34	140·4	conc. between tides in	
			sea wall.	
			1·800 1·900 2)3·700 1·850	
	60·00		Conc. (1 : 2½ : 5)	
	1·85		above h.w.l. in sea	
	0·60	66·6	wall.	
	60·00			
	0·75			
	0·50	22·5		
			89·1	
	60·00		Do. vert. shutterg.	
	0·60	36·0	to ditto.	
2/	60·00			
	0·50	60·0		
			96·0	
			Masonry 600 400 600 3)1·600 533	
	60·00		E.o. mass conc. sea wall	Masonry as facework to
	1·80	108·0	for P. st. blocks wi. an. av.	concrete measured in
			bed width of 533mm as	square metres as "extra
			batterd. face to wall, incl.	over" concrete.
			settg. & ptg. blocks in st.	
			dust mo., as specfd., below	
			l.w.l.	
			(4)	

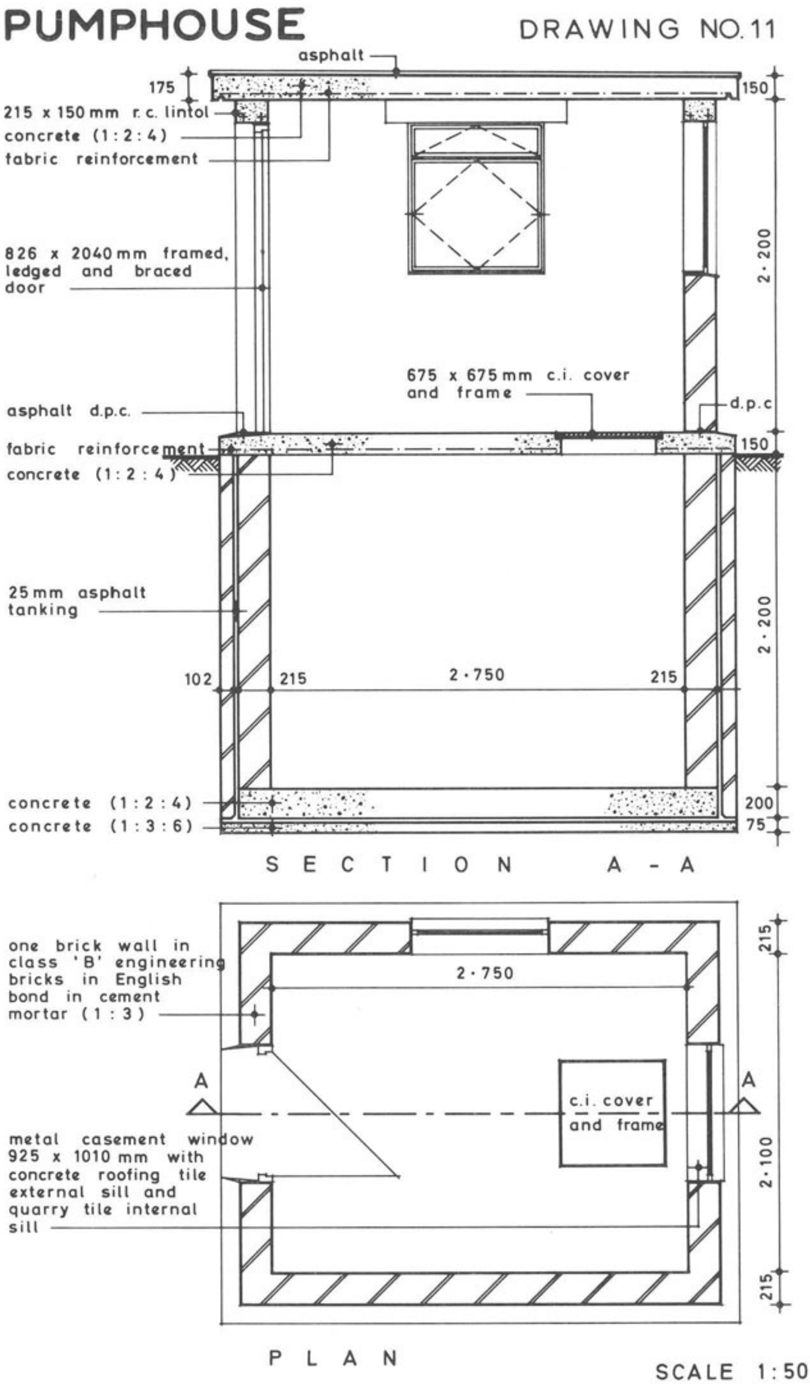
STONE-FACED SEA WALL (Contd.)

	60.00 2.40	144.0	E.o. mass conc. sea wall for P. st. blocks a.b. wi. av. bed width of 500mm, between tides.	
	60.00 0.70	42.0	Ditto. wi av. bed width of 400mm, wi. spld. upper edge, above h.w.l.	Height measured on back edge of stone.
	60.00 1.13 0.60	40.6	P. st. copg., wi. 2ce rdd. frt. edge as dwg., set & ptd. a.b.d. above h.w.l. 1.50|60.00 40	This item cannot be regarded as facework to concrete and is measured in cubic metres as general masonry.
40/	1	40	E.o. last for forming sinkg. in copg. 900mm lg., x 40mm wide x av. 40mm dp.	Descriptions of masonry must include :- a) type of workmanship, e.g. wall stones, coping stones, etc.
			Prom. Wall.	b) nature and position of work, e.g. walls, piers, vertical, battered, etc.
	60.00 0.53 0.60	19.1	P. st. 2ce chfd. base to wall, incl. settg. & ptg. a.b.d.	c) type of stone, e.g. limestone, sandstone, etc. d) type of joint mortar, e.g. cement, lime, etc.
	60.00 0.30 0.45	8.1	P. st. panel blocks, incl. settg & ptg. a.b.d.	All labours are included in the description of the stonework and are not separately measured.
	60.00 0.45 0.23	6.2	P. st. copg., 2ce thro., & wi. 2ce splyd. top, incl. settg. & ptg. a.b.d.	Note the order of length, breadth and height in the dimensions.

(5)

STONE -	FACED	SEA WALL		(Contd.)
			1·20|60·00 50	
50/	1	50	Bronze cramp, 150 x 40mm av. x 6mm th., incl. lettg. into & formg. sinkings in P. st. & runng. in lead.	Assuming that coping stones are in 1·20m lengths connected by bronze cramps and base to promenade wall connected to sea wall by galvanised dowels at 1·20m centres.
50/	1	50	G.i. dowel 12mm ϕ, 75mm lg. incl. lettg. into & formg. sinkgs. in P. st. & runng. in lead.	The tops of sea walls are often finished with tubular guardrails and these are best measured in linear metres with a full description, although they are not specifically mentioned in the S.M.M. of C.E.Q.
	60·00 0·30	18·0	Hor. d.p.c. of 2 cos. of slates, as specfd.	Alternatively, as is often the case, they may be covered by a prime cost sum.
			<u>Pavg. to Promenade</u>	
	60·00 1·35 0·30	24·4	Exc. for prom. in sandy-clay, av. 300mm dp. & remove.	Part of excavation already taken for sea wall. Depth given in description to indicate that it is shallow surface excavation.
	60·00 3·00	180·0	50mm red precast conc. pavg. slabs, all as specd., on & incl. 19mm bed of lime mo. & 75mm bed of ashes, to crossfall of 1 in 40, incl. groutg. on completn.	See S.M.M. of C.E.Q., clause 108 for method of measuring pavings. Keep the billed descriptions as brief as possible by making reference to specification clauses, where possible, but include essential features which have an important bearing on cost.

(6)


PUMPHOUSE
DRAWING NO. 11
asphalt
175
215 x 150 mm r.c. lintol
concrete (1:2:4)
fabric reinforcement
150
826 x 2040 mm framed, ledged and braced door
2·200
675 x 675 mm c.i. cover and frame
asphalt d.p.c.
d.p.c
fabric reinforcement
concrete (1:2:4)
150
25 mm asphalt tanking
2·200
102
215
2·750
215
concrete (1:2:4)
concrete (1:3:6)
200
75
SECTION A-A
one brick wall in class 'B' engineering bricks in English bond in cement mortar (1:3)
2·750
215
A
A
c.i. cover and frame
metal casement window 925 x 1010 mm with concrete roofing tile external sill and quarry tile internal sill
2·100
215
PLAN
SCALE 1:50

PUMPHOUSE

			Pumpwell.	EXAMPLE XI
			add 2·750 2·100 inner walls 2/215 430 430 asp. 2/25 50 50 outer walls 2/102 204 204 3·434 2·784	This example covers mainly building work of a type frequently encountered on civil engineering works, where the use of a second form of measurement would not be justified.
			depth. 2·200 conc. 200 asp. 25 conc. 75 2·500	The order of "taking-off" follows generally the order of carrying out the constructional work on the site. A logical sequence of "taking-off" assists materially in preventing the omission of items.
	3·43 2·78 2·50		Exc. for pumphse. n.e. 3m dp. & remove excavtd. matl.	Measured in 3m stages of depth as for pits, pierholes, etc.
			3·434 2·784 2/6·218 12·436	
	12·44 2·50		E.o. gen. excavn. for any additnl. excavn. & backfill reqd. for timberg. or workg. space (surface area of extl. face of wall mesd.).	
	3·43 2·78		Conc. (1:3:6), 75mm th., in carpet coat to pump well, fin. to rec. asp.	
	12·44		Ro. shutterg., 75mm hi., to edge of carpet coat.	

PUMPHOUSE (Contd.)

	Dimensions		Description	Notes
	3·43 2·78		Hor. asp. membrane, 25mm th., laid in 2cts. between layers of conc. in flr. to pumpwell.	Number of coats of asphalt given in addition to its thickness.
			12·436 less 4/2/102 816 11·620	
	11·62		Asp. ∠. fillet to tanking.	Measured in linear metres.
			2·750 2·100 add 2/215 430 430 3·180 2·530	
	3·18 2·53		Conc. (1:2:4), 200mm th., in flr. to pumpwell fin. wi. a smooth upper surf.	
			2·750 2·100 2/ 4·850 9·700 add corners 4/215 860 10·560	Note method of obtaining length of wall measured on its centre line.
	10·56 2·20		One-bk. wall in eng. bks., class 'B', in Eng. bond in c.m. (1:3) in pumpwell.	Separate items are to be provided for brickwork differing in value from the normal owing to its position in the work.

PUMPHOUSE (Contd.)

	9·70 2·20		E.o. cost of ord. bwk. for fin. wi. a fair face & ptg. wi. a flush jt. int.
			2·200 200 2·400
	11·62 2·40		Vert. asp. membrane, 25mm th., laid in 3cts., between bwk. in walls to pumpwell.
			12·436 less 4/102 408 12·028
			height 2·200 conc. 200 2·400
	12·44 2·40		H.b. wall in eng. bks. a.b.d.
			Superstructure
	3·43 2·78		Conc. (1:2:4), 150mm th., in susp. flr. to p.hse., reinforced wi. fabric reinft. (m/s) & fin. wi. a smooth upper surf. & Layer of wire mesh reinforcg. fabric (Ref. A 192), lapped 150mm at jts.

Facings or fair-faced work are measured in square metres as "extra over" the cost of ordinary brickwork.

Note that with waterproof membranes the following matters are to be covered in the description:-

a). Type of waterproofing materials, e.g. asphalt, bitumen sheeting, etc.

b). Number of coats or layers and thickness of material.

c). Slope of surface, e.g. horizontal, vertical, curved, etc.

Where mild steel or w.iron ladders are to be provided these are best enumerated with a full description. Alternatively, and as is often the case in practice, they may be covered by a prime cost sum.

Fabric reinforcement must be mentioned in the description of the concrete, as extra labour will be involved in working the concrete around the reinforcement.

PUMPHOUSE (Contd.)

	12.44		Wrot. shutterg., 150mm hi. to edge of flr. slab.	This shuttering will need to be wrought as the edge of the floor slab will be exposed.
	2.75 2.10		Wrot. shutterg to soff. of susp. conc. flr. slab over pump well. (opg. not ddtd.)	
			675 675 2/1.350 2.700	
	2.70		Wrot. shutterg. 120mm hi. to edge of flr. slab at opg. 2.700 add corners 4/2/50 400 3.100	Shuttering of 300mm in width or under measured in linear metres, stating the width. (S.M.M. of C.E.Q., clause 57).
	3.10		Form rebate, 50 x 50mm in sectn., in opg. in flr. slab to rec. cover.	
	0.68 0.68		Ddt. conc. (1:2:4), 150mm th., in susp. flr. to pumphse. & Ddt. layer of wire mesh fabric reinft.	

PUMPHOUSE (Contd.)

	1		C.i. cover & fr., wi. opg. 675 x 675mm & weighg. not less than 75kg, set in conc. flr. slab.	
			Walls.	
	10·56 2·20		One-bk. wall in eng. bks., class 'B', in Eng. bond in g.m. (1:1:6) in pumphse.	
	9·70 2·20		E.o. cost of ord. bwk. for fin. wi. a fair face & ptg. wi. a flush jt. int.	
			10·560 add corners 4/215 830 11·390	
	11·39 2·20		Ditto. ext.	There are no special facing bricks used externally, so it is necessary to measure an external fair face item.
	10·56		Hor. asp. d.p.c. 215mm wide to walls.	Measured in linear metres, as less than 300mm wide (See S.M.M. clause 76)

PUMPHOUSE (Contd.)

			Roof	
			add walls 2/215 2·750 2·100 430 430 o'hg. 2/150 300 300 3·480 2·830	Use of subheadings helps others to find their way through the dimensions.
	3·48 2·83		Conc. (1:2:4), av. 162mm th., in roof slab to p.hse. fin. wi. smth. upper surf. to falls to rec. asp. & reinfd. wi. fabric reinft. (m.s.). & Layer of wire mesh reinforcg. fabric a.b. & Asp. covg. in 2cts., fin. 25mm th., to falls on roof.	Give average thickness of roof slab with sloping top. It would be permissible to combine waterproofing work in floors and roofs, with the all-in rate covering laying to falls. (See S.M.M. of C.E.Q. clauses 77 and 78).
	2·75 2·10		Wrot. shutterg. to soff. of conc. roof slab.	
			3·480 2·830 2/ 6·310 12·620	
	12·62		Wrot. shutterg. av. 162mm hi., to edge of conc. roof slab.	

PUMP HOUSE (Cont.)

			Doors & wdws.
	1		Swd., frd. ledged & braced door, 826 x 2040 x 50mm, hung wi. a pr. of 300mm steel tee hinges to & incl. a 112 x 75mm swd. fr. & incl. yale lock. Price to incl. for paintg. the dr. & fr. wi. primer, 2 u/c's & gloss coat of oil pt., int. & ext. & fixg. the fr. to the bwk., as specd.
2/	1		Metal cast. wdw., size 925 x 1010mm to B.S. 990, hot dip. galvd., wi. bronze fittgs., fixd. to bwk. wi. lugs, glazed wi. 3mm clear sheet glass & painted wi. red lead primer, 2 u/c's & gloss coat of oil paint, int. & ext.
			826 fr. 2/62 (less reb.) 124 950
			2040 fr. (less reb.) 62 2·102

The measurement of joinery is not covered in the S.M.M. of C.E.Q.
It has been thought best to cover the door, frame, ironmongery and painting in a single enumerated item, although the Standard Method of Measurement of Building Works requires the subdivision into component parts.
Another alternative would be to measure in accordance with the Code for the Measurement of Building Works in Small Dwellings.
A single enumerated item has also been taken to cover the metal casements complete.
When measuring a large building, using the civil engineering method of measurement, it would be advisable to break down the windows and doors in the manner indicated in the building method, keeping the work in the various works sections separate. (e.g. joinery, glazing and paintwork).

PUMPHOUSE (Contd.)

			add bearngs 2/100 950 / 200 / 1.150 ; 925 / 200 / 1.125	
	0.95 2.10		Ddt. One-bk. wall in eng. bks. (door.	Deduction of brickwork and fair-faced work for door and window openings.
2/	0.93 1.01		& Ddt. E.o. for f.f. int. (wdws.	
	1.15 0.15		& (lintol (to dr.	Precast concrete lintols are best measured in linear metres. The number is stated so that the estimator can calculate the average length of lintol required.
2/	1.13 0.15		Ddt. E.o. for f.f. ext. (lintols (to wdws.	
	1.15		215 x 150mm precast R.C. lintols (1:2:4) reinfd. wi. 2no. 12mm m.s. rods.	The cost of building in the ends of lintols is included in the brickwork rates.
2/	1.13		(In 3 no)	
2/	2.10		F.F. to reveal, 102mm wide, ext. (door.	Fair face to reveals measured in linear metres, stating the width.
2/2/	1.01		F.F. to reveal, 60mm wide, ext. (wdws. & Ditto. 140mm wide, int.	
2/	0.93		Ext. wdw. sill of 2 cos. of conc. roofg tiles, 110mm wide as specd. & Int. wdw. sill of quarry tiles, 150mm wide, as specd.	Tile sills measured in linear metres, including cutting and fitting ends.

X – Measurement of Piling

THE METHOD of measuring the various types of piling is described in clauses 79 to 93 of the *Standard Method of Measurement of Civil Engineering Quantities*, which are now quoted in full accompanied by explanatory notes. Worked examples then follow covering the measurement of timber and concrete piles and steel sheet piling.

CLAUSES FROM THE *S.M.M. of C.E.Q.*

EXPLANATORY NOTES

PILING

Concrete Piles

79. Units of Measurement for Concrete Piles

The units of measurement for concrete piles are to be:

Concrete ... Cubic metre
Reinforcement ... Megagramme
Shoes, the weight being stated ... Number of each size
Handling and pitching piles ... Number
Driving piles to a given level—Driving piles to a given set—Re-driving lengthened piles—Dollying piles below ground level, the average depth being stated ... Number or linear metre of penetration
Travelling pile frame back to re-drive lengthened piles ... Per hour or per move
Cutting off the heads of piles ... Number
Stripping the heads of piles, the length to be stripped to be stated ... Number

Separate items are provided for the different materials contained in precast concrete piles, such as concrete, reinforcement and shoes, and for the operations of handling and pitching of the piles ready for driving and the actual driving, as well as ancillary operations, such as cutting off and stripping heads of piles. It will be noted that driving concrete piles can be measured by number or linear metre of penetration, and in practice one normally finds that the latter unit of measurement is adopted as being the most convenient and satisfactory way of measuring this work.

CLAUSES FROM THE *S.M.M. of C.E.Q.*

80. *Method of Measurement for Manufacture of Concrete Piles*

Concrete piles are to be measured to the lengths ordered by the engineer. The concrete in the piles is to be measured by multiplying the cross-sectional area of the pile by the length of pile as cast, from the head to the butt of the shoe, no deduction being made for chamfers, tapered points, or the volume of reinforcement. The rates for concrete in piles are to cover moulds.

Separate items are to be provided for piles of differing cross-sections and differing lengths proceeding by steps of 3 m.

For the method of measurement of steel in reinforced concrete piles see clauses 59 and 60. Separate items are to be provided for bar or rod reinforcement, steel links, helical bindings, forks and sleeves for toggles and lifting holes.

For the method of measurement of precast prestressed concrete piles see clause 56.

81. *Lengthening Concrete Piles*

When concrete piles are ordered to be lengthened in position after they have been driven, the materials used for lengthening are to be measured as described in clause 80, except that shuttering shall be measured separately in square metres. An item being provided in addition for the extra cost of lengthening the pile, including stripping the exposed end and forming connection of new with old work.

EXPLANATORY NOTES

The concrete in piles is to be measured for the total enclosing volume of the pile, with no deductions for chamfers, tapered ends, reinforcement, etc. As with all precast concrete work it is not necessary to measure moulds separately.

Note the method of classification according to cross-sectional dimensions and lengths (in 3 m stages throughout).

Reinforcement is to be separately classified according to its function, including sleeves cast into the piles to form lifting holes or to accommodate short lengths of bar, for lifting purposes, known as 'toggles'.

The method of measuring the lengthening in position of precast concrete piles deserves attention; involving the measurement of concrete, reinforcement and shuttering, and a special enumerated item to cover the extra cost involved in stripping the exposed end and connecting the new *in situ* work to the old precast section.

Timber Piles

82. *Units of Measurement for Timber Piles*

The units of measurement for timber piles are to be:

Timber ... Cubic metre
Shoes, the weight being stated ... Number of each size
Handling and pitching piles ... Number
Driving piles to a given level
Driving piles to a given set ... Number or linear metre of penetration

The units of measurement for timber piles are similar to those adopted for precast concrete piles.

83. *Method of Measurement and Classification of Items for Timber Piles*

Timber piles are to be measured to the lengths ordered by the engineer.

Separate items are to be provided for piles of lengths exceeding 9 m, in steps of 3 m.

If, under the specification, any tolerance on the cross-sectional dimensions of the timber is permitted above or below those shown upon the drawings or specified, mention of this should be made in the bill of quantities.

The supply and fixing of iron rings to the pile head before driving, as also the labour in cutting off the ringed portion or any portion damaged in driving is to be considered as included in the price for the timber.

Double scarfed or fished piles are to be measured under separate items, the unit of measurement being the cubic metre. The fish plates and bolts for these piles are to be measured separately by number. Boring boltholes is to be considered as included in the rate for the bolts.

It will be noted that timber piles exceeding 9 m in length only are to be kept separate, proceeding in 3 m stages, whereas concrete piles are classified in 3 m stages throughout. No additional items are required for the supply and fixing of iron rings to pile heads or the cutting off of ringed or damaged portions of timber piles, as these are to be covered by the timber rates. Similarly, the price for bolts includes the forming of bolt holes in the timber, unlike the building method where the holes are separately enumerated.

CLAUSES FROM THE *S.M.M. of C.E.Q.*

Concrete and Timber Piles

84. *Classification of Items for Handling and Pitching Piles*

Handling and pitching piles are to be included as one item, separate items being provided for piles of different cross-sections and lengths authorised by the engineer. For this purpose it is sufficient to group together piles of lengths up to 9 m, exceeding 9 m but not exceeding 12 m, and so on, the classification proceeding by steps of 3 m.

85. *Classification of Items for Pile Driving*

Separate items are to be provided for the driving of battered piles, double piles, sheet piles, piles in groups, isolated piles and lengthened piles, also for trial piles when these are required.

86. *Penetration*

It should be made clear in the bill of quantities how the penetration has been measured.

Sheet Steel Piling (Permanent)

87. *Units of Measurement for Steel Sheet Piling*

The unit of measurement for steel

EXPLANATORY NOTES

Note the method of grouping concrete and timber piles in lengths for the handling and pitching item (being a similar classification to timber in timber piles). See also the classifications for the driving of concrete and timber piles, i.e. whether driven singly, in groups, battered, etc.

The lengths of piles measured in the bill of quantities are normally stated as being given for tendering purposes only. The contractor will be paid the lengths of concrete piles, for instance, actually cast and driven; these lengths being determined by the engineer after the driving of trial piles.

Steel sheet piling is measured

sheet piling is to be the square metre measured in plane (not developed) elevation along the centre line of the piling. Corner piles, junction piles and other special piles are to be measured by their length in linear metres as extra over steel sheet piling.

Cutting or burning through steel sheet piling is to be measured by the linear metre in plane (not developed) elevation along the centre line of the piling.

Separate items are to be provided for cutting and burning under water.

in square metres with no allowance made for the irregular outline on plan of the sheeting. Corner, junction and other special piles are measured in linear metres as 'extra over' the normal steel sheet piling—no deduction is accordingly made from the area of steel sheet piling for them.

Cutting or burning through sheet steel piling is measured in linear metres with no allowance being made for the irregular outline of the sheeting, and keeping work carried out under water separate from that executed above, due to the much higher cost involved.

88. *Method of Measurement and Classification of Items for Steel Sheet Piling*

Steel sheet piles are to be measured to the lengths ordered by the engineer.

Separate items are to be provided for piles of lengths of 12 m and upwards in steps of 3 m.

The rates for steel sheet piling are to cover handling, pitching and driving.

Separate items are to be provided for piling to be driven under differing conditions.

When steel sheet piling is to be driven in two vertical lengths, fish joints, inclusive of labour and material, are to be measured by number.

The billed item for steel sheet piling, unlike those for concrete and timber piles, is a comprehensive item including the supply, handling, pitching and driving of the piling. Note the method of classification in 3 m stages, when the length exceeds 12 m.

It will usually be necessary to state the position in which the piling is to be driven as it will generally have a bearing on the cost of the work.

