



Fourteenth Edition

# Willis's Elements of Quantity Surveying

Roy Hills • Sandra Lee

WILEY Blackwell



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## Preface

This book was first published in 1935, and in the preface to that first edition, it stated that it was intended 'to be a book giving everything in its simplest form and to assist a student to a good grounding in first principles'. Each successive edition has been brought up to date; however, we have always striven to maintain the original guiding principles, which are as relevant today as they were over 80 years ago.

The text is intended to be studied as part of a measurement module or course with the support of a tutor and other appropriate study materials. A basic skill of being able to read drawings and knowledge of the construction of the works being measured is also required prior to starting to work through the examples in this text.

Whilst the use of the traditional bill of quantities continues to decline and today there is only one of a variety of options open to the industry for the procurement of construction contracts, nevertheless, the skills of measurement are still very much required in some form or another under most procurement routes.

This edition utilises the measurement rules to be found in the publication by the Royal Institution of Chartered Surveyors (RICS) of the second volume of the *New Rules of Measurement – Detailed Measurement for Building Works* (NRM2). This edition has been edited and updated by Roy Hills to bring it in line with the latest edition of the NRM2 and the use of spreadsheets to form the taking-off pages.

The basic structure of the book generally follows that of previous editions, setting down the measurement process from first principles and assuming the reader is coming fresh to the subject.

Whilst it is recognised that modern computerised measurement techniques utilising standard descriptions might appear far removed from traditional taking-off, it is only by fully grasping such basic principles of measurement that they can be adapted and applied to alternative systems. It is for this reason that the examples continue to be written in traditional form.

The book opens with an overview of the need for measurement and the differing rules governing measurement at different stages of the design or project cycle. The main focus of the book remains on the detailed measurement of elements of a building using the rules from NRM2, and it concludes with guidance on how to use the data collected during the measurement process to create the tender documents.

Whilst the role of the quantity surveyor is subject to continual change, we hope that students will find this book as useful as their predecessors have.

Sandra Lee

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The efforts of Ruth Pearson are gratefully acknowledged for the preparation of the drawings.

## Abbreviations

a.b.	as before
a.b.d.	as before described
agg.	aggregate
BCIS	Building Cost Information Service
BS	British Standard
CAWS	Common Arrangement of Work Sections
c/c	centres
ccu	cooker control unit
ddt	deduct
dia.	diameter
d.p.c.	damp-proof course
d.p.m.	damp-proof membrane
EDI	electronic data interchange
e.w.s.	earth work support
ex	out of
hw.	hardwood
JCT	Joint Contracts Tribunal
LED	light emitting diode
MC	Measurement Code
n.e.	not exceeding
NRM	<i>New Rules of Measurement</i>
n.t.s.	not to scale
PC	prime cost
r.c.	reinforced concrete
RIBA	Royal Institute of British Architects
RICS	Royal Institution of Chartered Surveyors
r.w.p.	rainwater pipe
SMM	Standard Method of Measurement
sso	switched socket outlet
sw	softwood
swg	standard wire gauge





# 1

## Introduction

### The modern quantity surveyor

The training and knowledge of the quantity surveyor have enabled the role of the profession to evolve over time into new areas, and the services provided by the modern quantity surveyor now cover all aspects of procurement, contractual, and project cost management. This holds true whether the quantity surveyor works as a consultant or is employed by a contractor or subcontractor. Whilst the importance of this expanded role cannot be emphasised enough, success in carrying it out stems from the traditional ability of the quantity surveyor to measure and value. It is on the aspect of measurement that this book concentrates.

### The need for measurement

There is a need for measurement of a proposed construction project at various stages from the feasibility stage through to the final account. This could be in order to establish a budget price, give a pre-tender estimate, produce contract documents for pricing, provide a contract tender sum, or evaluate the amount to be paid to a contractor. There are many construction or project management activities that require some form of measurement so that appropriate rates can be applied to the quantities and a price or cost established.

The measurement explained in this book is primarily for the production of a bill of quantities as part of the traditional procurement approach to construction. Other procurement approaches move the need for detailed measurement to later stages of the project cycle and away from activity undertaken by the client's team to that of the contractor's team.

### The need for rules

The need for rules to be followed when undertaking any measurement becomes clear when costs for past projects are analysed and elemental rates or unit rates are calculated and then applied to the quantities for a proposed project. For greater accuracy in pricing, it is

important to be able to rely consistently on what is included in an element or unit, and this helps build a more reliable cost database.

Following the Royal Institute of British Architects (RIBA) 2020 Work Stages, the measurement undertaken at Stage 1 – ‘Preparation and Briefing’ – needs to be of basic areas or functional units, and the relevant guidelines of the Royal Institution of Chartered Surveyors (RICS) are commonly followed. This enables comparisons to be made between different schemes and options when assessing the feasibility of a project. When preparing a cost plan, the need to include the same items in each element is important so that costs for that element can be accurately applied. In May 2009, the RICS published the first of its new set of rules for measurement dealing with the order of cost estimates and elemental cost planning. The RIBA work stages and the *New Rules of Measurement* (NRM) are explained a little further in Chapter 2.

The same need for rules applies when measuring for bills of quantities. If a document is to be used for tender purposes and included in a contract, then the contractor needs to know the basis of the measurement and what is included or excluded from an item to be priced. Historically, standard methods of measurement have been used to provide these rules and are available in various forms worldwide. The RICS NRM, detailed measurement for building works (NRM2), are part of the RICS ‘black book’ guidance for accepted practice in the UK. At post-contract stages, when measuring for variations or additional works, it is important that the rules used in the contract document (if applicable) are followed to minimise disputes.

## Establishing the approach

The approach to take for any measurement is to decide its purpose and the level of design detail available, enabling the adoption of the most appropriate rules and procedures.