Steel Box-Piles

89. *Units of Measurement for Steel Box-Piles*

Steel box-piles are to be measured by the linear metre. Separate items should be provided for handling,

CLAUSES FROM THE *S.M.M. of C.E.Q.*

driving, etc., and measured in a similar manner to that for concrete piles. (See clause 79.)

Cast 'in situ' Piling

90. *Units of Measurement for Cast 'in situ' Piles*

The units of measurement for cast *in situ* piles are to be:

Bringing the plant to the site, erecting, dismantling and removing it ... Lump sum

Driving casings to a given level or set ... Linear metre of penetration

Providing pile-shoes and/or formation of enlarged bases ... Number

Forming pile-shafts, including concrete and reinforcement ... Linear metre

Projecting reinforcement ... Number of sets

91. *Method of Measurement of Cast 'in situ' Piles*

The length of cast *in situ* piles is to be measured from the bottom edge of the steel or concrete casing to the top of the concrete core and the description shall state the load to be carried, the diameter and construction of the casing, the construction and reinforcement of the core and whether the casing is to be withdrawn or left in. The number of piles to which the total length relates shall also be given.

Separate items are to be provided for cast *in situ* piles which do not exceed 9 m in depth, for those which exceed 9 m and do not exceed 12 m in depth, and so on in steps of 3 m.

EXPLANATORY NOTES

The different form of measurement laid down in clause 90 for cast *in situ* concrete piles as compared with precast concrete piles, deserves attention. This includes a lump sum plant item, driving casings by the linear metre of penetration, enumeration of pile shoes, pile shafts in linear metres and enumeration of projecting reinforcement in sets per pile.

It will be noted that the billed description of cast *in situ* concrete piles is to include the load to be carried, diameter and construction of the casing, construction of the core, whether the casing is to be withdrawn or left in position and the number of piles included in the item, so that the average length of pile may be determined.

In addition they are classified into lengths exceeding 9 m in 3 m stages.

The provision of pile-shoes and the forming of enlarged bases are to be enumerated as extra over the length of the pile.

Sets of projecting reinforcement are to be measured as extra over the length of the pile and the length of projection stated.

Extraction of Piles

92. *Units of Measurement for Extraction of Piles*

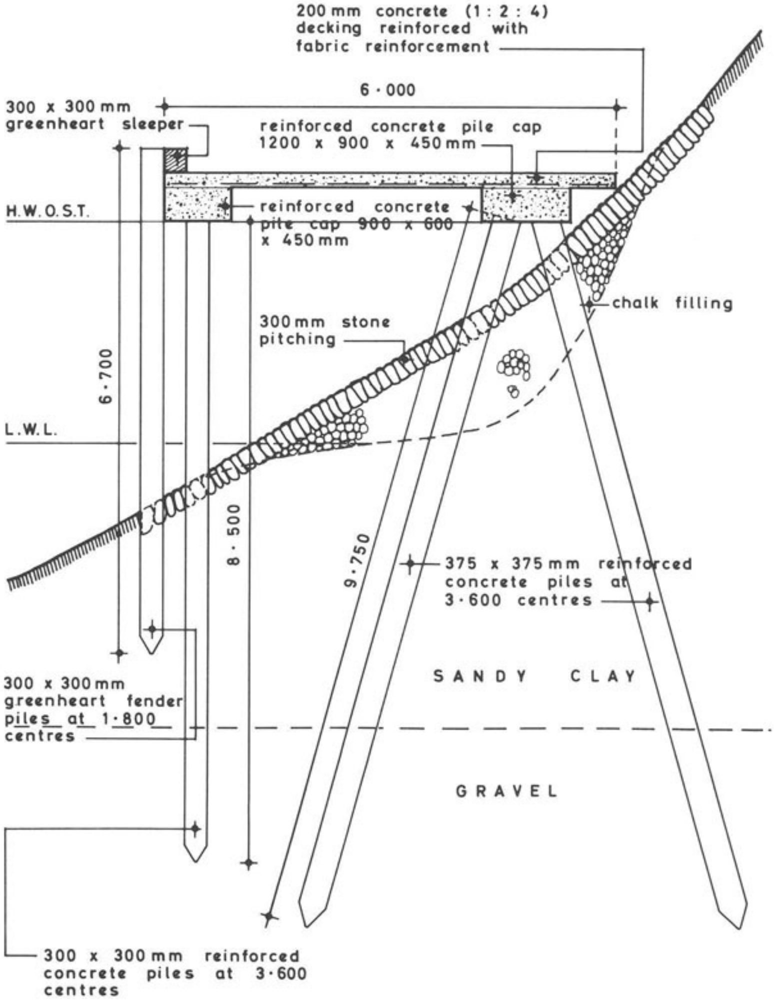
If, under the specification, it is necessary to provide for the extraction of steel sheet piling, separate items are to be provided for extraction and the unit of measurement is to be the square metre measured on plane elevation.

Testing

93. *Test Loading of Piles*

The test loading of piles as described in the specification is to be measured by number.

DRAWING NO. 12

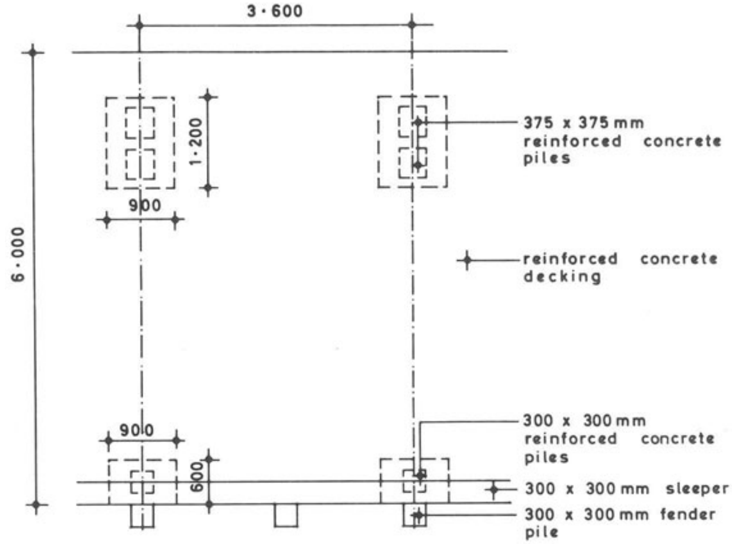


SECTION THROUGH QUAY

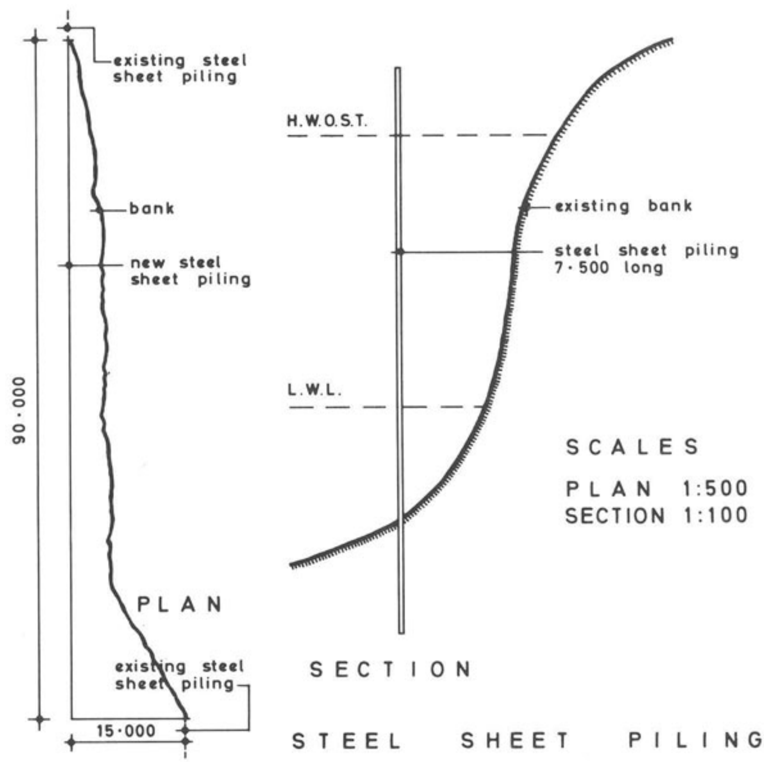
CONCRETE AND TIMBER PILING

SCALE 1 : 100

DRAWING NO. 13



PLAN OF QUAY SCALE 1:100



STEEL SHEET PILING

CONCRETE AND TIMBER PILING, etc. to QUAY. EXAMPLE XII

(108 m length of Quay taken.)

			<u>375 x 375mm R.C. Piles</u>
			$3.6\overline{)108.0}$ <u>30+1</u>
			exposed length 9.750 <u>add</u> for strippg. end & connectg. to pile cap & deck slab. <u>600</u> <u>10.350</u>
31/2/	10.35 0.38 <u>0.38</u>		R. conc. class 'B' in 375 x 375mm piles, 9-12m in len., all as specfd.
31/2/	<u>1</u>		Chilled c.i. shoe, as specified, weighing 25kg ea., incl. straps & castg. shoe into 375 x 375mm r.c. pile.

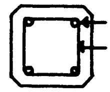
Adopt a logical sequence in the "taking-off," such as concrete piles and caps, concrete decking, timber piles and work to the embankment. Assuming this is an independant length of quay, then allowance will have to be made for the additional work at the far end of the quay. Dividing the total length by the spacing of the piles gives the number of spacings, as distinct from the number of piles.

31 pairs of 375 x 375mm piles. No deduction is made for tapered points, chamfers, etc. and the rates for the concrete in piles include the moulds (See S.M.M of C.E.Q. clause 80)

To assist the driving of piles and prevent them being damaged.

A preamble clause would cover the forming of holes through piles for fixing tackle for hoisting, pitching and driving. An alternative method is to build in a galvanised iron tube tied to the pile reinforcement and this would be covered by a separate enumerated item.

CONCRETE AND TIMBER PILING (Contd.)

			<u>Reinft. to 375 x 375mm Piles</u>	C.S. thro'. pile. 
			10·350 less shoe 300 10·050	The term "rod" has been used in this example to cover round rods or bars, as in the S.M.M. of C.E.Q.
31/2/4/	10·05		32mm ϕ m.s. reinforcg. rods in precast conc. piles.	Assuming that 4 main longitudinal reinforcing rods are provided to each pile.
			<u>Link reinft.</u> <u>shoe</u> 300 ÷ 75 = 4 av. len. over pr. of rods = 200 x 2 = 400 add for lappg. 2/75 150 550	6mm link reinforcement is taken at 150mm centres with additional links at the top and bottom of each pile. Each pair of main reinforcing rods is linked separately with a right angle or L shaped link, giving 4 links at each level.
31/2/4/4/	0·55		6mm ϕ m.s. rods in links in precast conc. piles, incl. all bendg. & fxg. to main reinft.	62 piles, with 4 sets of links in each shoe and 4 rods to each set of links. The reinforcement will subsequently be weighted up and billed in megagrammes.
			(links at shoe (end of piles. 10·350 less shoe 300 150) 10·050 67 add sets of additnl. links bott. 600mm @ 75mm ccs 4 600mm @ 100mm ccs 2 top. 900mm @ 75mm ccs 6 600mm @ 100mm ccs 2 81	Allow for additional links at each end of the pile, where they are provided at a closer spacing by adding the additional number involved over and above the number already taken (in the 67) at the normal 150mm spacing.

CONCRETE AND TIMBER PILING (Contd.)

			Length over pair of rods 375 less cover 2/40 80 2/ 295 590 add laps 2/75 150 740	
31/ 2/81/ 4/	0·74		6mm φ m.s. rods in links a.b. 1·500) 10·350 7	
31/ 2/7/ 2/	1		12 x 12mm c.i. separator, 300mm in len., wi. ends holl. to rec. 32mm rods & fxg. between main reinforcing rods in precast conc. piles.	Taken in pairs at 1·50m centres set diagonally to hold the main rods in position.
31/2/	1		Transport, handle & pitch 375 x 375mm r.c. piles 9–12m lg. in pairs 8·500 9·250 2) 17·750 8·875	Piles grouped according to length (See S.M.M. of C.E.Q. clause 84).
31/2/	8·88		Drive 375 x 375mm r.c. piles on batter in prs. thro'. chalk fillg., sandy-clay & gravel on slopg. river bank.	Length of penetration measured in linear metres.

CONCRETE AND TIMBER PILING (Contd.)

31/2/	1		Strip conc. from 600mm len. of 375 × 375mm r.c. pile & bind the exposed reinforcg. rods to the reinft. in the pile cap & deck slab.	
31/	1·20 0·90 0·45		R. conc. class 'B' in pile cap, cast insitu.	
31/	1·20 0·90		Wrot. shutterg. to soffit of pile cap.	It is considered desirable to use wrought shuttering to the pile caps as they will be exposed.
			1·200 900 2/ 2·100 4·200	It is not considered necessary to deduct the area occupied by the heads of the piles or measure cutting of shuttering around them.
31/	4·20 0·45		Wrot. vert. shuttering to pile caps.	Measured in square metres, as exceeds 300mm wide.
			1·200 900 less cover 2/40 80 80 1·120 820	
31/4/	1·12		25mm ϕ m.s. rods in pile caps.	Taking 4no. 25mm dia. reinforcing rods running in both directions to each pile cap.
31/4/	0·82			

CONCRETE AND TIMBER PILING (Contd.)

			300 x 300mm r.c. piles 8·500 add 600 9·100	Where it is necessary to lengthen a concrete pile, the following items will be involved:- a) Lengthening in accordance with the specification, including stripping and forming connection of new work to old (enumerated item). b) Concrete in linear metres c) Shuttering in moulds to lengthened piles in square metres. d) Reinforcement to ditto. by the megagramme, separating main bars from binders, etc.
31/	9·10 0·30 0·30		R. conc. class 'B' in 300 x 300mm piles, 9-12m in len., as specified.	
31/	1		Chilled c.i. shoe a.b. to 300 x 300mm r.c. pile, weighg. 21kg. ea.	
			Reinft. to 300 x 300mm Piles 9·100 less shoe 300 8·800	
31/4/	8·80		32mm ϕ m.s. rods in precast conc. pile reinft.	
			Link reinft. shoe. av. len. over pr. of rods 150 x 2 300 add laps 2/75 150 450	Build up all requisite dimensions in waste to reduce the liability of error and to assist others in working their way through the dimensions.

CONCRETE AND TIMBER PILING (Contd.)

31/4/4/	0·45		6mm ϕ m.s. rods in links a.b.	
			len. of links in main len. of pile. 300	
			less cover 2/40 80	
			220	
			X 2	
			440	
			add laps 2/75 150	
			590	Simpler to calculate number of links required by adjusting the number previously determined for the 375 x 375mm piles.
			Total no. of sets of links in 10·350 lg. pile = 81	
			less links in 1·250 len. at 150mm ccs. 8	
			73	Difference in length of piles = 10·350 less 9·100 = 1·250
31/73/4/	0·59		6mm ϕ m.s. reinforcg. rods in precast conc. piles. (links)	
			1·500 | 9·100 = 6	
31/6/2/	1		12 x 12mm separator, 225mm in len., a.b.d.	Note method of abbreviating description when a similar item has been taken previously.

CONCRETE AND TIMBER PILING (Contd.)

31/	1		Transport, handle & pitch 300 x 300mm r.c. piles, 9–12m in len.	
31/	5·10		Drive 300 x 300 mm r.c. piles, vert. thro.' sandy-clay & gravel on slopg. river bank.	It is important to give full information concerning the conditions of driving, including the plane in which the piles are to be driven.
			Pile Caps.	
31/	1		Strip conc. from 600mm len. of 300 x 300mm r.c. pile & bind the exposed reinforcg. rods to the reinft. in the pile cap & deck slab.	
31/	0·90 0·60 0·45		R. conc. class 'B', in pile cap cast insitu.	
31/	0·90 0·60		Wrot. shutterg. to soff. of pile cap.	
			900 600 2/ 1·500 3·000	
31/	3·00 0·45		Wrot. vert. shutterg. to pile cap.	

CONCRETE AND TIMBER PILING (Contd.)

			900 600 less cover 2/40 80 80 820 520	
31/4/	0·82		25mm ϕ m.s. rods in pile cap.	
31/4/	0·52			
			R.C. Decking	
	108·00 6·00		R. conc. class 'B' in susp. slab as quay deckg., av. 200mm th., wi. top surf. floated & fin. to falls, reinfd. wi. fabric reinft. (m/s). & Steel fabric reinft. weighg. not less than 2·3kg/sq.m, lapped 150mm at jts. & Wrot. shutterg. to soff. of quay deck slab.	Most conveniently measured in square metres, stating the thickness, where not exceeding 300mm thick.
31/	1·20 0·90		Ddt. wrot. shutterg. to ditto.	Deduction of shuttering has been made in this case as there is a considerable area involved.
31/	0·90 0·60		(pile caps.	

CONCRETE AND TIMBER PILING (Contd.)

2/	108·00		Wrot. shutterg., 200mm hi., to edge of deckg.	Wrought shuttering taken to all exposed edges in linear metres, where the width does not exceed 300mm.
2/	6·00			Any shuttering required at construction joints is covered by the concrete rates and is not therefore measured separately. Any expansion jointing required would be measured in linear metres, including the use of shuttering.
	108·00 0·30 0·30		300 x 300mm greenheart sleeper fxd. to quay above h.w.l., wi. 2 chfd. edges.	Measured in cubic metres as a constructional member (See S.M.M. of C.E.Q., clause 94).
			1·200)108·00 90+1	Bolts fixing sleeper taken at 1·20m centres and it will be noted that this item also
91/	1		25mm ϕ m.s. bolt, 500mm lg., wi. 50 x 50 x 10mm plate w. set in conc. deck slab & wi. n. & similar w. let into recess in green-heart sleeper & later fillg. recess wi. hard settg. bitumen, incl. borg. greenheart, 300mm dp. for 25mm bolt.	includes boring the timber. The bolts with plate washers at their bottom ends will have to be set in the concrete whilst it is still green. Bolts, plates, etc. used in conjuction with constructional timber members are enumerated, and not weighted up. (See S.M.M. of C.E.Q. clause 94).

CONCRETE AND TIMBER PILING (Contd.)

			Fender Piles 6·700 add len. to be ringed & removed after driving. 600 7·300 1·800 | 108·00 60+1	
61/	7·30 0·30 0·30		300 x 300mm greenheart fender piles, n.e. 9m in len., as specfd.	Note that no separate measurement of the ringing of pile heads and cutting off of ringed or damaged portions is required, as they are to be included in the timber price. (S.M.M. of C.E.Q. clause 83).
61/	1		Pointg. end of 300 x 300mm greenht. pile & shoeing wi. & incl. chilled c.i. shoe wi. mild steel straps, weighg. not less than 31·8kg ea. & boltg.	
61/	1		Transport, handle & pitch 300 x 300mm greenheart fender pile n.e. 9m in len.	

CONCRETE AND TIMBER PILING (Contd.)

61/	2.00		Drive 300 x 300mm greenheart fender pile to a sli. batter in sandy-clay on slopg. river bank.	
61/	1		25mm ϕ m.s. bolt, 600mm lg., wi. 50 x 50 x 10mm plate w. set in conc. deck slab & wi.n. & similar w. let into recess in greenht. pile, & later fillg. recess wi. hard settg. bitumen, incl. borg. greenht., 300mm dp. for 25mm bolt.	Bolts for connecting the heads of the fender piles to the concrete deck slab of the quay.
			<u>Work to Embankment.</u>	This is assuming no great variation in the cross sectional area of the filling required.
½/	108.00 5.70 1.45		Appd. hard chalk fillg., well consolidated in 300mm layers to rec. st. pitchg. on slopg. embankt. between tides.	The volume would normally be ascertained from a number of cross sections. The triangular cross sectional area is obtained with "give and take" lines drawn around the boundaries
	108.00 9.30		Appd. st. pitchg., 300mm th., laid to slopg. embankt. between tides & groutg. face wi. c.m. (1:3).	Stone pitching measured in square metres stating the thickness. (See S.M.M. of C.E.Q. clause 49).

			STEEL SHEET PILING (permanent) 90·000 15·000 105·000	EXAMPLE XIII
	105·00 7·50		Messrs. X. No. 3. Sectn. or other appd. interlockg. steel sheet pilg., weighg. not less than 62kg/lin. m & transportg., handlg., pitchg. & drivg. vert. n.e. 12m in len. in river wi. top fin. level of piles 900mm above H.W.O.S.T.	Measured in square metres including handling, pitching and driving, as S.M.M. of C.E.Q. clauses 87 and 88.
2/	7·50		E.o. steel sheet pilg. for conng. to extg. pilg. wi. & incl. junctn. piles.	Measured in linear metres as "extra over" steel sheet piling. (S.M.M. of C.E.Q. clause 87)
	7·50		E.o. steel sheet pilg. for corner piles.	
	105·00		Cut or burn-off top of steel sheet pilg. to reqd. level & remove cut off portion. (Provsnl.)	

STEEL SHEET PILING (Contd.)

	Item		Allow the Provsnl. Sum of £100 for excavatg. in pits or trenches below L.W.L. to remove obstructns. encountered durg. drivg. of perm. steel sheet pilg., such sum to be expended in part or in whole as directed by the Engr.	Note the use of Provisional Sums to cover uncertain or unforeseen work, the full extent of which cannot be accurately determined when quantities are being "taken-off."

XI – Measurement of Timberwork in Jetties, Wharves and Similar Structures

THE GENERAL principles relating to the measurement of this class of work are outlined in clauses 94 to 96 of the *Standard Method of Measurement of Civil Engineering Quantities*. These clauses are now quoted in full with explanatory notes entered beside them.

A worked example covering the measurement of timberwork in a jetty then follows.

CLAUSES FROM THE *S.M.M. of C.E.Q.* — EXPLANATORY NOTES

TIMBERWORK IN JETTIES, WHARVES AND SIMILAR STRUCTURES

94. *Units of Measurement for Timberwork*

The units of measurement for timberwork in jetties, wharves and similar structures are to be:

Timber constructional members and timber decking measured on the nominal size subject to the tolerance provided in the specification ... Cubic metre

Timber handrails, guard rails, treads to steps and similar work, fixed complete ... Linear metre

Steel or wrought iron straps, spikes, coach screws, bolts, plates and the like, including boring and fixing ... Number

It will be noted that the bulk of the timberwork is measured in cubic metres, based on nominal timber sizes with no deductions made for loss of timber on sawing and planing. The enumerated item for bolts includes their fixing and the boring of timber to accommodate them.

95. *Method of Measurement and Classification of Items for Timberwork*

Separate items are to be provided for timber constructional members of whole timber, half timber and scantlings. Separate items are to be provided for beams in excess of 9 m in

Note the classification of timberwork according to its type, length and position with regard to water levels. Although no deductions are made for

CLAUSES FROM THE *S.M.M. of C.E.Q.*

length and thereafter in steps of 3 m.

No deduction from cubic quantities of the timber is to be made for nosings, splays, sinkings and the like. The additional timber required for scarfs is to be included when measuring the cubic quantities of timber.

Timberwork is to be classified where necessary according to the position in which it is fixed in the work whether at or below low-water, between tides, or above high-water (the levels of demarcation being stated) or as shown on the drawings.

96. *Labour on Timberwork*

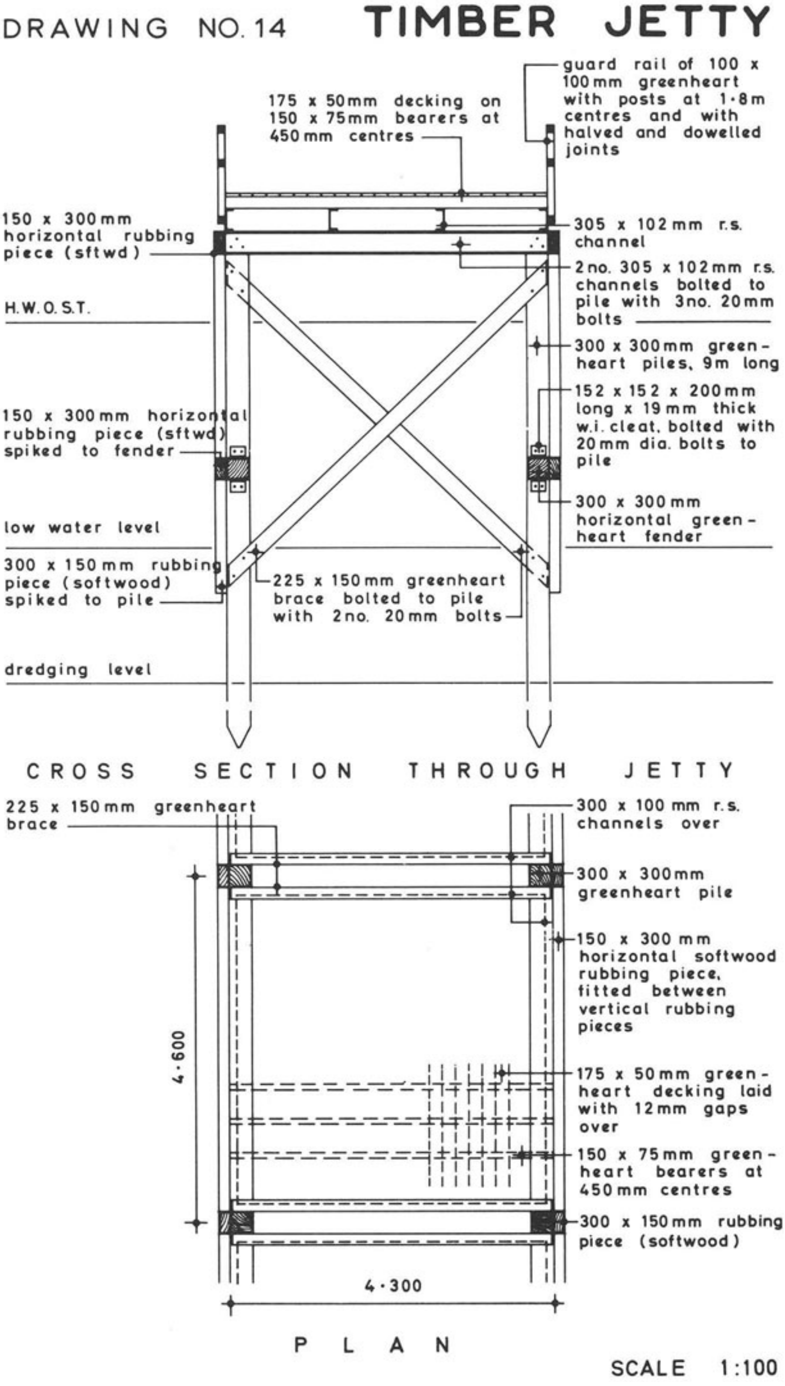
The description attached to the items of timberwork are to define the labour required to finish the work to the form shown upon the drawings, e.g. rounded nosings (as for copings), splayed and shaped ends (as for fenders), and notched, halved and scarfed joints.

EXPLANATORY NOTES

working timber below the surface, additions to length are made for scarfed joints—the additional length normally being calculated at twice the depth of the timber.

All labours required in working the timber to the shapes and forms indicated on the drawings are to be covered in the billed description of the timber and no separate billed items are taken.

TIMBER JETTY (92m length.)				EXAMPLE XIV
			4·600) 92·000 20+1	Add 1 to allow for a pair of piles at each end of the jetty.
			Piling. 9·000 add length for ringing & removal after driving. 600 9·600	
21/2/	9·60 0·30 0·30		300 x 300mm greenheart piles to jetty, 9-12m in len., as specd.	21 pairs of piles. Lengths taken in 3m stages when exceeding 9m. The supply and fixing of iron rings to pile heads and cutting off pile heads after driving is deemed to be included in the timber rates. (See S.M.M. of C.E.Q clause 83).
21/2/	1		Pointg. end of 300 x 300mm greenheart pile & shoeing wi. & incl. chilled c.i. shoe wi. mild steel straps, weighg. not less than 31·75kg, as specd., & boltg.	Note: On occasions jetties are supported on precast concrete rings, fixed vertically, with the enclosing space containing reinforced concrete. The precast rings would be measured in linear metres, the concrete in cubic metres and the reinforcement by the megagramme.


DRAWING NO. 14 TIMBER JETTY
175 x 50 mm decking on 150 x 75 mm bearers at 450 mm centres
guard rail of 100 x 100 mm greenheart with posts at 1·8 m centres and with halved and dowelled joints
150 x 300 mm horizontal rubbing piece (sftwd)
305 x 102 mm r.s. channel
2 no. 305 x 102 mm r.s. channels bolted to pile with 3 no. 20 mm bolts
H.W.O.S.T.
300 x 300 mm greenheart piles, 9 m long
152 x 152 x 200 mm long x 19 mm thick w.i. cleat, bolted with 20 mm dia. bolts to pile
150 x 300 mm horizontal rubbing piece (sftwd) spiked to fender
300 x 300 mm horizontal greenheart fender
low water level
300 x 150 mm rubbing piece (softwood) spiked to pile
225 x 150 mm greenheart brace bolted to pile with 2 no. 20 mm bolts
dredging level
CROSS SECTION THROUGH JETTY
225 x 150 mm greenheart brace
300 x 100 mm r.s. channels over
300 x 300 mm greenheart pile
150 x 300 mm horizontal softwood rubbing piece, fitted between vertical rubbing pieces
4·600
175 x 50 mm greenheart decking laid with 12 mm gaps over
150 x 75 mm greenheart bearers at 450 mm centres
300 x 150 mm rubbing piece (softwood)
4·300
PLAN
SCALE 1:100

TIMBER JETTY (Contd.)

21/2/	1		Transport, handle & pitch 300 x 300mm greenheart pile to jetty, 9–12m in len.	
21/2/	3·00		Drive 300 x 300mm greenheart pile to jetty, vert. in sand.	Desirable to state nature of soil through which pile is to be driven, where it is known with reasonable accuracy, as it will affect the rate of driving.
			Fenders & Braces 4·600 less piles 2/150 300 4·300	Continue with constructional timber members to jetty, followed by cleats, bolts, etc. There are 21 sets of piles but 20 bays to the jetty.
20/2/	4·30 0·30 0·30		300 x 300mm greenheart hor. fender & fxg. wi. bolts (m/s.) between tides.	Fender measured in cubic metres as a constructional member and length is only mentioned in the description if it exceeds 9m.
21/2/	6·05 0·23 0·15		225 x 150mm greenheart diagonal braces, wi. spld. ends & fxg. wi. bolts (m/s.), mainly between tides.	The extreme length of these timbers is taken.

TIMBER JETTY (Contd.)

20/2/4/	1		152 x 152 x 19mm w.i. L cleat, 200mm lg. holed for 4No. 20mm bolts (fenders to piles. fender 300 cleats 38 clear, etc. 40 378	4 cleats to each length of fender. Note build-up of length of bolt by taking thickness of members through which it will pass, plus 40mm for nut, washers and clearance.
20/2/4/	1		20mm ϕ m.s. bolt, 375mm lg., wi. n. & w., incl. fxg. & borg. greenht. 300mm dp. (thro. fenders.	Enumerated item for supplying and fixing bolt includes boring timbers.
21/2/4/	1		Ditto., incl. 50 x 50 x 8mm plate w., incl. do. (thro. piles. pile 300 brace 150 clear, etc. 40 490	Two bolts serve both cleats.
21/2/4/	1		20mm ϕ m.s. bolt, 500mm lg., wi. nut & 2 plate w., incl. fxg. & borg. greenht. 300mm dp. & 150mm dp. (braces to piles)	21 pairs of braces with 4 bolts to each brace.

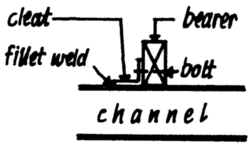
TIMBER JETTY (Contd.)

			<u>Rubbing Pieces</u>	This is the top horizontal rubbing piece which runs the full length of the jetty on each side. It is measured in cubic metres as a constructional member, including any labours, and its position with regard to water levels must be given. The method of fixing must be included in the description and the type of timber to which the rubbing piece is to be spiked must also be given, as this determines the ease or otherwise of driving the nails and boring holes and so affects the price.
2/	92.00 0.15 0.30		150 x 300mm swd. hor. rubbing piece, wi. rdd. edge, creosoted under pressure & spiked to greenht. piles, above h.w.l.	
20/2/	4.30 0.15 0.30		150 x 300mm swd. hor. rubbg. piece, creosoted under pressure & spiked to greenht. fender between tides.	The lower horizontal rubbing pieces run between the vertical rubbing pieces (20 lengths on each side)
21/2/	4.50 0.30 0.15		300 x 150mm swd. vert. rubbing piece, creosoted under pressure & spiked to greenht. pile, mainly between tides.	There are 21 sets of piles and vertical rubbing pieces.

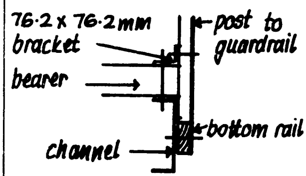
TIMBER JETTY (Contd.)

		Steel Framework.	Structural steel members are "taken-off" in linear metres, stating the weight in kg/lin. m.
21/2/	4.30	305 x 102mm x 46·14kg. R.S. channel & fxg. wi. bolts (m/s) under jetty deckg. above h.w.l.	The item is subsequently weighted up and entered in the bill of quantities in megagrammes. The drilling of holes for fixing bolts is not enumerated separately as it is covered in the steelwork rates.
		pile 300 2 channels 20 clear., etc. 40 360	
21/2/3/	1	20mm ϕ m.s. bolt, 360mm lg., wi. n.& w., incl. fixg. & borg. greenht. 300mm dp.	Bolts through webs of 2 channels and head of pile.
4/	92.00	305 x 102mm x 46·14kg R.S. channel a.b.d.	Channels running the full length of the jetty.
		2 chann. flanges 30 clear., etc. 40 70	
21/4/2/	1	20mm ϕ m.s. bolt, 75mm lg., wi. n.& w., incl. fixg.	1 bolt taken at each connection.

TIMBER JETTY (Contd.)

			Deckg. 450 | 92·000 205+1	
206/	4·30 0·08 0·15		150 x 75mm greenht. brrs. under jetty deckg. & fxg. wi. bolts (m/s) above h.w.l.	Bearers fixed to channels with steel angle cleats welded to channels and bolted to bearers.
206/ 4/	0·10		76·2 x 76·2 x 9·4mm m.s. L in welded cleats.	4 connections to each bearer. Welding of cleats to channels probably carried out at fabricator's works.
206/ 4/ 5/8/	0·10 0·01 0·01		Fillet weld. brr. 75 angle 10 clear., etc. 40 125	Volume of additional metal occupied by fillet welds weighted up and added to steelwork. (timesing factor of 5/8 taken to allow for convex surface of fillet weld).
206/ 4/	2		12mm ϕ m.s. bolt, 125mm lg. wi. n. & w., incl. fxg. & borg. greenht. 75mm dp.	

TIMBER JETTY (Contd.)

			width of deckg. 4·300 Total width of gaps $= \frac{1}{15} \times 4{\cdot}300 =$ 287mm allowance for 12·5mm gap between 175mm wide deckg. members = 1mm in 15mm 4·300 less gaps 287 4·013	Descriptions of structural timber members, decking, etc. should include the following:- (a). Type of timber, e.g. teak, greenheart, columbian pine, etc. (b). Size and shape of members. (c). Any special labours or finish. (d). Position of work, e.g. above or below water level, internal, external, etc.
	92·00 4·01 0·05		50mm th. greenht. jetty deckg., laid in 175mm widths, wi. 12mm gap between ea. bd., spiked to greenht. brrs., above h.w.l. (mesd. net.).	This is also measured in cubic metres (See S.M.M. of C.E.Q., clause 94).
			Guardrail.	
2/	92·00		Greenht. guardrail, 1·30m hi. to jetty above h.w.l. consistg. of 3no. 100 x 100mm rails, 100 x 100mm posts at 1·80m ccs, wi. halved & dowelled jts. & fxg. to jetty frmg. wi. bolts (m/s.).	Measured complete in linear metres. Double fixing of guardrail at 1·80m centres. 1). Bottom rail bolted to channel 2). Post bolted to bracket which is bolted to 150 x 75mm bearer.

TIMBER JETTY (Contd.)

			1·800 | 92·000 51+1	
52/2/	1		76·2 x 76·2 x 9·4mm m.s. L cleat, 76mm lg., holed for 4no. 12mm bolts. (bolts m/s.).	Enumerated as steel fixing items to jetty timberwork, as provided for in S.M.M. of C.E.Q., clause 94, and they are not attached to the constructional steelwork.
			post 100 angle 10 clear., etc. 40 150	
52/2/	1		12mm ϕ m.s. bolt, 150mm lg., wi. n. & w., incl. fixg. & borg. greenht. 100mm dp.	Bolts to posts.
			brr. 150 angle. 10 clear., etc. 40 200	
52/2/	1		Ditto., 200mm lg., wi. n. & w., incl. fixg. & borg. greenht. 150mm dp.	Bolts to bearers.
			bott. rail 100 chann. web 10 clear., etc. 40 150	

TIMBER JETTY (Contd.)

52/2/	1		12mm ϕ m.s. bolt, 150mm lg., wi. n.& w., incl. fxg. & borg. greenht. 100mm dp.	Bolts connecting bottom rail to R.S. channels at 1·80m centres. The drilling of the channel to form the bolt-holes will be covered by the steel-work rates. Measurement of painting of steelwork follows, assuming that the steelwork is to be painted by the main contractor after erection by him; otherwise covered by the steelwork rates.
			Painting.	
			305 2/102 204 2/ 509 1·018	Calculation of girth of channel = twice height + 4 times width.
4/	92·00 1·02		Remove all rust, grease, etc. & apply 2 cts. of bit. paint on g.s. of steelwk. to jetty a.f., all as specd.	Measured in square metres (See S.M.M. of C.E.Q., clause 101).
21/2/	4·30 1·02		(channs.	
20/2/4/	0·20		Ditto. on L cleats 200 – 300mm girth. (fenders (to piles	Painting to brackets measured in linear metres, as not exceeding 300mm girth.
206/4/	0·10		Ditto. 100 – 200mm gth. (brrs. to (channs.	It has been classified in 100mm stages of girth, although this is not required by the S.M.M.
52/2/	0·08		(posts to (brrs.	

XII – Measurement of Steel and Ironwork

THE MAIN principles to be followed in the measurement of this class of work are given in clauses 97 to 102 of the *Standard Method of Measurement of Civil Engineering Quantities*. These clauses are now quoted in full accompanied by explanatory notes.

A worked example illustrating the method of measuring a steel-framed gantry is also included.

CLAUSES FROM THE *S.M.M. of C.E.Q.* — EXPLANATORY NOTES

STEEL AND IRONWORK

(Structures in other metals may be measured in a similar manner)

97. *Unit of Measurement for Steel and Ironwork*

The unit of measurement for steel and ironwork is to be the megagramme.

The megagramme is the unit of measurement for steelwork in civil engineering work, whilst the kilogramme is used in building work.

98. *Repetition of Articles*

Where there is considerable repetition of articles of the same description and weight (as, for instance, foundation bolts), the weight of the single article is to be stated in the description.

99. *Calculation of Weights*

The weights of steel and iron entered in the bill of quantities are to be the calculated weights based on 785 kg per square metre of metal 100 mm thick for rolled and cast steel, 770 kg per square metre of metal 100 mm thick for wrought iron, and 725 kg per square metre of metal 100 mm thick for cast iron, or other appropriate unit or standard weight given in the British Standard Specifications or by makers for their own proprietary articles. In

It is important that the additional weight in rivet heads and fillet welds shall be added to the weight of the general steelwork, in order that they may be covered by the steelwork rates. The drilling of holes for bolts or rivets required for fixing the steelwork is also covered by the steelwork rates, without the need for special measurement.

CLAUSES FROM THE *S.M.M. of C.E.Q.*

arriving at these weights, tolerances for rolling margin and other permissible deviations from standard weights are to be ignored. An appropriate addition is to be made for the rivet heads or fillet welds, either by calculation of their weight or by adding a percentage. If the latter method is adopted, the assumed percentage is to be stated in the description.

100. *Classification of Items of Steel and Ironwork*

Separate items are to be provided for work of the same character but differing in regard to the labour for erection and fixing.

Separate items are to be provided for permanent bolts and nuts and for articles required for fixing permanently in position structural steel and ironwork, as, for example, holding-down bolts, anchor plates and the like.

101. *Painting Steel and Ironwork*

The cost of painting steel and ironwork at the factory is to be covered by the rates per megagramme for the structures in question.

Where the manufacture and erection of steel or ironwork are to be carried out by the same firm, the rate per megagramme is to cover all painting after erection at the site.

The unit of measurement for painting not covered by these directions is to be the square metre of steelwork

EXPLANATORY NOTES

It will be noted that steelwork to be erected in different positions entailing differing erection and fixing costs is to be split into separate items, even though all the steelwork in question is of the same section and serving the same function. Furthermore, holding-down bolts and similar fixing items are to form separate enumerated items, with adequate descriptions to meet the estimator's needs.

Painting of steelwork at the fabricator's works or on the site, where the fabricator is carrying out the work of erection, is included in the steelwork rates. Where the painting is carried out on the site other than by the fabricator of the steelwork, separate measurement in square or linear metres is required. When measuring lineal painting items some idea painted, and the linear metre for bars and other longitudinal members 300 mm in girth and under, the number of coats being stated.

of the width or girth involved should be given and 100 mm stages, up to 300 mm wide, is probably the best way of tabulating this class of work.

102. *Corrugated Sheeting*

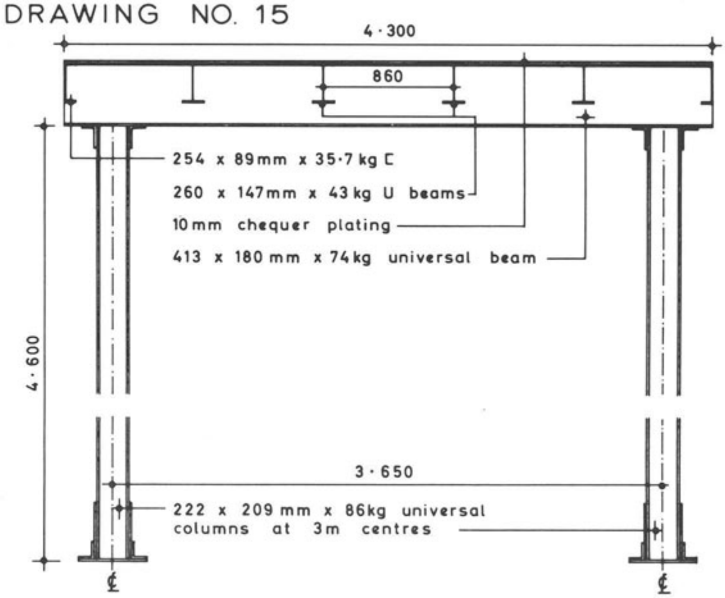
The unit of measurement for corrugated sheeting is to be the square metre covered, and the rate is to include cutting to size and all fastenings and laps.

Separate items are to be provided for forming openings.

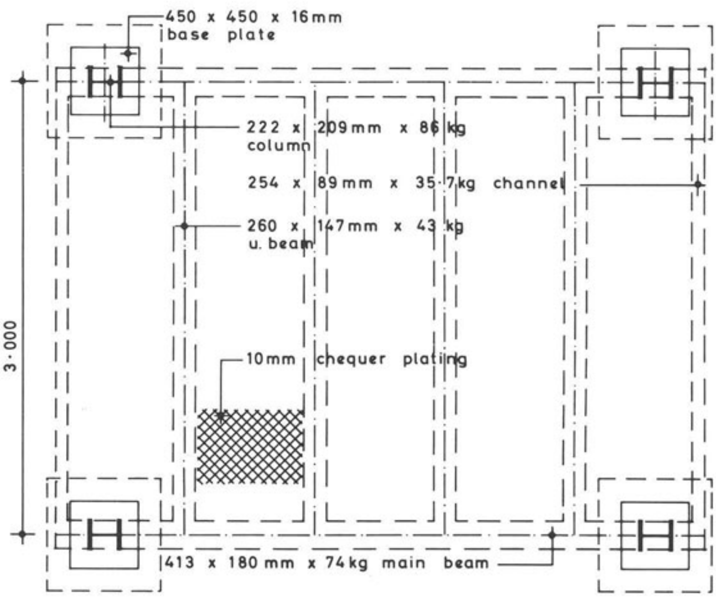
Corrugated sheeting is measured the nett area covered in square metres, with no allowance for laps, waste, etc.

STEEL-FRAMED GANTRY

DRAWING NO. 15



SECTION

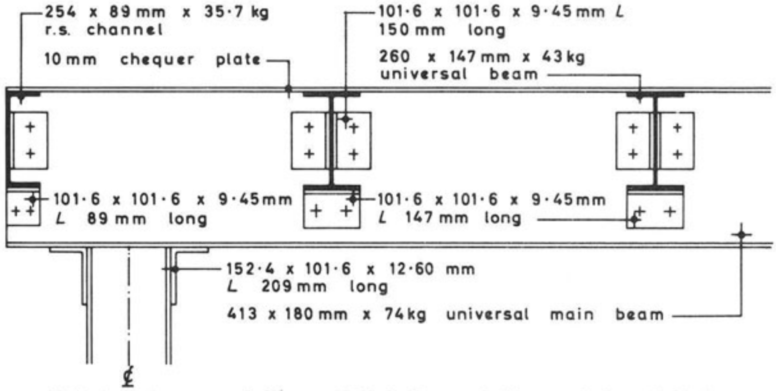


PLAN OF ONE BAY

SCALE 1:50

STEEL-FRAMED GANTRY

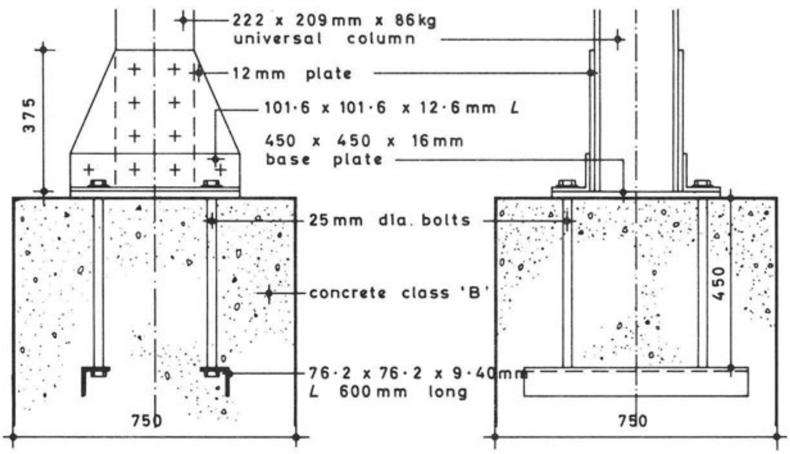
DRAWING NO. 16



DETAIL AT HEAD OF COLUMN

WEIGHTS OF SECTIONS

152·4 x 101·6 x 12·60 mm L	=	23·97 kg/m
101·6 x 101·6 x 12·6 mm L	=	18·90 kg/m
101·6 x 101·6 x 9·45 mm L	=	14·42 kg/m
76·2 x 76·2 x 9·40 mm L	=	10·56 kg/m
10 mm chequer plating	=	70 kg/sq.m



DETAILS AT BASE OF COLUMN

GANTRY DETAILS

SCALE 1:20

STEEL-FRAMED GANTRY

EXAMPLE XV

(30 m length)

The follg. in riveted steel frmwk.

			Beams
			3.000 | 30.000 10 + 1
11/	4.30		413 x 180mm x 74kg Universal beams. (main beams.
10/2/	3.00		254 x 89mm x 35.7 kg. R.S. channels. (subsid. beams.
10/4/	3.00		260 x 147mm x 43kg Universal beams (subsid. beams.

A logical sequence of "taking-off" is important, and the order that has been adopted for this example, is the measurement of main beams, followed by subsidiary beams and connections, then stanchions and connections.

All members are "taken-off" in linear metres, to be subsequently reduced to megagrammes, prior to billing. Separately classified where of differing character or subject to different erection costs, such as main girders (plate, lattice, etc.); framed girders; stanchions; bracing members; and special items (bearings, rods, handrailing, etc.).
10 bays with 2 lengths of channel to each bay.

It is unnecessary to deduct the very small thickness of the web to the main beam, when determining the length of the subsidiary beams.

STEEL-FRAMED GANTRY (Contd.)

10/5/2/	0·15		101·6 x 101·6 x 9·45mm x 14·42 kg ∠	Side cleats to beams and channels.
10/4/	0·15		(beam conns.	Brackets to beams.
10/2/	0·09			Brackets to channels.

These will also be "weighted up" by multiplying the total length by the weight per linear metre, and they are usually weighted up with the beams.

10/2/2/	12		(channs.	
2/2/	4		20mm r.h.s. (channs. at end of gantry.	
10/4/2/	14		(beams.	
2/4/	6		(beams at end of gantry.	

Rivet heads are added to the weight of the steelwork, the weight per 100 rivet heads being given in steelwork tables. e.g. 100 no. 20mm rivet heads weigh 8·5 kg.

Note the method used for arriving at the number of rivet heads at connections:-taking channels to main beams (first item):

10 is the number of bays, the first 2 is the number of channels per bay, the second 2 is the number of ends to each channel and 12 is the number of rivet heads per connection.

STEEL-FRAMED GANTRY (Contd.)

		<u>Stanchions</u>	*Where the rivets are taken through the subsidiary beam or channel, it will be necessary to double the number of rivets to give the number of rivet heads, as there are two faces involved. Similarly on the end bays, additional rivet heads will occur on the outside face of the main beam and these will need to be added.*
11/2/	4.60	222 x 209mm x 86kg Universal col.	
11/2/2/	0.21	152.4 x 101.6 x 12.60mm x 23.97kg ∠. (stan. conns.	*At top of stanchion (2 brackets to each stanchion). Usually "weighted-up" with stanchions.*
11/2/2/	12	20mm r.h.s.	*6 rivets to each bracket with 2 heads to take to each rivet.*
		375 less angle 102 273	
		450 209 2)659 330	*Note method of building-up dimensions of irregular area of plate in "waste."*

STEEL - FRAMED GANTRY (Contd.)

11/2/2/	0·45		12mm plate	
	0·10			
11/2/2/	0·33			
	0·27		(stan. bases.	
11/2/2/	0·45		101·6 x 101·6 x 12·6mm x 18·9kg L. (stan. bases.	
11/2/	0·45		16mm plate	
	0·45		(stan. base plates.	
11/2/2/	24		20mm r.h.s.	12 rivets to each set of brackets with 2 heads taken to each rivet. The extra cost of countersinking some of the rivet heads to the base plate will be covered by the steelwork rates and mentioned in the preamble clauses.

STEEL-FRAMED GANTRY (Contd.)

11/2/	4		25mm ϕ m.s. holdg. down bolt, 525mm lg. wi. n. & 2w. & Settg. ditto. in conc. to stan. base.	Separate item as different section of work.
11/2/2/	0·60		76·2 x 76·2 x 9·4mm x 10·56 kg L. (stan. base.	
11/2/2/	1		Settg. ditto., 600mm lg., in conc. in stan. base.	
			Chequer Plate	
	30·00 4·30		10mm th. chequer plate, weighg. 70kg/sq.m & fixg. to r.s. beams, 4·60m above g.l.	

STEEL-FRAMED GANTRY (Contd.)

			Painting	The same order is followed as in the "taking-off" of the steelwork
			Girths	
			Beams	
			413 x 180mm	Unnecessary to make allowance for the thickness of the web when measuring the inside flange faces.
			2/413 826	
			4/180 720	
			1·546	
			254 x 89mm	Girth of rolled steel joists = twice the height + 4 times the width.
			2/254 508	
			4/89 356	
			864	
			260 x 147mm	
			2/260 520	
			4/147 588	
			1·108	
				Painting of steelwork by main contractor is measured in square metres to the larger areas.
11/	4·30 1·55		Prepare & apply 1 ct. of r.l. primer & ② & ① to steelwk. a.f., ext., all as specd. (main beams.	The figures in circles represent 2 undercoats and 1 finishing coat of oil paint.
10/2/	3·00 0·86		(channs.	If the steelwork is painted by the steel fabricator, either at his works or on the site, then the painting is covered by the steelwork rates.
10/4/	3·00 1·11		(sub. beams.	

STEEL-FRAMED GANTRY (Contd.)

			222 x 209mm stan. 2/222 444 4/209 836 1·280	Most of the area of connecting brackets, etc., to be painted, will have already been taken with the beams, etc. The preparation work to the steel members prior to painting is normally covered in detail in the specification.
11/2/	4·60 1·28		(stans.	
11/2/2/	0·45 0·10		Prepare & apply 1 ct. of r.l. primer & ② & ① to stlwk. a.f. ext., all as specd. (angles.	
11/2/2/	0·33 0·27		(outside of plates.	Additional area to take to each stanchion base.
11/2/2/	0·10 0·10		(part of inside of angles.	The inside face of the 12mm plate and most of the angle will be cancelled out by the area of the flange of the stanchion which has been previously measured, but is, in fact, covered by the plate.
11/2/	0·45 0·45		(base plates.	
11/2/	0·45 0·45		Prep. & apply 2 cts. of bit. paint to steelwk. b.f. (u/s. of base plates. 4/76 = 304	
11/2/2/	0·60		Ditto. 200-300mm gth. (angles.	Measured in linear metres as barely exceeding 300mm girth and it can be priced more satisfactorily as a lineal item.
11/2/2/	2		Ditto., 25mm ϕ bolt, 525mm lg.	Best enumerated.

XIII – Measurement of Roads and Pavings

THE METHOD of measuring this class of work is outlined in clauses 103 to 110 of the *Standard Method of Measurement of Civil Engineering Quantities*. These clauses are now reproduced in their entirety with various explanatory notes entered beside them.

A worked example will then follow giving the dimensions for a section of estate road.

CLAUSES FROM THE *S.M.M. of C.E.Q.* — EXPLANATORY NOTES

ROADS AND PAVINGS

103. *Units of Measurement for Roads and Pavings*

The units of measurement for roads and pavings are to be:

Roads and pavings ... Square metre
Concrete foundations to kerbs and channels ... Linear metre
Kerbs and channels ... Linear metre
Fabric reinforcement ... Square metre
Bar or rod reinforcement ... Megagramme
Expansion joints ... Linear metre

For units of measurement for excavation, filling and forming, see clauses 39-49.

The unit of measurement for roads and pavings generally is the square metre. In the case of concrete foundations to kerbs and channels it is advisable to state the cubic content of concrete per linear metre of length to enable the estimator to attach a realistic price to the item. The description of expansion joints will include the provision of all necessary formwork.

104. *Macadam Roads*

The description of the items for macadamised and other metalled roads are to include the nature and finished thickness of bottoming and of top coatings. The rates are to cover any final preparation of the earth bed, rolling to the required finished thicknesses, and making good up to kerbs, channels, manholes and the like.

It will be noted that rates inserted against concrete and tarmacadam roads are to include for preparing the formation and making good the surfacing against kerbs, channels, manholes, gullies, etc. The foundation or sub-base to the road will also be included in the description.

105. *Concrete Roads*

The descriptions of the items for concrete roads are to state the

The channels to a concrete road are almost invariably

CLAUSES FROM THE *S.M.M. of C.E.Q.*

composition and thickness of the concrete. The rates are to cover any final preparation of the earth bed, finishing the surface of concrete as required by the specification, and making good up to kerbs, channels, manholes and the like.

The rate for expansion joints is to cover the cost of the additional material required to form the joint.

Channels formed in the surface of concrete roads are to be measured by the linear metre extra over the rates for concrete roads.

106. *Reinforcement of Concrete Roads*

Separate items are to be provided for the reinforcement of concrete roads.

For the method of measurement of steel reinforcement of concrete roads and the classification of items, see clauses 59 and 60.

107. *Asphalt Roads*

The descriptions of the items for asphalt roads are to state the nature of the asphalt, the number of coats and the total thickness. The rates are to cover making good up to kerbs, channels, manholes and the like.

108. *Pavings*

The descriptions of the items for pavings are to state the nature and size of the setts, flags or slabs to be used, including the thickness, the width of

EXPLANATORY NOTES

floated for a certain width and these are measured in linear metres as 'extra over' the rates entered against the concrete carriageway item.

The steel reinforcement in a concrete road cannot be included in the billed item for the concrete.

Rod or bar reinforcement is measured by the megagramme, keeping rods or bars of less than 25 mm diameter or side separate for each size. Fabric reinforcement is measured in square metres stating the weight in kg/sq m.

A full description of pavings such as slabs and setts is to be given, including the type of bedding and grouting and dethe courses (in the case of setts), and the nature of the bedding and grouting. The rates are to cover making good up to kerbs, channels, manholes and the like.

Separate items are to be provided for pavings laid between railway metals or over sleepers, and the rates for this class of paving are to cover the cost of trimming up to rails and guard rails.

tails of the bond should also be stated. Cutting and making good to kerbs, manholes, etc., is included in the rate for the superficial item and this undoubtedly extends to stop cock, sluice valve and hydrant boxes.

109. *Kerbs and Channels*

The descriptions of the items of kerbs and channels are to state the nature of the bedding and jointing. Separate items are to be provided for curved work in kerbs and channels where less than 10 m in radius, differentiating between curves exceeding 5 m and those of 5 m in radius and under.

Channels formed of setts occurring in sett pavings are to be measured by the linear metre extra over the cost of the paving.

Note that the method of bedding and jointing kerbs and channels is to be included in the descriptions of these items and the grouping to be adopted for curved work. It would appear that radius kerbs to curves of 10 m radius and over and straight kerbs laid to curves require no special treatment, which seems rather unsatisfactory having regard to the higher cost of this work over that of straight work.

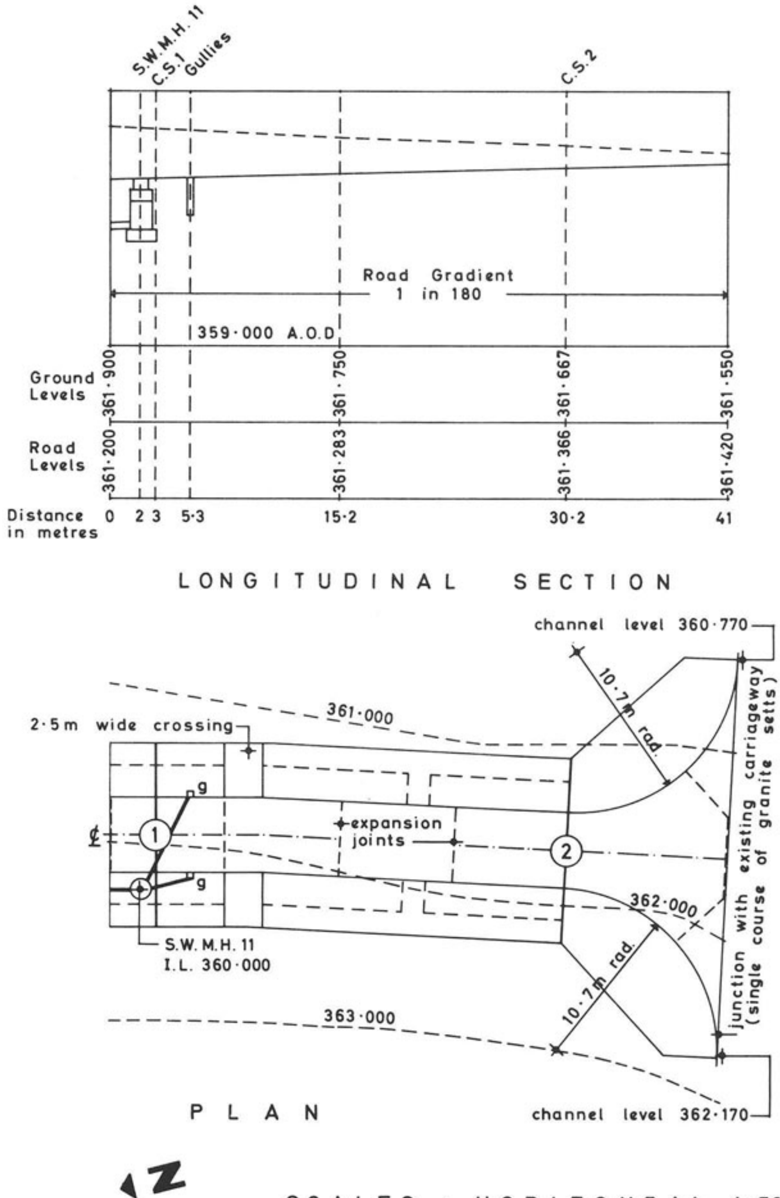
See explanatory notes accompanying Example XVI.

110. *Deductions for Manholes and the Like*

No deductions are to be made from the measurement of paved surfaces for manholes and similar structures of an area of 1 square metre or less; nor are any deductions to be made from the measurement of kerbs and channels for gullies and the like of 1 linear metre or less.

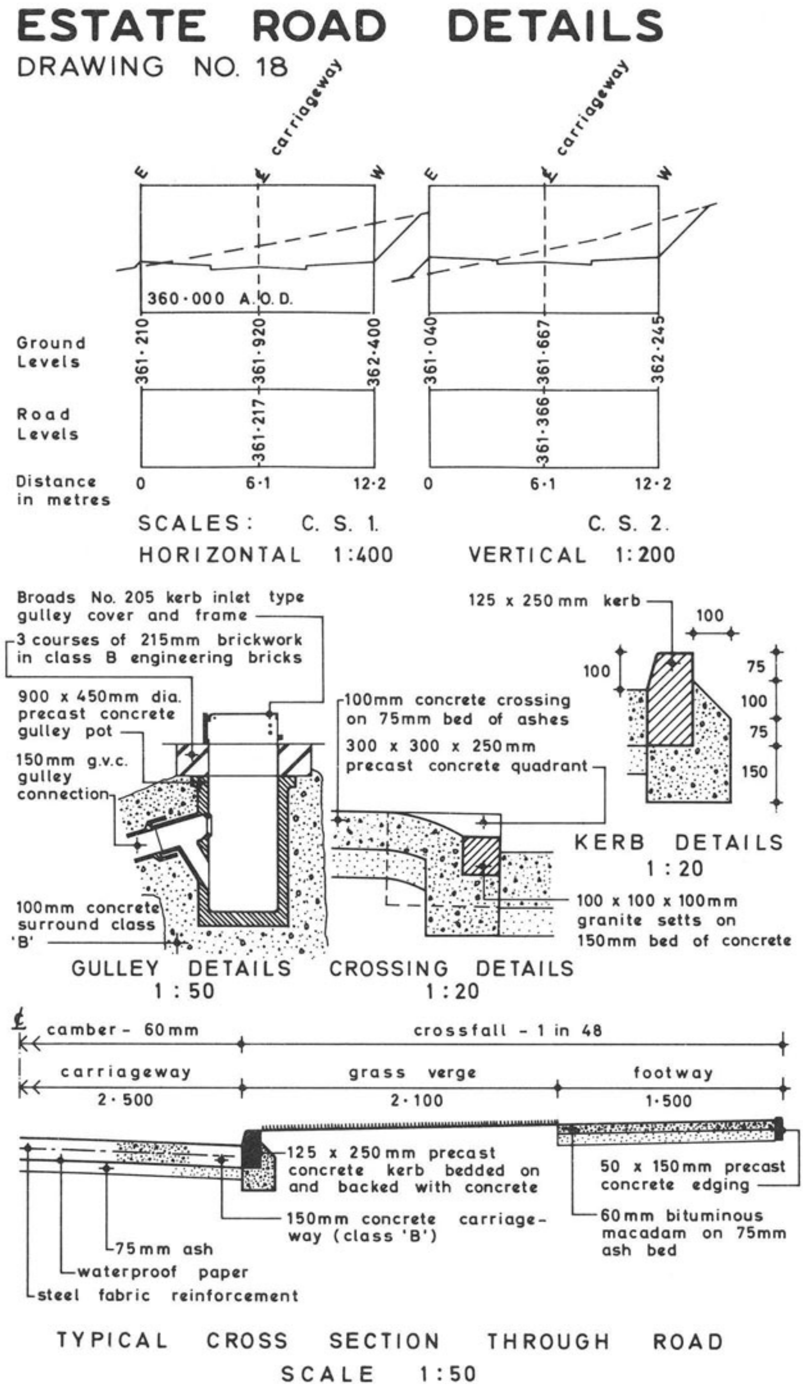
Normally no deductions are necessary from the areas of paved surfaces for manholes, gullies, boxes, etc., as these are all well below the limiting area of 1 sq m.

DRAWING NO. 17 ESTATE ROAD



SCALES : HORIZONTAL 1:500

VERTICAL 1:100


ESTATE ROAD DETAILS
DRAWING NO. 18
carriageway
E
W
360·000 A.O.D.
Ground Levels
361·210
361·920
362·400
361·040
361·667
362·245
Road Levels
361·217
361·366
Distance in metres
0
6·1
12·2
SCALES: C. S. 1. C. S. 2.
HORIZONTAL 1:400 VERTICAL 1:200
Broads No. 205 kerb inlet type gulley cover and frame
3 courses of 215mm brickwork in class B engineering bricks
900 x 450mm dia. precast concrete gulley pot
150mm g.v.c. gulley connection
100mm concrete surround class 'B'
GULLEY DETAILS 1 : 50
100mm concrete crossing on 75mm bed of ashes
300 x 300 x 250mm precast concrete quadrant
100 x 100 x 100mm granite setts on 150mm bed of concrete
CROSSING DETAILS 1 : 20
125 x 250mm kerb
100
100
75
100
75
150
KERB DETAILS 1 : 20
camber - 60mm
crossfall - 1 in 48
carriageway
grass verge
footway
2·500
2·100
1·500
125 x 250mm precast concrete kerb bedded on and backed with concrete
50 x 150mm precast concrete edging
150mm concrete carriage-way (class 'B')
60mm bituminous macadam on 75mm ash bed
75mm ash
waterproof paper
steel fabric reinforcement
TYPICAL CROSS SECTION THROUGH ROAD
SCALE 1:50

ESTATE ROAD — EXAMPLE XVI

			Excavn.	The excavation is taken separately for carriageway, kerbs and footways, etc., due to the varying depths in each case.
			Carriageway.	
			av. depth at C.S.1. 361·920, 361·217, add 703, road thickns 225, 928	
			av. depth at C.S.2 361·667, 361·366, 301, 225, 526, 928, 2) 1·454	
			av. depth. of excavn. 727	
			width: carriageway 5·000, add kerbs 2/225 450, 5·450	
			Bellmouth depths. −70 E. side, 350 W. side, 2) 280, add 140, road thickness 225, 365	−(fill)
	41·00			Additional area of one side of bellmouth = 3/14 x radius^2 (area of square, with side equal to length of radius less area of quadrant or 1/4 circle of same radius).
	5·45		Exc. for carriageway & footways, n.e. 1·50m dp., haul a distance n.e. 100m & spread, level & consolidate in 300mm layers as fillg.	
	0·73			
2/3/14/	10·70			
	10·70			
	0·37		(bellmths.	
			41·000, less rad. kerb 10·700, 30·300	Additional excavation for kerb foundations below road formation kept separate as more expensive hand digging is involved.
2/	30·30			
	0·23			
	0·08		Exc. in shallow tr. below form. level for kerb fdns. & dispose a.b.	
2/1/2/22/7/	10·70			Area of quadrant of circle = $\frac{1}{2}\pi R$ (1/4 x $2\pi R$).
	0·23			
	0·08		(bellmth.	

ESTATE ROAD (Contd.)

		Footways			
			E. side	W. side	The fill required under footways and verges on the east side will be made up of excavated material and this is included in the excavation disposal. The whole of the area of paths and verges is normally stripped of vegetable soil so that some excavation is required even in places which will subsequently receive fill.
		av. depth at C.S.1.	60	900	
		add thickness of path or verge	135		
			195		
		av. depth at C.S.2.	− 250 (fill)	700	
		less thickness of path or verge	135		
			− 115 (fill)		
				2) 1·600	
				0·800	
		add thickness of path or verge		135	
				0·935	
			E. side		
		C.S.1.	195		
		C.S.2.	150 (surf. strip)		
			2) 345		
			172		
		width. path		1·500	Excavation of kerb and backing already taken with carriageway and so needs to be deducted from overall width of path and verge.
		verge		2·100	
				3·600	
		less. kerb & backg.		225	
				3·375	
	30·30 3·38 0·94	Exc. for carriageway & footways, a.b.			Depths to surface of paving at extreme ends of paths calculated thus:-
	30·30 3·38 0·17	(surf. strip, etc. (on E. side.			

			E. side	W. side
	channel level		360·770	362·170
	add depth of kerb + half x fall on path.		137	137
			360·907	362·307

Bellmth

	E. side.	W. side
C.S.2.	−250	700
extremity	−407	543
	2) −657	2) 1·243
	−328	622
add thickness of path or verge.	135	135
	−193 (fill)	757

	E. side	W. side
Ground level of centre of path at extremity (interpolated from contours)	360·500	362·850
less finished level	360·907	362·307
Depth	−407 (fill)	543

ESTATE ROAD (Contd.)

	12·60 5·20 0·76		*Exc. for carriageway & footways a.b.* (paths at (bellmth.
	12·60 5·20 0·15		(surf. strip (on E. side.

Battered Slopes

width of bank
(incl. 150mm additnl. excavn for top soil).

	E. Side	W. Side
C.S. 1	150	2·650
C.S. 2	850	2·850
	2)1·000	2)5·500
av. width.	500 (fill)	2·750
bellmouth	850	2·850
	1·750	750
	2)2·600	2)3·600
av. width.	1·300 (fill)	1·800

Height of bank	E. Side	W. Side
C.S. 1.	150	1·050
C.S. 2.	450	950
	2)600	2)2·000
	300	1·000
bellmth.	450	950
	1·000	750
	2)1·450	2)1·700
	725	850

½/	30·30 2·75 1·00		(w. side. *Exc. for carriageway & footways a.b.*
½/	10·00 1·80 0·85		(bellmth (w. side.
½/	30·30 0·50 0·15		(e. side. (surf strip) (fill)
½/	10·00 1·30 0·15		(bellmth (e. side. (surf strip) (fill)

Dimensions of length and width are average dimensions scaled from the drawing. (av. length x ⅔ height over that length)

Note: The additional 40mm depth of excavation over the area of the two crossings, as compared with footway and verge excavation, is not large enough to justify separate measurement. Similarly, the additional excavation for quadrants over that required for kerbs would be more or less cancelled out by the smaller amount of excavation required for granite setts as compared with kerb – A sense of proportion must be maintained.

Assuming slopes of 1 in 2.

Volume of bank excavation = length x ½ (average width x average depth). If the quantity of fill exceeded the excavation, a separate item of fill would have to be taken.

ESTATE ROAD (Contd.)

Timesing	Dimensions	Squaring	Description
	41·00		E.o. gen. excavn. for excavatg. top soil av. 150mm dp., haul distance n.e. 100m & depositg. in spoil heaps ready for re-use.
	5·00		
2/ 3/14/	10·70		
	10·70		
2/	30·30		
	3·60		
2/	12·60		
	5·20		
			Carriageway.
	41·00		R. conc., class 'B' in road slab, 150mm th., reinfd. wi. fabric reinft. (m/s) & mech. vibrated, all as specd., on & incl. w.p. (bellmth.) paper & 75mm consolidated bed of ashes. Prices to incl. for use of all nec. fwk.
	5·00		&
2/ 3/14/	10·70		Steel fabric reinft., sq. mesh, weighg 2·5kg/sq.m, wi. 150mm laps at jts.
	10·70		
2/	30·30		E.o. conc. road slab for forming floated channel, 250mm wide.
2/ 1/2/ 22/7/	10·70		

Removal of top soil is measured in square metres as "extra over" the general excavation, which has already been measured (See S.M.M. of C.E.Q., clause 40). Stripping turf is dealt with in a similar manner.

Single item in square metres covering the ash bed, waterproof paper and concrete road slab complete.

The rates cover any final preparation of the formation, finishing the surface of the concrete as required by the specification and making good up to kerbs, channels, manholes, etc., without the need for specific mention (S.M.M. of C.E.Q., clause 105).

Fabric reinforcement is measured the area covered in square metres, stating the weight and amount of laps. The rates are to cover all cutting and waste. (See S.M.M. of C.E.Q., clause 60).

We are not too concerned with the slightly longer length of channel measured on its centre line (i.e. mean radius of 10·825) as this item is measured in linear metres.

ESTATE ROAD (Contd.)

2/	1		E.o. conc. road slab for dishg. & floatg. ard. ent. to kerb inlet type gulley.	
5/	5·00		Expansion jt. in 150mm conc. road slab, all as specd., incl. use of fwk.	Measured in linear metres, including all materials required to form the joint.
	10·70		(bellmth.	
2/	4·40		("	
	5·00		("	
			Crossings.	
			3·600	
			less setts 100	
			3·500	
2/	3·50		Conc. class 'B' in crossg., 100mm th., mech. vibrated & all as specd., on & incl. w.p. paper & 75mm consolidated bed of ashes. Prices to incl. for use of all nec. fwk.	
	2·50			
			Kerbs.	
2/	30·30		Precast conc. kerb, 125 x 250mm laid st. &/or curved (rad. ex. 12m), all as specd., incl. b.&j. in c.m. (1:3).	No differentiation is made between kerbs that are laid straight and those laid to a flat sweep, although more care and skill is required to lay kerbs in the latter category, resulting in higher cost.

ESTATE ROAD (Contd.)

2/	30.30		Conc. class 'C,' bed & backg. to kerb (0.046 cu. m/lin m), incl. all nec. shutterg.	sq mm 225 x 150 = 33 750 125 x 100 = 12 500 46 250 = 0.04625 sq.m. Volume per linear metre = 1.00 x 0.046 = 0.046 cu.m
			setts 2.500 quadrants 2/300 600 3.100	It is advisable to give the amount of concrete required per linear metre of kerb. Alternatively a dimensioned sketch could be incorporated in the bill of quantities, so that the Contractor can readily estimate the quantity of concrete required in the absence of detailed drawings.
2/	3.10		Ddt. precast conc. kerb a.b.d. & Ddt. conc. bed & backg. to ditto. (crossgs.	
2/ ½/ 22/7/	10.70		Precast conc. kerb to rad. ex. 5m & n.e. 12m, all as specd., incl. b. & j. in c.m. (1:3) & Conc. bed & backg. to rad. kerb., a.b.d.	The 10m limit of radius given in the Standard Method has been increased to 12m (40ft.), and this procedure was also recommended in "Notes on the Second Edition of the Specification for Road and Bridge Works and on the preparation of Bills of Quantities" issued by the Ministry of Transport (1959). In this way all radius kerbs, which are much more expensive than straight, are covered by separate items.

ESTATE ROAD (Contd.)

			Granite Setts.	
2/	2.50		Single cos of 100 x 100 x 100mm granite setts, & layg., all as specfd., incl. b.&j. in c.m. (1:3). (crossgs.	
2/	10.70		(junctn. (wi.xtg.rd.	
	5.00		("	
			&	Volume of concrete bed under setts :-
			Conc. class 'C' in bed to setts, (0.03 cu m/lin m), incl. all nec. shutterg.	c.s.a. = 200 x 150 = 30 000 sq.mm Volume per linear metre = 1 x 0.03 = 0.03 cu m.
2/	10.70		Take up xtg. precast conc. kerb & remove from site.	
	5.00			
2/	2		Precast conc. quadrant, 300 x 300 x 250mm, & layg., all as specfd., incl. b.&j. in c.m. (1:3).	To crossings (one each side at junction of kerbs and setts). The measurement of quadrants is not specifically mentioned in the S.M.M. of C.E.Q. (alternative would be to number as 'extra over' kerb).
			&	
			Conc. class 'C' in bed & backg. to quadrant (0.048 cu m ea.), incl. all nec. shutterg.	Bed to quadrant 400 x 400 x 250 — 0.040 Backing to quadrant 600 x 100 x 125 — 0.008 Total volume of concrete in cu m — 0.048

ESTATE ROAD (Contd.)

			Paths & Verges	
			30·300 *less* crossg. 2·500 27·800	
2/	27·80 1·50		60mm bit. macadm. footway surfacg. wi 50mm base cos.&10mm wearg. cos., all as specfd., on & incl. 75mm consolidated bed of ashes.	It will be noted from the S.M.M. of C.E.Q., clause 104, that the rates for macadam work are to include for any final preparation of formation, rolling to required finished thickness and making good up to kerbs, manholes, etc.
2/	1·98 1·50		(verge crossgs.	
2/	12·60 5·20		(bellmth.	
			verge 2·100 *less* kerb 125 1·975	
2/	27·80		Precast conc. rdd. path edging, 50 x 150mm & layg., all as specd.	
2/	10·00		&	Bed of concrete to edging c.s.a. (sq.mm) 100 x 75 = 7500 Backing to ditto. 75 x 50 = 3750 Total area 11250 sq mm
			Conc. class 'C' in bed & backg. for path edging (0·011 cu m/lin m), incl. all necessary shutterg.	Volume of concrete / lin m = 1 x 0·011 = 0·011 cu m.
			30·300 *less* crossgs. 2·500, 1·500 = 4·000 26·300	
2/	26·30 1·98		Trim verges, spread appd. top soil, 150mm dp. from spoil heaps, grade to falls & seed, all as specfd., at rate of 0·05kg/sq m.	Trimming, soiling and seeding of grass verges, measured in square metres (See S.M.M. of C.E.Q. clause 48).

ESTATE ROAD (Contd.)

	27·80 0·65		Trim surf. of bank to gradient of 1 in 2, spread appd. top soil, 150mm dp., to slopes & seed, all as specd., at rate of 0·05kg/sq. m.	(E. side.
	27·80 2·85			(W. side.
	10·00 1·00			(bellmth E. side.
	10·00 1·90			(bellmth W. side.

Length of slope calculated or scaled from drawings or enlarged sketches.
Any trees to be planted would be enumerated and new hedges measured by the linear metre. (provision and planting in both cases).

S. W. Drainage.

2/	1		Precast conc. gulley pot, 450mm dia. x 900mm dp., all as specfd., jtd. to 150mm g.v.c. pipe & settg. on 100mm conc. class 'C' bed & surrdg. wi. 100mm of conc. class 'C', supportg. 3 cos. of 215mm bwk. in class 'B' eng. bks. in c.m. (1:3). Provide & set Messrs. Broads No. 205 kerb inlet type gulley cover & frame on the bwk. Prices to incl. for all nec. excavn. & timberg.

Road gullies are to be enumerated and full descriptions given. (See S.M.M. of C.E.Q. clause 116)

Catchpits would be dealt with in a similar manner.

ESTATE ROAD (Contd.)

			Depths. (incl. 150mm conc. bed. gulley 900 m.h. 1·287 2) 2·187 av. depth. 1·094	
	3·00 6·50		Exc. tr. for 150mm drain pipe, n.e. 1·50m dp., (av. 1·0m dp.), backfill & remove surplus.	Average depth usually given to nearest 250mm and classified in 1·50m stages of depth, where not exceeding 6m deep. (See S.M.M. of C.E.Q. clause 40).
			&	
			150mm dia. B.S. g.v.c. pipes, laid & jtd. in c.m. (1:2).	Pipes measured in lineal metres.
			&	
			150mm conc., class 'C', bed & surrd. to 150mm g.v.c. pipe.	Not specifically covered by the S.M.M. of C.E.Q., but normally measured in linear metres.
2/	1		E.o. 150mm g.v.c. pipe for bend.	Bend probably needed at the gulley outlet to obtain the required gradient on the gulley connection. Connections to the manhole would be taken when measuring the manhole.

XIV – Measurement of Sewers and Drains

THE METHOD of measuring sewers and drains is largely detailed in clauses 112, 114, 115, 116, 117 and 118 of the *Standard Method of Measurement of Civil Engineering Quantities*. These clauses are reproduced in full with explanatory notes added where considered desirable.

Worked examples follow illustrating the method to be adopted for the measurement of a sewer constructed of glazed-ware and concrete pipes with concrete tube manholes, and a length of cast iron tunnel lining.

CLAUSES FROM THE *S.M.M. of C.E.Q.* — EXPLANATORY NOTES

SEWERS AND DRAINS

112. *Units of Measurement for Earthenware, Stoneware, Asbestos Pipes and Concrete Pipes with Cement or Open Joints*

The units of measurement for earthenware, stoneware, asbestos pipes and concrete pipes with cement or open joints are to be:

Sewers and drains, including laying and jointing pipes ... Linear metre

Bends, junctions and other fittings measured extra over pipe sewers and drains ... Number of each type

Cuts ... Number

This clause covers the measurement of pipe sewers and drains with cement or open joints and so covers the majority of sewers and drains. It will be noted that the lineal item of pipe includes the laying and jointing of the pipes, with excavation and concrete beds, etc., separately measured. Cuts to pipes are enumerated, stating the diameter and material of the pipe in each case.

114. *Alternative Methods of Measurement for Sewers and Pipe Lines*

Alternatively, sewers, drains and pipe lines may be measured by the linear metre of complete work. In this case, separate items are to be provided for work carried out in tunnel and in open cut, the average, mini-

The alternative method of measuring sewers by the linear metre of complete work, with a subsidiary bill giving the detailed quantities of work involved in the construction of a linear metre of sewer, is useful on occasions, and is particularly suitable mum and maximum depths from ground level to invert being given. A subsidiary bill in the description column should follow the item in the bill of quantities giving the detailed measurements comprised in one linear metre of the complete work. The quantities in the subsidiary bill should be taken out in accordance with the principles and units of measurement as set out herein.

for tunnel work. Its use for tunnel work is illustrated in Example XVIII. The need for the subsidiary bill, when using this method, cannot be overemphasised.

115. *Classification of Items for Pipes*

Separate items are to be entered for pipes of different classes as defined in the British Standard Specifications, and for different diameters under these classes.

It is essential that pipes of different classes, as recognised in British Standards and by the manufacturers, should be kept as separate items, as well as varying diameters of pipe, as these have an important influence on price.

116. *Gulleys, Drain Fittings and Manholes*

Gulleys, penstocks and similar drain fittings are to be enumerated and full descriptions given.

Manholes, inspection chambers and the like are to be measured in detail, in accordance with the directions given in the appropriate sections for the constituent materials, subject to the modification provided for in clause 29.

Manholes are normally split into their component parts and measured in detail. There is, however, the alternative method of enumerating manholes in groups accompanied by a subsidiary bill giving detailed quantities of the component parts in an average sized manhole of the particular group, although this latter method is not used a great deal in practice.

117. *Excavation and Concrete*

Excavation, reinstatement of surfaces, rubble drains and concrete are to be dealt with as set out in clauses 39-49 and 52-63.

Excavation of sewer and drain trenches is measured in linear metres, stating the diameter of the pipe or width of concrete protection. The average depth of excavation is given

CLAUSES FROM THE *S.M.M. of C.E.Q.*

EXPLANATORY NOTES

in the billed description and the excavation is split into 1·50 m stages of depth up to 6 m deep and then onwards in 3 m stages, measured from ground level to bottom of trench. E.g. one length of trench might be exceeding 4·50 m and not exceeding 6 m deep, and the next length exceeding 6 m and not exceeding 9 m deep.

118. *Sewers in Concrete, Reinforced Concrete, Brickwork and Cast-iron Segments*

Sewers constructed in concrete, reinforced concrete, brickwork or cast-iron segments are to be dealt with as set out in clauses 52-63, 64-69 and 97-102 respectively. Reference should also be made to clause 29.

EXAMPLES XVII AND XVIII FOLLOW

EXAMPLE XVII (DRAWINGS NOS. 19 AND 20)
SEWERS

It is desirable and quicker, and there is less risk of error if sewer and manhole schedules are prepared on the lines indicated in this example. The 'taking-off' process then becomes greatly simplified merely involving the extraction of the particulars from the schedule and combining totals where appropriate.

Sewer Schedule

Location	*Type and size of pipe*	*Length of pipe in metres*	*No. or size of junctns.*	*Length of trench n.e. 1·50 m dp & av. depth*
M.H.s. 1–2	225 mm conc. pipe	90·000 less m.h.s. 1·200 88·800	—	—
2–3	225 mm conc. pipe	162·000 90·000 72·000 less m.h.s. 1·200 70·800	—	—
3–4	150 mm g.v.c. pipe	205·000 162·000 43·000 ss m.h.s. 1·200 41·800	—	—
4–5	150 mm g.v.c. pipe	265·000 205·000 60·000 less m.h.s. 1·200 58·800	4 No. 100/150 mm	—
5–6	150 mm g.v.c. pipe	321·000 265·000 56·000 less m.h.s. 1·200 54·800	4 No. 100/150 mm	—
6–7	150 mm g.v.c. pipe	387·000 321·000 66·000 less m.h.s. 1·200 64·800	—	—

Length of trench 1·50–3·0 m dp. and av. depth (in brackets)	*Length of trench 3·0–4·50 m dp. & av. depth (in brackets)*	*Length of tarmac road (breaking up & reinstatement)*	*Excavation in road, verge or field*	*No. of hedges, fences and ditches*
90·000 less m.h.s. 1·650 3.0–4.50m dp. 74·000 76·650 14·350 (2·750)	74·000 (3·750)	6·500	10·000 verge 6·500 road remainder field	1 tbr. fence 1 hedge
72·000 less m.h.s. 1·650 70·350 (2·250)	—	—	field	2 hedges 1 ditch
43·000 less m.h.s. 1·650 41·350 (2·000)	—	6·000	6·000 road remainder field	1 hedge
60·000 less m.h.s. 1·650 58·350 (2·000)	—	58·350	road	—
56·000 less m.h.s. 1·650 54·350 (1·750)	—	54·350	road	—
66·000 less m.h.s 1·650 64·350 (1·500)	—	13·000	13·000 road, remainder verge	—

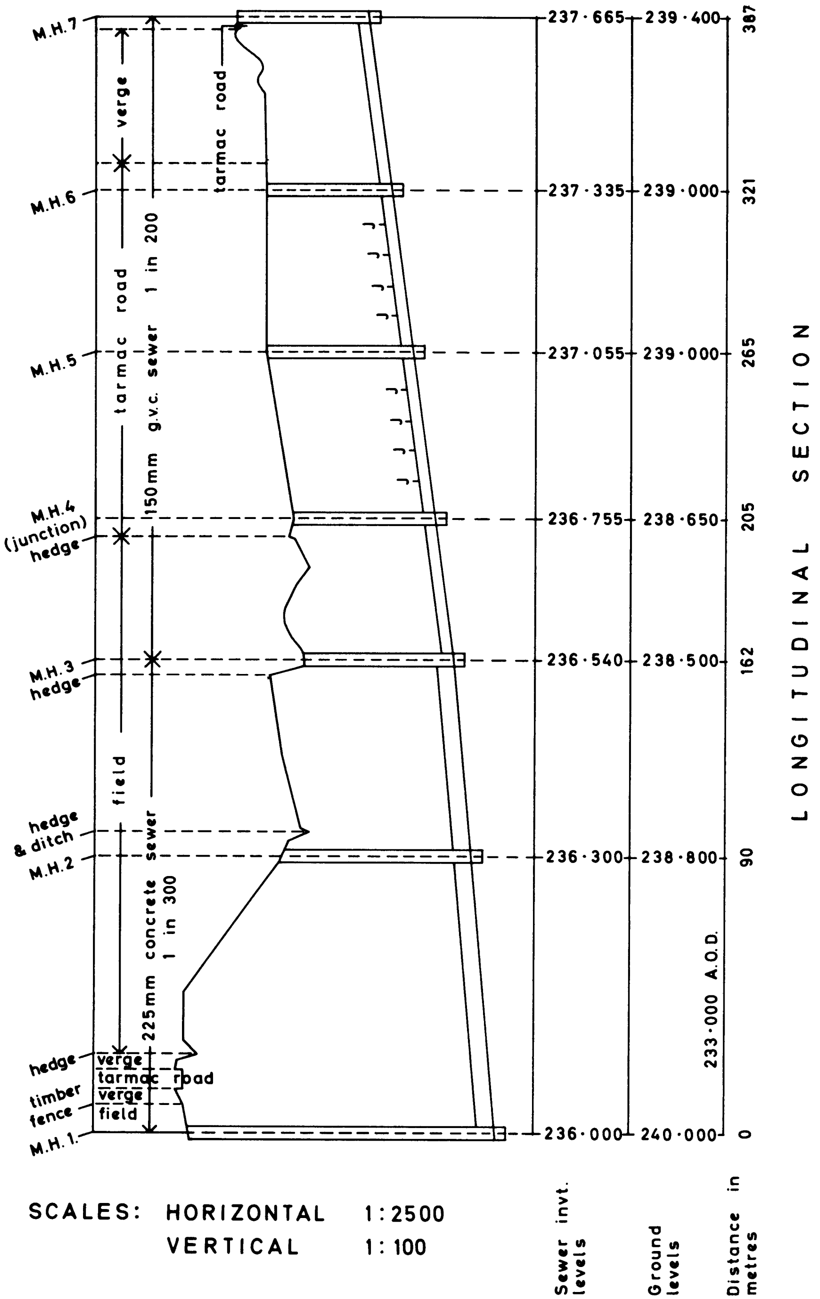
MANHOLE SCHEDULE

Manhole No.	*Ground level*	*Invert level*	*Total depth*	*Depth of 1200 mm rings* + 170 mm (*for base and channel*)	*Depth of 1200–675 mm taper*	*Depth of 675 mm rings*
1	240·000	236·000	4·000	1·500	600	1·000
2	238·800	236·300	2·500	750	600	300
3	238·500	236·540	1·960	600	600	—
4	238·650	236·755	1·895	450	600	—
5	239·000	237·055	1·945	600	600	—
6	239·000	237·335	1·665	300	600	—
7	239·400	237·665	1·735	300	600	—
Totals	—	—	15·700	4·500	7 No. (4·200)	1·300

Depth of 215 mm bwk.	*Type of M.H. cover*	*Sewer sizes*	*Junctions size & no.*	*Type of channel*	*No. of step irons (all in pre-cast units)*	*Combined depth of cover, cover slab & base wall*	*Location*
150	Medium	2/225	—	225 straight	10	750	field
100	Medium	2/225	—	225 curved	5	750	field
—	Medium	1/225 1/150	—	225–150 straight	4	750	field
95	Heavy	3/150	1/150	150 curved with junctn.	4	750	road
—	Heavy	2/150	—	150 curved	4	750	road
15	Heavy	2/150	—	150 curved	3	750	road
85	Heavy	2/150	—	150 straight	3	750	road
445	3 Med. 4 Heavy	5/225 10/150	1/150	—	33 No.	—	

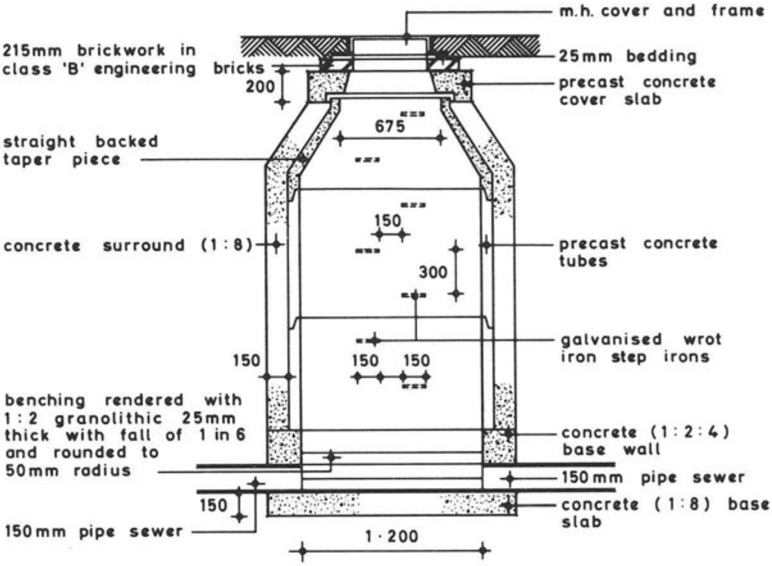
SEWER

DRAWING NO. 19

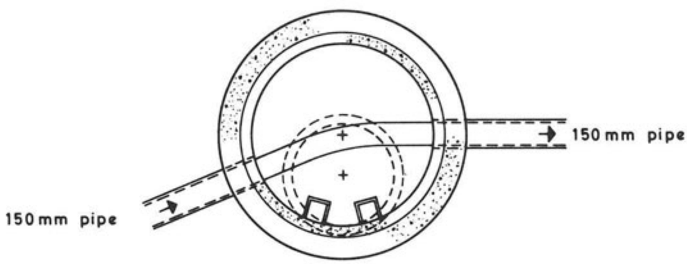


SEWER MANHOLE DETAILS

DRAWING NO. 20



SECTION



PLAN

SCALE 1:50

SE	WER		EXAMPLE XVII
		Mhs. 1 – 2	The rates for sewer trench and manhole excavation are to include for timbering, trimming bottoms and keeping excavations clear of water. (S.M.M. of C.E.Q. clause 41).
	10.00	Exc. in roadside verge for 225mm sewer, 3.0 – 4.5m dp. (av. 3.750 dp.), backfill & remove surplus, incl. final reinstatement of surf.	
		74.000 less (verge & road) 16.500 57.500	Trench excavation is measured in linear metres and taken in 1.50m stages of depth up to 6m deep, giving also the average depth of each length. The average depths have been given in stages of 250mm.
	57.60	Ditto. in field.	Lengths of trench excavation have been taken up to the outside face of each manhole.
	6.50	Ditto. in road (breakg. up & reinstatement of tarmac m/s.).	
	14.35	Exc. in field for 225mm sewer, 1.50 – 3.0m dp., (av. 2.750 dp.), backfill & remove surplus, incl. final reinstatement of surf.	Excavation for different sizes of pipe and that to be carried out under different conditions must be kept separate.

SEWER (Contd.)

			M.h.s. 2–3.	
	70·35		Exc. in field for 225mm sewer, 1·50 – 3·0m dp. (av. 2·250dp.), backfill & remove surplus, incl. final reinstatement of surf.	It is sometimes necessary on sewerage schemes to deepen and widen water-courses, drainage ditches, etc. when the most appropriate unit of measurement would seem to be the cubic metre.
			M.h.s. 3–4 41·350 less (road) 6·000 35·350	
	35·35		Ditto. for 150mm sewer, 1·50 – 3·0m dp. (av. 2·000 dp.), do.	
	6·00		Ditto. in road (M.h.s. 3–4)	Note how the location of each section of sewer is given for ease of reference in the future.
	58·35		(breakg. up & reinstatement (M.h.s 4–5) of tarmac m/s.)	
	54·35		Ditto. in road but (M.h.s. 5–6) 1·750 av. depth.	
			M.h.s. 6–7 64·350 less (road) 13·000 51·350	
	51·35		Exc. in roadside verge for 150mm sewer, 1·50 – 3·00m dp. (av. 1·500 dp.), backfill & remove surplus, incl. final reinstatement of surf.	

SEWER			(Contd.)	
	13·00		Ditto. in road (breakg. up & reinstatement of tarmac m/s).	The breaking up and reinstatement of tarmac-adam roads over pipe sewers is an "extra over" item given in linear metres. (See S.M.M. of C.E.Q. clause 40.).
	6·50		E.o. excavatn. for 225mm sewer for breakg. up & perm. reinstatement of tarmac. carriageway over line of tr. (M.h.s. 1–2)	
	6·00 58·35 54·35 13·00		Ditto. for 150mm sewer. (M.h.s. 3-4) (M.h.s. 4-5) (M.h.s. 5-6) (M.h.s. 6-7)	
	1		E.o. tr. excavn. for 225mm sewer for passg. under tbr. fence. (M.h.s 1–2)	Additional labour and expense is involved and a separate item is therefore necessary.
3/	1		Ditto. for passg. under hedge (M.h.s. 1-3)	
	1		Ditto. for passg. under ditch. (M.h.s. 2-3)	
	1		E.o. tr. excavn. for 150mm sewer for passg. under hedge (M.h.s. 3-4)	

SEWER		(Contd.)	
	88·80 70·80	225mm s. & s. conc. pipe sewer, laid & jtd. in c.m. (1 : 2) (M.h.s. 1–2 & 2–3)	
2/	1	Ex. for cut to 225mm conc. pipe.	
	41·80 58·80 54·80 64·80	150mm B.S. g.v.c. pipe sewer, laid & jtd. in c.m. (1:2) (M.h.s. 3–4) (M.h.s. 4–5) (M.h.s. 5–6) (M.h.s. 6–7)	
4/	1	Ex. for cut to 150mm g.v.c. pipe.	Separately enumerated as S.M.M. of C.E.Q., clause 112.
4/ 4/	1 1	E.o. 150mm g.v.c. pipe for 100mm off 150mm junction. (M.h.s. 4–5) (M.h.s. 5–6) & 100mm dia. stoneware stoppers to junctns. as specd. & Oak stake, as specd. & driven into grd. as junction marker.	Ditto.

SEWER (Contd.)

	15·00		Conc. class 'C' in 150mm bed to 150mm pipe. (Provsnl.)	Provisional item in linear metres to cover any soft spots that may be found in the trench bottoms.
	10·00		Ditto. to 225mm pipe (Provsnl.)	
	88·80 70·80		Water test 225mm conc. pipes, as specd. (M.h.s. 1–3)	Not specifically mentioned in the S.M.M. of C.E.Q., but usually measured in linear metres. Alternatively, it may be included as a single lump sum item.
	41·80 58·80 54·80 64·80		Ditto. 150mm g.v.c. pipes. (M.h.s. 3–7)	
	The follg. in 7No. Precast conc. tube manholes.			Measure manholes under a suitable heading, giving the number of manholes.
			Intl. diameter 1·200 add walls 2/225 450 ext. dia. 2 / 1·650 ext. rad. 0·825 depth 2·500 (m.h. 2) 1·960 (m.h. 3) add bases 2/170 340 4·800	
22/7 /	0·83 0·83 4·80		Exc. for circ. m.h. in field, n.e. 3·0m dp. & backfill & remove surplus. (m.h.s. 2 & 3)	Excavation to manholes (pits) is measured in cubic metres in 3m stages of depth, measured from ground level in each case. (See S.M.M. of C.E.Q. clause 40).

SEWER		(Contd.)	
		depth	
		1·895 (m.h. 4)	
		1·945 (m.h. 5)	
		add 1·665 (m.h. 6)	
		bases. 1·735 (m.h. 7)	
		4/170 680	
		7·920	
22/7/	1·65 1·65 7·92	Exc. for circ. m.h. in tarmac. road, n.e. 3·0m dp., & backfill & remove surplus. (breakg. up & reinstatg. tarmac m/s.). (m.h.s. 4, 5, 6 & 7)	
		4·000 add. base 170 4·170	
22/7/	1·65 1·65 4·17	Ditto. in field, n.e. 6·0m dp. & backfill & remove surplus. (m.h. 1.)	
22/7/	3·30 4·80	E.o. gen. excavn. for any additional excavn. & backfill for timberg. or workg. space. (area of sides of net excavn. mesd.).	It is advisable to provide this separate item to cover any additional excavations required for timbering, working space, etc., when measuring manholes.
22/7/	3·30 7·92		
22/7/	3·30 4·17		

SEWER			(Contd.)	
4/ $\frac{22}{7}$/	0·83 0·83		E.o. gen. excavn. for breakg. up tarmac. carriageway & perm. reinstatement. (m.h.s. 4, 5, 6 & 7)	The additional labour consolidating the tarmacadam around the manhole cover and frame will cancel out the void which the cover and frame occupy.
7/ $\frac{22}{7}$/	0·83 0·83		Conc. (1:8) in base slab, 150mm th. 1·200 add 2/½/225 225 1·425	Can be measured in square metres or cubic metres. (See S.M.M. of C.E.Q. clause 54).
7/ $\frac{22}{7}$/	1·43 0·23 0·40		Conc. (1:2:4) in base wall. 400 150 550	
7/ $\frac{22}{7}$/	1·65 0·55		Sawn vert. curved shutterg. to rad. of 825mm.	Differentiate between sawn and wrought shuttering and between straight and curved, vertical and horizontal, etc. It is also advisable to give the radius for curved shuttering.
7/ $\frac{22}{7}$/	1·20 0·40		Wrot. vert. curved shutterg. to rad. of 600mm.	

SEWER			(Contd.)	
5/	1		Form or leave hole in 225mm conc. wall for 225mm pipe.	Enumerated in accordance with S.M.M. of C.E.Q., clause 57.
10/	1		Ditto. for 150mm pipe.	
7/22/7/	0·60 0·60 0·23		Fine conc. benchg. (1:2:4) fin. to reqd. shapes & falls.	
7/22/7/	0·60 0·60		Grano. renderg. (1:2), 25mm th. to benchgs. & chans.	
7/2/	1·30 0·08		(sides of chans.	
	1·20		Channel, g.v.c. st., h.r. 225mm dia., all as specd., incl. beddg. (m.h.1.)	Measured in linear metres.
	1·30		Ditto., curved, do. (m.h. 2.)	There are changes of direction at manholes 2, 3, 4, 5 and 6, so that curved channels are required.
	1·20		Ditto., 150-225mm dia. taper, do. (m.h. 3.)	

SEWER (Contd.)

3/	1·30 0·80	Channel, g.v.c. curved, h.r., 150mm dia. all as specd., incl. beddg. (junction.) (m.h.s. 4, 5 & 6)	
	1·20	Ditto., st., do., incl. do. (m.h. 7).	
	4·50	1200mm intl. dia. precast conc. chbr. rings, incl. w.i. step irons b.i., & jtg. in c.m. (1:2), all as specd.	Best method is to measure the precast concrete rings per linear metre of depth and enumerate the tapers.
	1·30	675mm intl. dia. ditto., incl. do.	
7/	1	1200 to 675mm intl. dia., precast conc. taper rings, incl. do.	

S E	W E R		(Contd.)	
7/	1		Precast conc. cover slab, 1100mm ov'll. dia. x 200mm dp., wi. circ. opg., incl. settg. in c.m. (1:2) all as specd.	
			1.650 less 2/½/150 150 1.500	
22/7/	4.50 1.50 0.15		Conc. (1:8), in surrd., (1200mm rings. 150mm th., to precast conc. rings. (shutterg. m/s).	Measured in cubic metres, as mass concrete. Length measured on centre line of concrete surround.
22/7/	1.30 0.95 0.15		(676mm rings.	
7/22/7/	0.60 1.30 0.15		(tapers.	
22/7/	4.50 1.65		Sawn vert. curved shutterg. to rad. of 825mm. (1200mm rings.	These are expensive items and should be fully described, and it is probably advisable to state the radius for curved work.
22/7/	1.30 1.10		Ditto. to rad. of 550mm. (675mm rings.	
7/22/7/	0.60 1.45		Sawn taperg. curved shutterg. to mean rad. of 725mm. (tapers.	

SEWER			(Contd.)	
			add 2½/215 500 215 715	Height of brickwork is taken from schedule (p. 267).
22/7/	0·72 0·45		One-bk. wall, curved to mean rad. of 358mm in class 'B' eng. bks. in c.m. (1 : 3), incl. f.f. intly.	The provision of internal fair face has been included in with the brickwork item in this case, due to the limited quantity involved.
4/	1		Heavy wt. c.i. m.h. cover & fr., 550mm dia., p.c. £14 ea. & settg. on & incl. 25mm bed of c.m. (1:2), all as specd. (m.h.s. 4–7).	
3/	1		Med. wt., ditto., p.c. £10 ea., & do. (m.h.s. 1–3).	
	(End of Manholes.)			Note method of indicating end of work taken under a sectional heading.

CAST IRON TUNNEL LINING. EXAMPLE XVIII

This class of work is best measured in accordance with the alternative method of measurement for sewers and pipelines laid down in clause 114 of the Standard Method of Measurement of Civil Engineering Quantities. The tunnel work will then be measured by the linear metre of work complete with a subsidiary bill in the description column giving the detailed measurements making up one linear metre of the complete work.

The follg. in 350 linear metres of 2·40m extl. dia. cast iron tunnel lining.

	350	lin m	2·40m extl. dia. (2·23m intl. dia.) shield driven tunnel in cast iron segments, from access shaft No. 4 eastwards to access shaft No. 3.

Details of one linear metre of complete work.

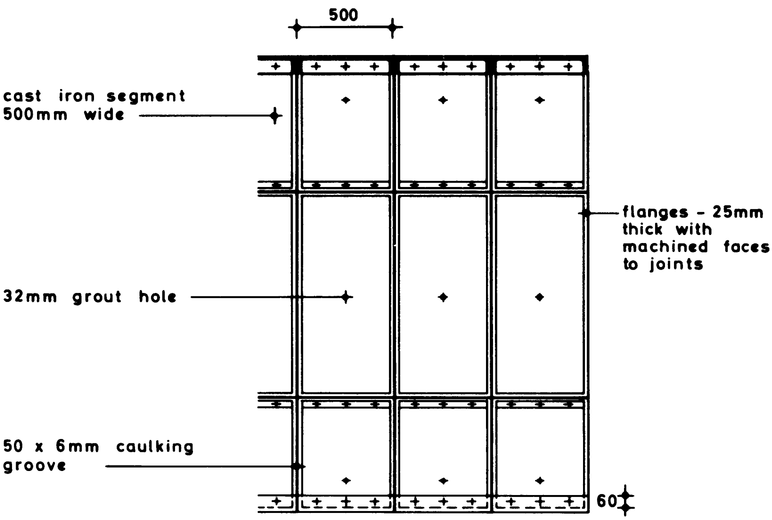
22/7 /	1·20 1·20 1·00		Exc. in sand in free air, in shield driven tunnel, incl. removal of all excavtd. matl.

The quantity of excavation is taken the net sectional area of the tunnel, and any excavation beyond the outer face of the tunnel lining is covered by an item of overbreak (superficial area of outer face of lining).

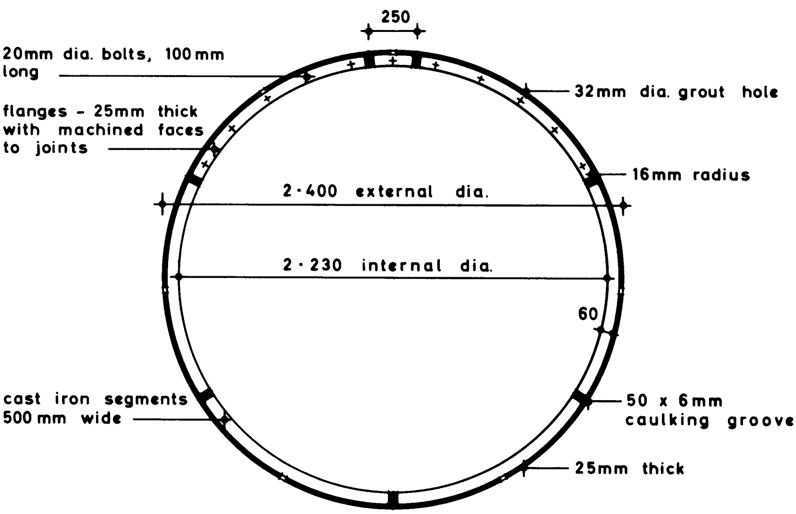
Work carried out in free air must be kept separate from that carried out in compressed air.

CAST IRON TUNNEL LINING

DRAWING NO. 21



INTERNAL ELEVATION



CROSS SECTION

SCALE 1:40

CAST	IRON		TUNNEL LINING	(Contd.)
22/7/	2·40 1·00		Additnl. excavn. in tunnel for overbreak. & Pressure grout ard. outside of tunnel lining in c.m. (1:2) grout.	
	1·00		Transport & assemble c.i. tunnel lining rings, made up of 7 segments to ea. complete ring, 500mm wide & jtg. (caulkg. of jts. m/s.)	There will be two complete rings to a linear metre of tunnel lining.
			extl. dia. 2·400 less 2/½/ ling. thickness 25 mean dia. 2·375 extl. dia. 2·400 less 2ea. ling. thickness 50 less 2/½/ flange width. 60 110 mean girth of circum. flange 2·290	

CAST IRON TUNNEL LINING (Contd.)

				All the metalwork in the cast iron segments will be weighted up and billed in megagrammes.
22/7/	2.38			
	1.00		(lining.	
			25mm metal	
2/2/22/7/	2.29			
	0.06		(circum. (flanges.	2 complete rings with 2 circumferential flanges to each ring.
7/2/	1.00			
	0.06		(Long. (flanges.	
2/2/22/7/3/14/	2.29			16mm radius fillets to all flanges.
	0.02			
	0.02		Metal in fillets.	Volume of additional metal contained in them is the total flange length x 3/14 x (16mm)²
7/2/3/14/	1.00			
	0.02			
	0.02			
			Total depth of flange 85	No adjustments are necessary for bolt-holes, grout holes, caulking grooves and bolt seatings, as the net result would be very small indeed.
			<u>less</u> depth of caulking groove 50	
			35	

CAST IRON TUNNEL LINING (Contd.)

			extl. dia. of lining. 2·400 less 2/½/ depth of machined face 35 2·365	
2/2/22/7/	2·37		Machng. faces of circum. & long. flanges, 35mm wide.	A carefully machined surface is required to each contact face.
7/2/	1·00			
			½/60 25 30 55	
			extl. dia. of lining. 2·400 less 2 x outer face of lining to centre of caulkg. groove 2/55 110 2·290	
2/22/7/	2·29		Caulkg. jts. between circum. & long. flanges in rust ct., as specd.	
7/	1·00			
			Bolts Circum. 6 large segments wi. 5 bolts. to ea. 30 1 small segment wi. 1 bolt. 1	

CAST IRON TUNNEL LINING (Contd.)

			Bolts.	
			Longitudnl. 3 bolts to ea. pr. of flanges to ea. ring.	
2/	31		20mm ϕ m.s. bolt 100mm lg wi n. & 2w. (circum.	
2/7/	3		(long.	
			Plugs	
2/	7		32mm ϕ scrd. w.i. plugs, incl. tappg. grout hole.	2 rings with 7 grout holes to each ring (1 to each segment).

Note: Precast concrete tunnel linings are similarly measured. They are often 600mm in width, giving 1⅔ rings per lineal metre.
The handling and erection of the lining segments are generally enumerated in rings with the bituminous packing between joints measured in linear metres.
Where an insitu concrete lining is applied to the inner face of the precast concrete segments, as in sewer work, this is usually measured in cubic metres.

XV – Measurement of Pipe Lines

THE METHOD to be used in measuring pipe lines formed of pipes with caulked lead or other special joints is described in clauses 111, 113, 114, 115 and 117 of the *Standard Method of Measurement of Civil Engineering Quantities*. These clauses are reproduced in full accompanied by explanatory notes.

A worked example covering a length of cast iron water main with various specials and fittings is also included in this chapter.

CLAUSES FROM THE *S.M.M. of C.E.Q.*

PIPE LINES

111. *Supply of Materials*

The pipes and accessories for pipe lines may be provided by the contractor as part of the contract, or they may be supplied to the contractor at a specified place, in which case he has to to take delivery, transport to storing ground, and distribute and lay. When the pipe materials are to be supplied to the contractor, the quantities and weights of the various classes of materials per metre (or kilometre) of pipe line are to be stated.

EXPLANATORY NOTES

With pipe line contracts, unlike most other contracts, the employer frequently supplies the pipes, specials and fittings. The Employer may be a statutory undertaker, such as a water undertaking, supplying water over a large area and keeping large stocks of pipes, specials and fittings to meet all future forseeable needs. Again, with cast iron and steel pipes, specials and fittings, the delivery period has, on occasions, extended into years and the employer has been compelled to maintain large stocks of these items to prevent serious delays arising in the carrying out of projects.

The contractor may be required to take delivery from the employer's stores, transport, distribute around the site and subsequently lay to the lines shown on the drawings. The quantities of pipes and specials

CLAUSES FROM THE *S.M.M. of C.E.Q.*

EXPLANATORY NOTES

of which delivery is to be taken and transported to site is given in linear metres stating the weight per linear metre of pipe of each class and size. Where the pipes and specials are to be supplied and delivered—the pipes are measured in linear metres and the specials enumerated.

113. *Units of Measurement for Cast Iron, Steel and Wrought Iron Pipes and Concrete or Composite or Asbestos Pipe with Caulked Lead or other Special Joints*

The units of measurement for cast iron, steel and wrought iron pipes and concrete or composite or asbestos pipe with caulked lead or other special joints are to be:

Pipes, supplied and delivered.
. . . Linear metre
(effective length, i.e. back of socket to spigot)

Making-up pieces and collars (including all pipes not of standard length), supplied and delivered.
. . . Number of each type

Standard bends, tees and other specials, supplied and delivered.
. . . Number of each type

Non-standard bends, tees and other specials, supplied and delivered.
. . . Number of each type

Taking delivery of pipes, bends, tees and specials, and transporting (where pipes are supplied to the contractor).
. . . Linear metre (effective length)

Distributing and laying pipes, bends, tees and specials.

Note the TWO different methods used for determining the length of pipes:

(a) Where dealing with the supply, delivery and transporting of pipes the unit of measurement is the linear metre of effective length (inside socket to end of spigot, e.g. 5·50 m).

(b) Where dealing with the distributing and laying of pipes, the unit of measurement is the linear metre of pipe line actually laid, with no allowance for waste lengths of pipe resulting from cuts, and is measured over bends and other specials. All cuts to pipes are enumerated.

. . . Linear metre of pipe line as laid

Jointing, including jointing material, bolts and other fastenings.

. . . Number of joints

Brackets, slings, and other supports, supplied and fixed.

. . . Number of each type

Insulating covering for pipes

. . . Linear metre of pipe line

Valves, expansion joints, anchors and similar fittings, supplied and fixed.

. . . Number of each type

Cuts. . . . Number

114. *Alternative Methods of Measurement for Sewers and Pipe Lines*

Alternatively, sewers, drains and pipe lines may be measured by the linear metre of complete work. In this case, separate items are to be provided for work carried out in tunnel and in open cut, the average, minimum and maximum depths from ground level to invert being given. A subsidiary bill in the description column should follow the item in the bill of quantities giving the detailed measurements comprised in one linear metre of the complete work. The quantities in the subsidiary bill should be taken out in accordance with the principles and units of measurement as set out herein.

In pipe line contracts or where the pipe line forms a substantial part of the work to be carried out, the pipes and pipe fittings may be entered by number, the diameter, length, thickness and weight of metal in each class of pipe or pipe fitting being given. The items may or may not include taking delivery and laying, according to the nature of the contract.

The alternative method of measurement described for use with sewers and tunnel work can also be applied to the measurement of pipe lines. A further alternative is to supply an enumerated schedule of all pipes, specials and fittings, giving the diameter, length, thickness and weight of each item. These alternatives have the principal merit of reducing the time spent in preparing the Bill of Quantities, etc., and in pricing.

CLAUSES FROM THE *S.M.M. of C.E.Q.*

115. *Classification of Items for Pipes*

Separate items are to be entered for pipes of different classes as defined in the British Standard Specifications, and for the different diameters under these classes. Valve chambers, hydrant boxes and the like are to be measured in detail, in accordance with the directions given in the appropriate sections for the constituent materials, subject to the modification provided for in clause 29.

117. *Excavation and Concrete*

Excavation, reinstatement of surfaces, rubble drains and concrete are to be dealt with as set out in clauses 39-49 and 52-63.

EXPLANATORY NOTES

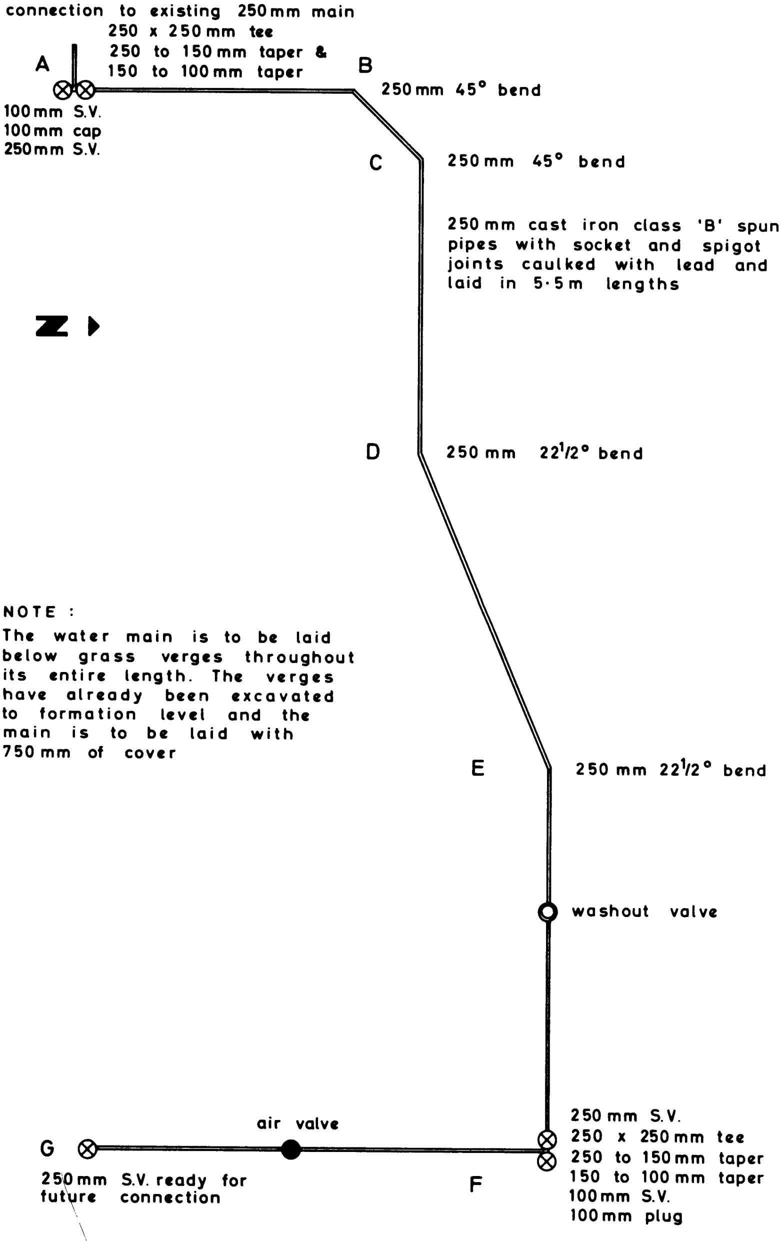
Pipes of different classes and diameters must be kept separate due to the considerable variations in prices that are involved.

Valve chambers, hydrant boxes, etc., are normally measured in detail but an alternative method of measurement is outlined in clause 29 of the *Standard Method*, whereby the chambers or boxes are enumerated as single comprehensive items with a subsidiary bill included in the description column of the main bill, giving the quantities of the component items making up a typical chamber or box.

Excavation of pipe line trenches is measured in linear metres, in 1·50 m stages of depth, (up to 6 m deep), stating the diameter of the pipe, as for sewers and drains.

WATER	MAIN			EXAMPLE XIX
			<u>Excavtn. & pipewk.</u>	The use of sub-headings helps in breaking down the "taking-off" work into manageable sections and makes it easier to follow.
	1		Exc. to a depth of approx. 1·05m to locate end of extg. 250mm main & provide sufficient space for burng. out plug (m/s.), backfill & remove surplus.	Enumerated item, fully described, for locating end of existing main.
	7·50		Exc. tr. in field (to A	Trench excavation is measured in linear metres, working systematically along the pipeline from A to G. (See S.M.M. of C.E.Q. clause 40).
	47·50		for 250mm dia. (A to B.	
	16·00		c.i. water main & (B to C.	
	48·50		specials, av. 1·05m (C to D.	
	56·50		dp. & n.e. 1·50m (D to E.	
	63·50		dp., backfill & (E to F.	
	75·00		remove surplus. (F to G.	
			&	
			Distribute & lay 250mm dia., c.i. pipe, bends, tees & specials.	Measured in linear metres of pipeline as laid. Length of specials of less than 250mm dia. is so small a proportion of the whole as not to justify separate mention.
			&	
			Allow for testg. main at a pressure of 827kN/sq. m for 30 mins.	

DRAWING NO. 22 **WATER MAIN**



NOTE :
The water main is to be laid below grass verges throughout its entire length. The verges have already been excavated to formation level and the main is to be laid with 750mm of cover

SCALE 1 : 1250

WATER MAIN (Contd.)

7·00	Supply & deliver	(to A.
46·00	250mm dia. spun	(A to B.
15·50	iron, s. & s. pipes	(B to C.
48·00	to B.S. 1211, class	(C to D.
56·00	'B,' in 5·50m effective	(D to E.
62·00	lens., as far as	(E to F.
74·00	possible, & coated,	(F to G.
	all as specd.	

Lengths of pipework supplied and delivered are less than the excavation lengths as the lengths of specials have been deducted, as these are separately enumerated. Alternatively, the pipes and pipe fittings may be billed by number, giving details of the length, diameter, thickness and weight of metal in each pipe and fitting, where the pipeline forms a substantial part of the contract, as in fact it does in this example.

<u>Joints.</u>

2		(to A.
9		(A to B.
2	Make caulked	(tee & bend
3	lead & spun	(B to C.
1	yarn, s.& s. jts.	(bend.
9	on 250mm dia.	(C to D.
1	c.i. pipes.	(bend.
11		(D to E.
1		(bend.
12		(E to F.
2		(W.O. & bend.
14		(F to G.
1		(A.V.

Joints to pipelines enumerated, stating size of pipe and type of joint.
No. of joints on each leg of pipeline found by dividing the length of pipeline by the pipe lengths to be used; i.e. 5·50m in this case.
e.g. A to B $5{\cdot}5\overline{)46}$ = 9

It would not be accurate to take the total length in metres of pipeline complete and divide by 5·50 to give the number of joints, due to the use of some shorter lengths of pipe.

WATER MAIN (Contd.)

			Specials	
	1		Supply & deliver c.i. taper to B.S. 1211, coated, all as specd., wi. 150mm soc. & 250mm spigot. (F.	Supply and delivery of bends, tees, and specials enumerated. The distributing and laying has already been measured in linear metres as part of the pipeline.
	1		Ditto., wi. 250mm soc. & 150mm spigot. (A.	Describing bends, tees, and specials in this way provides sufficient information for ordering purposes.
	1		Ditto., wi. 100mm soc. & 150mm spigot. (F.	
	1		Ditto. wi. 150mm soc. & 100mm spigot. (A.	
2/	1		Supply & deliver 250 x 250 x 250mm c.i. tee piece to B.S. 1211, coated, all as specd. (A. & F.	

WATER MAIN (Contd.)

2/	1		Supply & deliver 250mm dia. c.i. 45° bend to B.S. 1211, coated, all as specd. (B & C.	
2/	1		Ditto., 22½° bend do. (D & E.	
	1		Supply & deliver c.i. s. & s. hydrant tee, 250 x 250 x 63mm wi. flanged branch for W.O., coated, all as specd. (E to F.	
3/	1		Supply & deliver 250mm dia. c.i. flanged spigot & Ditto. flanged soc. (A.F. & G.	Flanged spigots and sockets are needed to connect the spigot and socket pipes to the flanged valves. It is generally considered advisable to use sluice valves with flanged joints as they can more effectively withstand the pressures resulting from the opening and closing of the valves.
2/	1		Ditto. 100mm dia. c.i. flanged spigot. & Ditto. flanged soc. (A. & F.	

WATER MAIN (Contd.)

			Valves	
3/	1		Supply & fix 250mm dia. double flanged S.V., all as specd. (flanged jts. m/s.) (A.F & G.	Valves enumerated, including supplying and fixing, keeping each type and size separate.
2/	1		Ditto. 100mm dia. do. (A & F.	
	1		Supply & fix small orifice single A.V., all as specd. (G to F.	
	1		Supply & fix 63mm dia., spindle type hydrant as W.O., all as specd. (E to F.	
			Sundries, cuts, etc.	
9/	1		Cuts on 250mm dia. c.i. pipe.	at A, B, C, D, E, F, G, A.V. & W.O.

WATER MAIN (Contd.)

2/	1		Make caulked lead s. & s. jt. on 150mm dia. c.i. pipe (A & F.	
4/	1		Ditto., 100mm dia., do. (A & F.	
	1		Burn out plug from end of xctg. 250mm main & store for re-use	
	1		Supply & deliver 100mm dia. c.i. plug. (F.	Plugs and caps are used to seal exposed ends of main.
	1		Ditto. 100mm dia. c.i. cap. (A.	
3/	2		Make flanged jt. between 250mm dia. S.V. & c.i. main, incl. supply of bolts. (A. F & G.	Flanged joints also enumerated, including the supply of bolts.

WATER MAIN (Contd.)

2/	2		Make flanged jt. between 100mm dia. S.V. & c.i. main, incl. supply of bolts. (A & F.	
	1		Ditto. 63mm dia. (W.O.	
7/	1		Supply r. conc. marker post, (p.c. £0·85 ea.) & conc. in the reqd. posn., incl. boltg. on plate supplied by water undertakg. all as specd.	Valve markers.
			<u>Valve chbrs.</u> 250mm S.V. = 3 100 mm S.V. = 2 W.O. = 1 A.V. = 1 7	Valve chambers are measured in detail (See S.M.M. of C.E.Q. clause 115).

WATER MAIN (Contd.)

The follg. in 7No. Valve Chbrs., ea. 430 x 330 x 1050mm dp., intly.

			add 440 340 walls 2/102.5 205 205 645 545	Note use of headings for work of this type.
			Intl. depth. 1·050 *add* base. 100 1·150	
7/	0·65 0·55 1·15		Exc. for valve chbr. n.e. 1·50m dp. & remove excvtd. mat.	The 3m stages of depth applicable to pit, pierhole and manhole excavation can hardly apply to such shallow constructional work as valve chambers.
7/	0·65 0·55		Conc. (1:3:6) in base to valve chbr., 100mm th.	
			ht. 1·050 440 *less* cover 150 340 900 2/780 1·560 *add* corners 4/102.5 410 1·970	
7/	1·97 0·90		H.b. walls to valve chbr. in eng. bks., class 'B' in c.m. (1:3)	

WATER MAIN (Contd.)

7/	1·56 0·90		E.o. cost. of eng. bwk. to valve chbr. for f.f. int., flush ptd. as the work proceeds.	
7/	2		C.& f. half bk. wall ard. 250 mm dia. pipe.	
5/2/	0·44		E.o. cost of eng. bwk. a.b. for oslg. 2 cos. in ht., ea. cos. proj. 40 mm, incl. ptg. retns. (S.V.s. 340 less 2/60 120 220	The small surface boxes to the S.V. chambers necessitate more corbelling. –3 courses in the width and 2 in the length. Deduct the overlap of one set of oversailing courses on the other.
5/2/	0·22		Ditto. 3 cos. in ht., do. (S.V.s. 340 less 2/40 80 260	
2/2/	0·44		Ditto., 1 cos. in ht., do. (W.O. & A.V.	
2/2/	0·26			

WATER MAIN (Contd.)

5/	1		Supply & fix c.i. surf. box for S.V., 95mm clear dia. at top & 160mm at bott., 175mm dp., weighg. not less than 13kg, all as specd.	Surface boxes enumerated, with essential details given in the description. Alternatively, it might be considered reasonable to omit the sizes of the boxes, as these can be obtained by reference to the specification.
	1		Ditto. c.i. surf. box for W.O. valve, wi. 350 x 250mm clear opg. at top & 425 x 295mm at bott. & 150mm dp., all as specd.	
	1		Ditto, c.i. surf box for A.V., 375 x 325mm clear opg. at top & 400 x 350mm at bott. & 150mm dp., all as specd.	

(End of Valve Chbrs.)

XVI – Measurement of Railway Trackwork

THE METHOD to be adopted in measuring railway trackwork is described in clauses 119 to 121 of the *Standard Method of Measurement of Civil Engineering Quantities*. These clauses are reproduced in full together with some explanatory notes.

A worked example then follows covering the measurement of a length of railway trackwork.

CLAUSES FROM THE *S.M.M. of C.E.Q.*	EXPLANATORY NOTES
	RAILWAY TRACKWORK
119. *Supply of Materials*	
In railway trackwork the materials and accessories required may be provided by the contractor as part of the contract, or, as is frequently the case, the materials and accessories, other than ballast, are supplied to the contractor at a specified place, and he has to take delivery and distribute and lay them in the track. The general principle governing measurement of railway trackwork is, therefore, to give separate items for:	Note the split-up of the measurement of railway trackwork into four separate component sections, and that, as with pipework, the employer may provide the materials and accessories, with the exception of ballast.
(a) Track materials and accessories, other than ballast, supplied and delivered at a specified point.	
(b) Supplying and spreading ballast.	
(c) Distributing, laying and adjusting the track.	
(d) Laying switches, crossings and the like, and fixing accessories.	
120. *Units of Measurement for Track Materials*	
The units of measurement for track materials (supplied and delivered only) are to be:	The units of measurement for the supply and delivery of the various track materials should be carefully noted. A full description of the rails is required
Rails (stating description of rail, for instance, whether bullheaded or flat-	

bottomed, the length of rail, section and weight per metre) ... Megagramme
Sleepers (stating necessary particulars) ... Number
Crossing timbers ... Cubic metre
Guard rails ... Megagramme
Ordinary chairs (stating weight per chair) ... Number
Spikes (stating weight per spike) ... Number
Chair screws (stating weight per screw) ... Number
Track bolts and nuts (stating weight per bolt and nut) ... Number
Fishplates (stating weight per pair) ... Number
Fishbolts and nuts (stating weight per bolt and nut) ... Number
Keys ... Number
Trenails ... Number
Switches, complete ... Number of sets
Crossings of various angles ... Number of each angle
Diamond crossings or elbows of various angles (stating number of each angle) ... Number of sets
Bolts, nuts and washers not covered above ... Megagramme
Sleeper plates, tie plates, packing plates, anchors and the like (under separate items) ... Number

and the particulars relating to sleepers would include the material, size and any treatment required, such as pressure creosoting of timber. With most of the enumerated items it is also necessary to state the weight of each item in the billed description.

121. *Unit of Measurement for Track Laying*

The units of measurement for ballasting and tracklaying are to be:

Ballast (nature of material and, if of stone or slag, limiting size to be stated) including distribution along formation, and spreading to required thickness and level to receive sleepers. ... Cubic metre

The unit of measurement for the supply and laying of ballast is the cubic metre, with a full description of the material being given, keeping bottom and top ballast separate.

The laying of track is measured in linear metres of track

CLAUSES FROM THE *S.M.M. of C.E.Q.*

Ballast for boxing up, including distribution and spreading
... Cubic metre

Laying plain track (including taking delivery, distribution and handling of material, straightening and packing to line and level, adjusting curves and boxing up) ... Linear metre of track

Note: Where the track materials are to be supplied to the contractor, the quantities and weights of each component per kilometre of plain single track are to be given in the description of this item.

Laying guard rails, extra to laying track. ... Linear metre of guard rail

Bending rails on curves of radius less than 300 m, extra to laying track. ... Linear metre of track

Timber for fixing accessories
... Cubic metre

Separate items for laying plain track are to be given for different types of sleepers and where they are provided already chaired.

Laying switches and crossings, diamond crossings or elbows is to be treated as extra to laying of plain track, a separate item being provided for each type, the number being stated in each case, and no deduction being made in the length of the plain track for the length occupied by the switches or crossings. Measurement at junctions or crossovers is to be made from points of switches.

The fixing of accessories, such as switch level boxes, buffer stops and the like, is to be treated separately from

EXPLANATORY NOTES

complete, with switches, crossings and elbows enumerated as 'extra over' the laying of plain track. The fixing of switch level boxes, buffer stops and similar accessories are to be separately enumerated.

track-laying and the number of each class is to be given separately. The items are to show whether the contractor is to supply and fix the accessories, or only to take delivery and fix but not to supply them.

EXAMPLE XX—RAILWAY TRACKWORK

(450 m length of straight single track)

(Excavation assumed to have been measured)

Specification Notes

(1) *Ballast.* The ballast shall be clean, hard broken stone to pass a 60 mm ring, laid to a width of 3·15 m. The ballast shall be laid after the formation has been prepared and rolled to a depth of 450 mm below top of rail level.

Before the sleepers are laid, bottom ballast shall be laid to a consolidated depth of 150 mm. The permanent way material shall then be laid and the sleepers packed up with top ballast for a width of 375 mm on each side of each rail. After the rails have been accurately adjusted, lined and surfaced, the top ballasting shall be completed for a width of 3·15 m and neatly trimmed and boxed flush with the sleepers.

(2) *Sleepers.* Sleepers shall be of creosoted redwood, 2·60 m long and 250 by 125 mm in section laid at 750 mm centres. The faces of the sleepers shall be dressed under each rail to accommodate chairs, etc.

(3) *Rails.* The gauge of the railway track shall be 1·44 m and the rails shall be steel bull-headed section conforming to B.S. 9 and weighing 47 kg/lin m and supplied in 18 m lengths.

(4) *Fishplates.* The fishplates shall be of the four-hole type conforming to B.S. 47 and weighing 14 kg/pair. Steel fish bolts and nuts to be 24 mm by 120 mm long, weighing 0·85 kg each.

(5) *Chairs.* The chairs are to be of cast iron, standard variety, weighing 20 kg each, bolted to the sleeper with 3 No. chair bolts 22 mm diameter by 185 mm long with washers 80 mm square, weighing 1 kg each. The keys are to be steel spring keys to railway standard pattern.

(6) *Tracklaying.* The rails shall be accurately laid to line, level, gauge and to the correct radii of the respective curves, with such super-elevation on the outer rail on curves as may be required by the engineer, and the price for tracklaying must include all these costs.

Metal slips 8 mm thick, shall be inserted in the rail joints to provide expansion spaces and shall be kept in the joints until the rails have been lined and secured.

No closing length of less than 4·50 m shall be used and all cuts in rails shall be square and clean. The prices inserted by the contractor shall include for all cutting and waste arising out of the tracklaying and the whole of the work shall be carried out in accordance with present-day first class railway practice.

RAILWAY TRACKWORK EXAMPLE XX

(150 m length of straight single track.)

	150·00 3·15 0·15		Stone ballast, graded 60mm down, distributed, spread & rolled to reqd. levels & thickness to rec. sleepers.	All ballast is measured in cubic metres, keeping bottom and top ballast separate on account of the different amounts of labour involved.
	150·00 3·15 0·13		Ditto. for boxg. up sleepers, incl. distributn., spreadg. & levelling.	
			750) 150·00 200+1	Number of sleepers obtained by dividing length of track by spacing of sleepers (centre to centre) and adding one to allow for a sleeper at each end of the track.
201/	2·60 0·25 0·12		Ddt. last. (space occupied (by sleepers.	

The follg. in track matls. (supplied & delvd. only.)

				Supply and delivery of track materials is kept separate from the laying of them.
2/	150·00		Steel bullheaded rails to B.S. 9., weighg. 47kg/lin m in 18m lens., drilled as reqd. for fishbolts.	The description of rails is to include whether they are bullheaded or flat-bottomed, length of rail, section and weight per metre. (S.M.M. of C.E.Q., clause 120).

RAILWAY		TRACKWORK (Contd.)	
		18)150 9	
2/9/	2	M.s. fishplates of 4 hole type to B.S. 47, weighg. 14kg/pr.	9 joints to each 150m length of rail, including the junction with existing track. There are two fish-plates to each joint, made up of one plate on each side of the rail.
2/9/	4	M.s. fishbolt & 2n. 24mm ϕ & 120mm lg., weighg. 0·85kg ea.	4 fishbolts to each joint. Note the method of indicating the weight of each unit in the enumerated items.
201/	1	Sleepers in creosoted redwood, 250 x 125mm in section & 2·60m lg., wi. dressed faces, all as specd.	Number of sleepers has been previously calculated. (Precast concrete sleepers are now being used in increasing numbers – the method of measurement would be the same).
201/	2	C.i. standard chair (3 hole type) for bullheaded rails, weighg. 20kg ea.	2 chairs to each sleeper.

RAILWAY TRACKWORK (Contd.)

201/2/	3		M.s. chairbolt, 25mm ϕ & 185mm lg., wi. 2 no. 80mm sq. w., weighg. 1kg ea.	3 bolts to each chair (2 on the inside and 1 on the outside of the track).
201/	2		Steel spring keys to rly. standard patt.	Keys wedge the rails in the chairs
	(End of track matls. - supply & delvy.)			
	150·00		Layg. single standard gauge plain track, consistg. of tbr. sleepers, c.i. chairs & bullhead rails (47kg/lin. m), incl. takg. delvy., distributg., handlg., straightening & packg. to line & level, all as specd.	

XVII—Bill Preparation Processes

'Working-up' Generally

This chapter is concerned with the final stages leading up to the preparation of bills of quantities for civil engineering work, after the dimensions have been 'taken-off'. The term 'working-up' is applied to all the various operations collectively and can comprise the following processes:

(1) Squaring the dimensions and entering the resultant lengths, areas and volumes in the third or squaring column on the dimension paper.

(2) Transferring the squared dimensions to the abstract (illustrated in Example XXI), where they are written in a recognised order, ready for billing, under the appropriate section headings, and are subsequently totalled and reduced to the recognised units of measurement in readiness for transfer to the bill.

(3) In the bill of quantities, the various items of work making up the job, are then listed under appropriate section headings, with descriptions printed in full and quantities given in the recognised units of measurement, as laid down in the *Standard Method of Measurement of Civil Engineering Quantities*. The bill also contains rate and price columns for pricing by contractors when tendering for the job.

'Billing-direct'

The 'working-up' process which has been used extensively in quantity surveyors' offices is very lengthy and various ways of shortening this process have been developed. One of the older methods introduced was to 'bill direct', by transferring the items direct from the dimension sheet to the bill, thus eliminating the need for an abstract, and so saving both time and money.

The 'billing-direct' system can be used where the number of similar items is not too extensive and the job is not too complex in character. Drainage work is a particular instance where this shorter method can, with advantage, be adopted on occasions.

With the object of speeding-up the 'working-up' process and reducing the labour involved, further methods using electronic computers on a national basis or a 'cut and shuffle' system in the quantity surveying office have been developed recently. These new methods will be described later in this chapter.

Squaring the Dimensions

The term 'squaring the dimensions' refers to the calculation of the numbers, lengths, areas and volumes and their entry in the third or timesing column on the dimension paper. This means that the quantities of items may subsequently need reducing to the correct units of measurement in the abstract, or on the dimension sheet when the items are to be 'billed-direct'.

Examples follow which illustrate the squaring of typical dimensions on a dimension sheet.

	Dimensions			Notes
7/ 2/	15·20	212·8	Rough vert. shuttg. to sides of attached piers. av. 300 mm wide, incl. rakg. cuttg. on both edges	Lineal item: Total length is 212·80 m or 212 metres, 800 millimetres (14 × 15·20 m).
	90·00 10·00	900·0	Wrot. vert. shuttg. to face of ret. wall.	Square item: area is 900 sq m or m².
	90·00 2·40 1·00	216·0	Conc. (1 : 2½ : 5) in ret. wall fdn.	Cubic item: Volume of concrete is 321 cu m or m³. Note method of casting up a series of dimensions relating to the same item with the total entered in the description column.
	50·00 2·10 1·00	105·0	321·0	

When there are timesing figures entered against the item to be squared, it is often simpler to multiply one of the figures in the dimension column by the timesing figure before proceeding with the remainder of the calculation. Alternatively, the total obtained by the multiplication of the figures in the dimension column is multiplied by the timesing figure.

The squaring must be checked by another person to eliminate any possibility of errors occurring. All squared dimensions and waste calculations should be ticked in coloured ink or pencil on checking and any alterations made in a similar manner. Amended figures need a further check. Where calculating machines are used for squaring purposes a check should still be made.

Abstracting

An example showing typical completed abstract sheets is given in Example XXI, later in this chapter, and the items will subsequently be produced in bill form in Example XXII. The abstract in Example XXI covers the dimensions for the stone-faced sea wall 'taken-off' in Example X (Chapter 9), where the dimensions have been squared in readiness for abstracting. As each item is transferred to the abstract the description of the appropriate dimension item is crossed through with a vertical line on the dimension sheet, with short horizontal lines at each end of the vertical line, so that there shall be no doubt as to what has been transferred.

The abstract sheets are ruled with a series of vertical lines spaced about 25 mm apart and are usually of double A4 width.

Each abstract sheet is headed with the job reference, sheet number and section of the work to which the abstracted dimensions refer. The section headings normally follow those given in the *Standard Method of Measurement of Civil Engineering Quantities* and are usually produced in the same order.

The items will be entered in the abstract in the same order as they will appear in the bill, as the primary function of the abstract is to classify and group the various items preparatory to billing and to reduce the dimensions to the recognised units of measurement. Descriptions are usually spread over two columns with the appropriate dimension(s) in the first column and any deductions in the second column. The total quantity of each item is reduced to the recognised unit of measurement such as kilogrammes to megagrammes.

It is good practice to precede each description in the abstract with the prefix C, S, L or No. denoting that the item is cubic, square, lineal or enumerated to reduce the risk of errors arising with regard to units or quantities.

As to the order of items in each section of the abstract, the usual practice is to adopt the order of cubic, square, lineal and finally enumerated items, with labour items preceding labour and materials, smaller items preceding larger ones and cheaper items preceding the more expensive in each group.

Where it is necessary to abstract a number of similar items but of different sizes, the best procedure is to group these items under a single heading with each size entered in a separate column, as shown in the following example.

G.v.c. pipe sewer, laid & jtd. in c.m. (1:2).

150 mm dia.	225 mm dia.	300 mm dia.	375 mm dia.
154·00 (6) 186·00 (9) 218·00 (10)	104·00 (7) 192·00 (8) 184·00 (9)	226·00 (10) 176·00 (11)	204·00 (11) 142·00 (12)

The number entered in brackets after the dimension represents the page number of the dimension sheet from which the dimension has been extracted.

All squaring and abstracting work and the transfer of the abstract items to the bill must be checked by a second person to verify their accuracy.

Billing

Example XXII, given later in this chapter, incorporates the billed items for the stone-faced sea wall, based on the entries in the abstract forming Example XXI. As each item is transferred to the bill it is crossed out on the abstract to prevent any risk of errors occurring during the transfer stage.

The order of billed items will be the same as in the abstract and they will be grouped under suitable section headings. There will generally be a number of preamble clauses at the head of each section relating to financial aspects of the work in the section concerned and giving guidance to the contractor in his pricing of the items.

Typical preamble clauses in the excavation section, for instance, might read as follows:

(1) Excavation rates are to include for the following:

- (a) excavation in any type of soil or filling, except rock.
- (b) levelling and bottoming up.
- (c) setting aside and ultimately disposing of surplus excavated material, as directed.
- (d) roughly forming and trimming all slopes and trenchings to bottom of excavations.
- (e) providing all temporary drainage and pumping that may be necessary to keep the excavations and trenches free from water.
- (f) providing all necessary timbering and strutting.
- (g) backfilling as described.

(2) The excavation for trenches, manholes, etc. will be measured from the formation level, after the surface excavation for the roads has been carried out; except in cases where filling is required when it will be measured from stripped level, after removal of surface soil. Trench excavation is measured between manholes, with the manholes measured separately.

Each item in the bill is indexed, usually by the numbering of items in the first column for ease of future reference. It will be noticed that all words in the billed descriptions are inserted in full without any abbreviations and this procedure should always be adopted to avoid confusion of any kind arising. Furthermore, it is considered good practice to bracket each description of more than one line in length on the right-hand side, to show clearly the nature and extent of the item relating to a particular quantity.

Provision is made for the total sum on each page of the bill relating to a given section of work to be transferred to a collection. The total of each of the collections is transferred to a summary; the total of which will constitute the tender sum. This procedure is preferable to carrying forward the total from one page to another in each section, as the subsequent rectification of errors in pricing may necessitate alterations to a considerable number of pages.

Billed descriptions must be concise yet must not, at the same time, omit any matters which will be needed by the contractor if he is to be able to make a realistic assessment of the price of the particular item.

The first bill may be a 'Preliminaries Bill' which includes all the general matters covering the contract as a whole, which it is considered should be brought to the notice of contractors when pricing the bill of quantities.

RECENT DEVELOPMENTS IN 'BILL PREPARATION'

General Introduction

New measurement and processing techniques have been introduced in recent years and they are now being used to an increasing extent, as they are resulting in a speeding up of 'working-up' operations and a reduction in the overall cost of preparing bills of quantities.

Over the years many quantity surveyors and engineers have experimented with a number of systems designed to eliminate part of the 'working-up' process. These systems include the elimination of the abstract by 'billing direct' as described earlier in this chapter, 'taking-off' direct on to abstract sheets and using full descriptions in the abstract to permit the abstract to be edited as a draft bill. It was, however, generally found that each of these systems could only function satisfactorily under a certain set of conditions and were not, therefore, of universal application.

'Cut and Shuffle'

In 1961, Messrs. Dearle and Henderson, a London firm of chartered quantity surveyors, introduced a new quantity surveying technique known as the 'cut and shuffle' system of producing bills of quantities, and this method was described in a paper presented by B. D. Henderson at the 1961 Annual Conference of the Royal Institution of Chartered Surveyors. This method received a great deal of publicity and this system, or variations of it, is now being used extensively by quantity surveyors throughout the country. Its use on a large scale will reduce considerably the numbers of 'working-up' staff required in quantity surveyors' offices, of which there is a great shortage, and the Royal Institution of Chartered Surveyors, with an eye to the future, has omitted the subject of 'abstracting and billing' from its examination syllabus in the quantity surveying section. Some of the original 'workers-up' may well be engaged on cost planning, cost analysis work and associated services, which should prove much more fruitful to all concerned, including the employer, as the orthodox system of 'working-up' is both lengthy and tedious in the extreme.

Briefly, the 'cut and shuffle' method is operated in the following manner and eliminates the preparation and checking of the abstract and the preparation of the draft bill.

(a) 'Taking-off' is usually carried out on a 360 × 230 mm sheet of translucent paper, ruled vertically into four columns, providing space for four items per sheet (one only in each column). Dimensions are entered on one side only of each sheet and each column is stamped with the name and number of the job and each column is numbered. 'Ditto' items must include a reference to the column number of the main item, so that details can be found.

(b) As sections of the 'taking-off' are completed, the side casts are checked and 'repeat' dimensions calculated.

(c) When the 'taking-off' is complete, or substantial sections completed in the case of a very large job, each column is marked with the sectional heading abbreviation and a dyeline copy of each dimension sheet is obtained. Where this system has been introduced into small offices, carbon paper has been used to produce copies during the early stages of implementation.

(d) The 'taker-off' retains the original set of dimensions, but the dyeline copy is cut into four slips, each measuring 90 × 230 mm and containing one item or part of an item.

(e) The slips are shuffled or sorted into sections, such as excavation, concrete work, brickwork, etc., similar items are collected together and the whole of the slips placed, as near as possible, in bill order.

(f) The slips are then edited to form the preliminary draft bill, with further slips inserted as necessary to provide preamble clauses, headings and end clauses, the correct unit is entered on the 'parent' or primary item slips and the other item slips are marked 'a.b' (as before). As each section is edited it is passed to a calculator operator for squaring.

(g) The calculator operator squares, casts, reduces and inserts the reduced quantity on the 'parent' item slip. This operation is double checked.

(h) All other than 'parent' item slips are extracted leaving only descriptions and quantities which are to be printed, thus forming the draft bill.

(i) Any further checks on the draft bill are made and stencils are then cut, checked and duplicated. The typists are made familiar with standard quantity surveying abbreviations thus avoiding the need for rewriting full descriptions in the draft bill.

(j) The other than 'parent' item slips are now replaced to provide an abstract in bill order for reference purposes should variations occur on the job.

Use of Computers

Great advances have been made in recent years in the development of electronic digital computers and in 1960 the Royal Institution of Chartered Surveyors set up a working party to consider the possibilities of the use of computers in connection with the working up of quantity surveyors' dimensions.

Various manufacturers of computers have also been carrying out investigations and one such organisation is offering a computer service to quantity surveyors and engineers in working up bills of quantities, calculating earthwork quantities, etc.

Computers are, broadly speaking, large accounting machines with a large number of registers which can accumulate numbers and store instructions. They can also add, subtract, multiply and divide and take logical decisions. The instructions are usually transferred on to punched paper tape, fed into the computer and stored there.

For working-up bills of quantities it is necessary to prepare a standard library of preliminary, preamble and description items, all bearing a particular code reference which will be entered against each item on the dimension sheet. It has been estimated that a national library of standard descriptions should contain some 25 000 items and even then the average bill might contain up to 10 per cent of items which do not conform to the standard descriptions and are termed 'rogue' items.

The computer is thus able to produce complete bills of quantities using the dimensions from the dimension sheets, suitably coded, and a library of standard descriptions and preambles. The library details would probably be punched on to paper tape and then written on to magnetic tape which forms part of the computer store.

The dimensions and appropriate code references are then punched on to paper tape and the computer squares the dimensions, arranges all the items in proper sequence and prints out the quantities together with full descriptions in the form of a complete draft bill using automatic electric typewriters. 'Rogue' items will incorporate the nearest code reference with a space for entering the remainder of the description by hand later.

Computers operate at very high speeds and some can perform approximately 60,000 additions or subtractions or 20,000 multiplications per second. It has been estimated that a suitable computer using magnetic tape could produce a bill of quantities from the coded dimensions for a small building or civil engineering contract in half an hour and a bill for a large contract in about 2½ hours.

There have been two basic approaches to the problem of using a computer to assist in the preparation of bills of quantities:

(1) For the computer to do all the calculations, sorting and printing of the bill on the basis of a standard library of descriptions held in the store.

(2) To use the computer to do all the calculations and sort the items into bill order, the draft bill of quantities being prepared in the normal manner by the quantity surveyor.

The first method entails many man/years of development and needs the continual use of a computer. The second method is a simpler process which saves the time and effort involved in the preparation of a standard library of descriptions. Both methods entail time and expense in programming, nevertheless some private and official quantity surveyors, as well as computer manufacturers and bureaux, have considered it worthwhile to invest in this field.

The difference in costs between producing a bill of quantities by rationalised traditional practice and by computer has not yet been clearly demonstrated, although it is believed that bills for jobs over £100 000 in value are usually cheaper if processed by computer. One of the chief advantages of using a computer is the speed with which the bills can be produced; more quickly than by rationalised traditional methods and very much more quickly than by the traditional method. Additional advantages are that building can be commenced earlier and that mistakes are less likely to go undetected.

Readers requiring further information on the operation of computers might like to refer to C. Dent. *Quantity Surveying by Computer* (Oxford University Press). In addition, the report of the Computer Techniques Conference gives a comprehensive account of the use of computers by quantity surveyors in this country and of development work in this field, in addition to containing a useful bibliography of other works on the subject (R.I.C.S., 'Computer Techniques', 1967).

STANDARD PHRASEOLOGY

The Central Electricity Generating Board has developed a standard phraseology for use in the preparation of civil engineering bills of quantities. The main objective is the standardising of words and format and this should also assist in computerisation and the development of a coded library of descriptions (C.E.G.B., *Phraseology for Civil Engineering Works*; George Godwin).

STONE - FACED SEA WALL **EXAMPLE XXI**

Abstract of dimensions obtained from Example X (Chapter 9).

EXCAVATION.

C/ Exc. below l.w.l. in sandy-clay for sea wall, n.e. 9m dp., backfill as nec. & remove surplus excavtd. matl.

770·8 (1)
= 771 m³

C/ Ditto. between tides, n.e. 6m dp., do.

303·3 (1)
= 303 m³

C/ Ditto. above h.w.l. n.e. 3m dp., do.

105·2 (1)

= 105 m³

C/ Exc. for promenade in sandy soil av. 300mm dp., & remove.

24·4 (6)

= 24 m³

S/ E.o. gen. excavn. below l.w.l. for any additnl. excavn. & backfill reqd. for timberg. or workg. space (area of sides of excavn. mesd.)

342·0 (2)
= 342 m²

S/ Ditto. between tides for do.

140·9 (2)

= 141 m²

S/ Ditto. above h.w.l. for do.

92·9 (2)

= 93 m²

STEEL SHEET PILING

S/ Supply, handle, pitch & drive, Messrs. 'X', No. 3 sectn. steel sheet piling, at base of sea wall wi. top fin. level approx. 2·50m below l.w.l.

224·7 (2)

= 225 m²

STONE - FACED SEA WALL

CONCRETE

Note: the items of shuttering follow immediately the items of concrete to which they relate

c/ Conc (1:2½:5) below l.w.l. in sea wall

658·6 (3)
= 659 m^3

s/ Ro. vert. shuttering to ditto.

282·0 (3)
= 282 m^2

L/ Ro. shutterg. to sloping surf. of ditto., 350 mm wide

60·0 (3)
= 60 m

c/ Conc (1:2½:5) between tides in sea wall

316·6 (3)
= 317 m^3

s/ Ro. vert. shutterg. to ditto.

140·4 (4)
= 140 m^2

c/ Conc. (1:2½:5) above h.w.l. in sea wall

89·1 (4)
= 89 m^3

s/ Ro vert. shutterg. to ditto.

96·0 (4)
= 96 m^2

STONE - FACED SEA WALL.

Note : cubic items taken first, followed by any square items, then lineal and enumerated ones.

MASONRY.

CUBES

C/P. st. copg., wi. 2ce rdd. frt. edge, as dwg., set & ptd. in st. dust mo., as specd., above h.w.l.

40·6 (5)

= 41m³

C/P. st. 2ce chfd. base to wall, incl. settg. & ptg. a.b.d.

19·1 (5)

= 19m³

C/P. st. panel blocks incl. settg. & ptg. a.b.d.

8·1 (5)

= 8m³

C/P. st. copg. 2ce thro. & wi. 2ce splyd. top, incl. settg. & ptg. a.b.d.

6·2 (5)

= 6m³

SUPERS

S/E.o. mass conc. sea wall for P. st. blocks wi. an av. bed width of 533mm, as battered face to wall, incl. settg. & ptg. blocks in st. dust. mo., as specd., below l.w.l.

108·0 (4)

= 108m²

S/Ditto. wi. av. bed width of 500mm, between tides

144·0 (5)

= 144m²

S/Ditto. wi. av. bed width of 400mm, wi. spld. upper edge above h.w.l.

42·0 (5)

= 42m²

S/Hor. d.p.c. of 2 cos. of slates, as specd.

18·0 (6)

= 18m²

STONE - FACED SEA WALL

MASONRY
(numbered items)

PAVINGS

No/ E.o. P. st copg. for forming sinkg. in copg., 900mm lg. x 40mm wide x av. 40mm dp.				5/ 50mm red precast conc. pavg. slabs, all as specd., on & incl. 19mm bed of lime mo. & 75mm bed of ashes, to crossfall of 1 in 40 & incl. groutg. on completion.	
40 (5)	No.			180·0 (6)	Odt
				= 180 m²	
No/ Bronze cramp 150 x 40mm (av.) x 6mm th., incl. lettg. into & formg. sinkgs. in P. st. & runng. in lead.					Note: any deductions to the paving item would be made in this column, with a heading as indicated above. The total of the deductions would then be deducted from the total in the previous column prior to reducing.
50 (6)	No.				
No/ G. i. dowel, 12mm dia. & 75mm lg., incl. lettg. into & formg. sinkgs. in P. st. & running in lead.					
50 (6)	No.				

NOTE: In a fairly straightforward job like this with a limited number of items and where the quantities can be totalled on the dimension sheets, it is quite feasible to omit the abstract and transfer the quantities direct from the dimension sheets to the bill.

EXAMPLE XXII—BILL OF QUANTITIES

For Stone-faced Sea Wall

(prepared from abstract in Example XXI)

Item No.	*Description*	*Qty.*	*Unit*	*Rate*	£
Note:	Each section would be preceded by preamble clauses relating to matters which affect the section of work generally and have a bearing on price.				
	Excavation				
1.	Excavate below low water level in sandy clay for sea wall, not exceeding 9 m deep, backfill as necessary and remove surplus excavated material	771	cu m		
2.	Ditto between tides, not exceeding 6 m deep, and do.	303	cu m		
3.	Ditto above high water level, not exceeding 3 m deep, and do.	105	cu m		
4.	Excavate for promenade in sandy soil, average 300 mm deep and remove.	24	cu m		
5.	Extra over general excavation below low water level for any additional excavation and backfill required for timbering or working space (area of sides of excavation measured)	342	sq m		
6.	Ditto. between tides for do.	141	sq m		
7.	Ditto. above high water level for do.	93	sq m		
	To Summary			£	

	Steel Sheet Piling				
8.	Supply, handle, pitch and drive Messrs. 'X' No. 3 section steel sheet piling at base of sea wall, with the top finished level approximately 2·50 m below low water level.	225	sq m		
	To Summary			£	
	Concrete				
9.	Concrete (1 : 2½ : 5) below low water level in sea wall.	659	cu m		
10.	Rough vertical shuttering to ditto.	282	sq m		
11.	Rough shuttering to sloping surface of ditto 350 mm wide.	60	lin m		
12.	Concrete (1 : 2½ : 5), between tides, in sea wall.	317	cu m		
13.	Rough vertical shuttering to ditto.	140	sq m		
14.	Concrete (1 : 2½ : 5) above high water level in sea wall.	89	cu m		
15.	Rough vertical shuttering to ditto.	96	sq m		
	To Summary			£	
	Masonry				
16.	Portland stone coping with twice rounded front edge, as drawing, set and pointed in stone dust mortar, as specified, above high water level.	41	cu m		
17.	Portland stone twice chamfered base to wall, including setting and pointing as before described.	19	cu m		
	To Collection			£	

Bill of Quantities for Stone-faced Sea Wall—continued

Item No.	*Description*	*Qty.*	*Unit*	*Rate*	£
18.	Portland stone panel blocks, including setting and pointing as before described.	8	cu m		
19.	Portland stone coping, twice throated and with twice splayed top, including setting and pointing as before described.	6	cu m		
20.	Extra over mass concrete sea wall for Portland stone blocks with an average bed width of 533 mm, as battered face to wall, including setting and pointing blocks in stone dust mortar, as specified, below low water.	108	sq m		
21.	Ditto with average bed width of 500 mm, between tides.	144	sq m		
22.	Ditto with average bed width of 400 mm with splayed upper edge, above high water level.	42	sq m		
23.	Horizontal damp-proof course of two courses of slates, as specified.	18	sq m		
24.	Extra over Portland stone coping for forming sinking in coping, 900 mm long by 40 mm wide by average 40 mm deep.	40	no.		
25.	Bronze cramp 150 by 40 mm (average) by 6 mm thick, including letting into and forming sinkings in Portland stone and running in lead.	50	no.		
	To Collection			£	

26.	Galvanised iron dowel 12 mm diameter and 75 mm long, including letting into and forming sinkings in Portland stone and running in lead.	50	no.		
	To Collection			£	

Collection

	£
From page 323	
,, ,, 324	
,, ,, 325	
To Summary £	

Note: This will be repeated for each section of the work which is spread over two or more pages of the bill, otherwise the total of the particular section will be transferred to the Summary.

	Pavings				
27.	50 mm thick red precast concrete paving slabs, as specified, on and including 19 mm bed of lime mortar and 75 mm bed of ashes, to crossfall of 1 in 40, and including grouting on completion.	180	sq m		
	To Summary			£	

Note: This work has been billed on the assumption that each section of the work will be billed separately. Alternatively, it might be considered preferable to keep all the work together in a single section as 'Stone-faced Sea Wall' in the bill, due to the comparatively small number of items involved, in which case the total from each page will be transferred to a collection on the last page, and the total of this page will be transferred to the summary.

Appendix I – List of Abbreviations

a.b. *as before*
a.b.d. *as before described*
additnl. *additional*
adj. *adjoining*
a.f. *after fixing*
agg. *aggregate*
appd. *approved*
ard. *around*
asp. *asphalt*
attchd. *attached*
av. *average*
A.V. *air valve*

backg. *backing*
battg. or batterg. *battering*
bd. *board*
bdg. *boarding*
bearg. *bearing*
beddg. *bedding*
bellmth. *bellmouth*
benchg. *benching*
b.f. *before fixing*
b.i. *build in*
bit. *bitumen or bitumastic*
bk. *brick*
bldg. *building*
b.o.e. *brick on end*
borg. *boring*
bott. *bottom*
b. & p. *bed and point*
br. *branch*
brr. *bearer*
b.s. *both sides*
B.S. *British Standard*
bwk. *brickwork*

cap. *capacity*
ccs. *centres*
c. & f. *cut and fit*
chan. *channel*
chbr. *chamber*
chfd. *chamfered*
chy. *chimney*
c.i. *cast iron*
circ. *circular*
circum. *circumferential*
c.m. *cement mortar*
conc. *concrete*
conn. *connection*
constn. *construction*
c.o.p. *circular on plan*
copg. *coping*
cos. *course(s)*
covg. *covering*
c. & p. *cut and pin*
Cr. *Contractor*
c.s. *cross section*
ct. *cement or coat*
cu *cubic*

ddt. *deduct*
deckg. *decking*
dep. *deposit*
dia. or diam. *diameter*
dim. *diminishing*
dist. *distance*
do. *ditto. (that which has been said before)*
dp. *deep*
d.p.c. *damp-proof course*
dr. *door*
dwg. *drawing*

ea. *each*
embankt. *embankment*
eng. *engineering*
Eng. *English*
Engr. *Engineer*
ent. *entrance*
E.O. *extra over*

ex. *exceeding or extra*
exc. *excavate*
excavn. *excavation*
ext. *externally*

facewk. *facework*
fcg. *facing*
fdn. *foundation*
f.f. *fair face*
fillg. *filling*
fin. *finished*
fittg. *fitting*
f.l. *floor level*
floatg. *floating*
flr. *floor*
F.O. *fix only*
follg. *following*
form. *formation*
fr. *frame*
frd. *framed*
frg. *framing*
frt. *front*
ftg. *footing*
fwk. *formwork*
fxd. *fixed*
fxg. *fixing*

galvd. *galvanised*
gen. *general*
g.i. *galvanised iron*
g.l. *ground level*
g.m. *gauged mortar*
grano. *granolithic*
grd. *ground*
greenht. *greenheart*
groutg. *grouting*
g.s. *general surfaces*
gth. *girth*
g.v.c. *glazed vitrified clay*

ha *hectare*
h.b. *half brick*
h.c. *hardcore*
hi. *high*
holl. *hollowed*
hor. *horizontal*
h.r. *half-round*
ht. *height*
hwd. *hardwood*
h.w.l. *high water level*
H.W.O.S.T. *high water of spring tides*

incl. *including*
int. *internally*
intl. *internal*
invt. *invert*

jt. *joint*
jtd. *jointed*
junctn. *junction*

kg *kilogramme(s)*
km *kilometre (s)*
k.p. & s. *knot, prime and stop*

l. *labour*
la. *large*
layg. *laying*
len. *length*
lg. *long*
lin *lineal*
ling. *lining*
l.m. *lime mortar*
long. *longitudinal*
l.w.l. *low water level*

m *metre(s)*
matl. *material*
mech. *mechanically*
med. *medium*
mesd. *measured*
m.g. *make good*
Mg *megagramme(s)*
m.h. *manhole*
min. *minimum*

mm *millimetre(s)*
mo. *mortar*
m.s. *mild steel*
m/s. *measured separately*

n.e. *not exceeding*
nec. *necessary*
no. *number*
n. & w. *nut and washer*
n.w. *narrow widths*

O.D. *Ordnance Datum*
o'hg. *overhang*
opg. *opening*
ord. *ordinary*
oslg. *oversailing*
ov'll *overall*

patt. *pattern*
pavg. *paving*
p.c. *prime cost*
P.ct. *Portland cement*
perm. *permanent*
p.hse. *pumphouse*
pilg. *piling*
p.m. *purpose made*
psn. *position*
ppt. *parapet*
pr. *pair*
prepd. *prepared*
proj. *projection*
provsnl. *provisional*
P.st. *Portland stone*
pt. *paint*
ptd. *pointed*
ptg. *pointing*
ptn. *partition*
pumpg. *pumping*

rad. *radius*
rakg. *raking*
r.c. or r. conc. *reinforced concrete*
rdd. *rounded*
reb. *rebate*
rec. *receive*
red. *reduced*
reinfd. *reinforced*
reinft. *reinforcement*
reqd. *required*
ret. *retaining*
retd. *retained or returned*
retn. *return*
r. & g. *rubbed and gauged*
r.h. *rivet head*
r.l. *red lead*
rly. *railway*
ro. *rough*
R.S. *rolled steel*
r.s.j. *rolled steel joist*

scrd. *screwed*
sec. or sectn. *section*
settg. *setting*
s.g.w. *salt-glazed ware*
shuttg. or shutterg. *shuttering*
sk. *sunk*
s.l. *short length*
sli. *slight*
slopg. *sloping*
smth. *smooth*
soc. *socket*
soff. *soffit*
specd. or specfd. *specified*
spld. *splayed*
sq *square*
s.q. *small quantities*
s. & s. *spigot and socket*
st. *stone*
stan. *stanchion*
stlwk. *steelwork*
strt. *straight*
surrd. *surround*
surf. *surface*
susp. *suspended*
S.V. *sluice valve*
swd. *softwood*

tankg. *tanking*
tapd. *tapered*
tarmac. *tarmacadam*
tbr. *timber*
tempy. *temporary*
t. & g. *tongued and grooved*
th. *thick*
thro. *through or throated*
timbg. or timberg. *timbering*
tr. *trench*

U beam *Universal beam*
u/c *undercoat*
u/s *underside*

vert. *vertical*
vol. *volume*

walg. *waling*
wdw. *window*
wethd. *weathered*
wi. *with*
w.i. *wrought iron*
W.O. *wash-out*
workg. *working*
w.p. *waterproof*
wrot. *wrought*
wt. *weight*

xtg. *existing*

Y.st. *York stone*

Note: The abbreviation S.M.M. of C.E.Q. has been used extensively throughout this book and refers to the *Standard Method of Measurement of Civil Engineering Quantities.*

Appendix II – Mensuration Formulae

Figure	*Area*
Square	$(\text{side})^2$
Rectangle	length $\times$ breadth
Triangle	$\frac{1}{2} \times$ base $\times$ height or $\sqrt{[s(s-a)(s-b)(s-c)]}$ where $s = \frac{1}{2} \times$ sum of the three sides and a, b and c are the lengths of the three sides.
Hexagon	$2{\cdot}6 \times (\text{side})^2$
Octagon	$4{\cdot}83 \times (\text{side})^2$
Trapezoid	height $\times \frac{1}{2}$(base$+$top)
Circle	$(22/7) \times \text{radius}^2$ or $(22/7) \times \frac{1}{4}$ diameter^2 (πr^2) $(\pi D^2/4)$ circumference $= 2 \times (22/7) \times$ radius or $(2\pi r)$ $(22/7) \times$ diameter (πD)
Sector of Circle	$\frac{1}{2}$ length of arc $\times$ radius
Segment of Circle	area of sector$-$area of triangle.

Figure	*Volume*	*Surface Area*
Prism	Area of base $\times$ height	circumference of base $\times$ height
Cube	(side)^3	$6 \times$ (side)^2
Cylinder	$(22/7) \times$ radius$^2 \times$ length ($\pi r^2 h$)	$2 \times (22/7) \times$ radius $\times$ (length + radius) ($2\pi r(h+r)$)
Sphere	$(4/3) \times (22/7) \times$ radius^3 ($4/3\pi r^3$)	$4 \times (22/7) \times$ radius^2 ($4\pi r^2$)
Segment of Sphere	$(22/7) \times$ (height/6) $\times$ (3 radius^2 + height^2) ($[\pi h/6] \times [3r^2+h^2]$)	curved surface $= 2 \times (22/7) \times$ radius $\times$ height (h) ($2\pi rh$)
Pyramid	$\frac{1}{3}$ area of base $\times$ height	$\frac{1}{2}$ circumference of base $\times$ slant height
Cone	$\frac{1}{3} \times (22/7) \times$ radius$^2 \times$ height ($\frac{1}{3}\pi r^2 h$)	$(22/7) \times$ radius $\times$ slant height (l) (πrl)
Frustum of Pyramid	$\frac{1}{3}$height$[A+B+\sqrt{(AB)}]$ where A is area of large end and B is area of small end.	$\frac{1}{2}$ mean circumference $\times$ slant height
Frustum of Cone	$(22/7) \times \frac{1}{3}$height$(R^2+r^2+Rr)$ where R is radius of large end and r is radius of small end. ($\frac{1}{3}\pi h[R^2+r^2+Rr]$)	$(22/7) \times$ slant height $(R+r)$ ($\pi l[R+r]$) where l is slant height

For Simpson's rule and prismoidal formula see Chapter VI.

Appendix III—Metric Conversion Table (Analogue)

LINEAR

ft.	*in.*	*m*	*mm*
	$\frac{1}{8}$		3
	$\frac{1}{2}$		12
	$\frac{3}{4}$		20
	1		25
	$1\frac{1}{4}$		30
	$1\frac{1}{2}$		40
	2		50
	3		75
	4		100
	$4\frac{1}{2}$		115
	6		150
	7		175
	8		200
	9		225
	10		250
1	0		300
1	2		350
1	6		450
2	0		600
2	6		750
3	0	1	
4	0	1·25	
5	0	1·5	
6	0	2	
10	0	3	
11	0	3·3	
15	0	4·5	
20	0	6	
30	0	9	
40	0	12	
100	0	30	

SQUARE

ft^2	*in.*^{2}	*m*^{2}
	36	0·025
	48	0·03
1	0	0·1
3	0	0·3
4	0	0·4
10	0	1
12	0	1·25
	3	2000 mm^2
	6	4000 mm^2

yd^2	*m*^{2}
1	1
100	80
1000	840

CUBE

ft^3	*m*^{3}
1	0·03
6	0·15
10	0·25
20	0·5
100	2·5

WEIGHT (MASS)

lb	*kg*
1	0·45
10	4·5
100	45

cwt	*kg*
1	50

ton	*kg*
1	1000

PRESSURE

1000 lbf/in^2 = 7 MN/m^2

10 tonf/in^2 = 155 MN/m^2

NOTE. MN = meganewton

LIQUID

gal	*litre*
1	4·5
10	45

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Page numbers shown in italics refer to the Examples