Having an ability to read and understand the rules for measurement for bills of quantities should enable the measurer to appreciate the requirements of different rules and approaches.

## Method of study

Before you start to work through the chapters on each element, it is advised to study Chapters 1–7 in order to grasp the basic principles thoroughly. You should understand the form in which dimensions are usually written, irrespective of whether a computer system will eventually be used to record dimensions in practice.

Knowledge of elementary building construction and simple mensuration and trigonometry is assumed; where knowledge is weak in these subjects, further study is recommended before proceeding further with measurement.

Chapter 5 explains some of the alternative systems that are used in practice, and Chapter 6 explains how girths and centre lines are calculated.

Chapter 7 contains notes on general procedure rules for taking-off which should be read before attempting to study actual examples of measurement, and to which subsequent referral may also be useful.

Chapters 8–19 represent the sections into which the taking-off of a small building might be divided, and these should be worked through one at a time. The principal applicable clauses of NRM2 are referred to in each chapter and should be studied concurrently. After the chapter has been read, the examples should be worked through. It should be possible to follow every measurement by reference to the drawing. It may therefore be appropriate for you to copy or print off the drawings so that they can be read alongside the dimensions.

The examples of taking-off in this book are small isolated parts of what could be the dimensions of a complete building and are not a connected series. When they have been mastered in their isolation, it will be much easier to see how they might be expanded and fitted together to compile a bill of quantities for a complete building.

Chapters 20 and 21 deal with preliminaries and bill preparation, which are more logically dealt with after taking-off, as this is often a separate process.

## Examples

The measurement examples are included to illustrate the measurement of individual elements of a small building. They assume that full specification clauses would be set out in preambles to the bill (or separate specification) and are not included here (see Chapter 21).

The dimensions that are set down in the dimension column when taking-off are given to the nearest two decimal places of a metre. Side casts (or waste calculations, as they are sometimes called) are used to calculate these dimensions, and are given in millimetres to ensure accuracy.

The examples in the chapters are presented in a traditional dimension format, this being considered the best system for a textbook and what the candidate will usually be faced with in the examination room. Abbreviations have been used for deductions where a description sufficient to recognise an item clearly is all that is required. The abbreviations used in the descriptions are listed in the 'Abbreviations' section at the beginning of this book.



## 2

### Detailed Measurement

#### Method of analysing cost

It is evident that if a building is divided up into its constituent parts, and the cost of each part can be estimated, an estimate can be compiled for the whole work. It was found in practice that by making a 'schedule' setting out the quantity of each item of work for a project, the labour and material requirements for these could be more readily assessed. This schedule at Royal Institute of British Architects (RIBA) stage 4 can be in the form of a bill of quantities which, when priced by a contractor, provides a tender sum for a project. It must not be forgotten that a traditional bill of quantities only produces an estimate. It is prepared and priced before the erection of the building and gives the contractor's estimated cost. Such an estimated cost, however, under the most commonly used construction contracts, becomes a tender and a definite price for which the contractor agrees to carry out the work as set out in the bill. The bill must, therefore, completely represent the proposed work so that a serious discrepancy between actual and estimated cost does not arise.

#### Origin of the bill of quantities

Competitive tendering is one of the basic principles of most classes of business, and if competitors are given comprehensive details of the requirements, it should be fair to all concerned. However, historically when tendering based on drawings and specification, builders found that considerable work was involved in making detailed calculations and measurements to form the basis for a tender. They realised that by getting together and employing one person to make these calculations and measurements for them all, a considerable saving would be made in their overhead charges. They began to arrange for this to be done, each including the surveyor's fee for preparing the bill of quantities in their tender, and the successful competitor paying. Each competing builder was provided with the same bill of quantities which could then be priced in a comparatively short space of time. It was not long before this situation was realised by the architect and employer. Here the employer was paying indirectly for the quantity surveyor through the builder, whereas the surveyor could be used as a consultant if a direct appointment was made. This would give the employer

greater control over the amount paid to the surveyor and the opportunity to increase the service that was provided. In this way, the quantity surveyor began to get the authority of the employer and was employed to prepare a bill of quantities for tendering purposes.

## The measurement process

The main purpose of a bill of quantities is therefore for tendering. Each contractor tendering for a project is able to price the work on exactly the same information with a minimum of effort. This gives rise to the fairest type of competition.

Despite the decline in the use of bills of quantities, a large portion of the value of all building work in the UK is still let using lump-sum contracts with firm or approximate quantities, therefore requiring measurement. Most other procurement routes, such as design and build and management contracting in its various forms, also involve quantification of the work in some form or the other by the main contractor, subcontractor, or package contractor, and therefore the measurement process continues to be of importance.

Computerised and other alternative measurement systems have become more widely used. However, it is only by having a detailed understanding of the traditional method of setting down dimensions and framing descriptions that such systems can be fully understood and properly utilised. There continues to be development of 3D computer-aided design software programs that integrate with building information modelling, and the ability to generate quantities directly from the computer model. These software programs, however, have difficulty in producing quantities in accordance with any standard method and as yet have not removed the need for the quantity surveyor to check and validate the model, the quantities it generates, and to prepare the tender and contract documents.

## Attributes of a quantity surveyor

What, then, are the desired measurement skills of a good quantity surveyor? An ability to describe clearly, fully, and precisely the requirements of the designers and present the bill of quantities so that the contractor's estimator can quickly, easily, and accurately arrive at the estimated cost of the work is essential. This being so, it is obviously important that the surveyor should be able to write clearly in language that will not be misunderstood, and have a sound knowledge of building materials and construction and of customs prevailing in the industry. Moreover, the surveyor must be careful and accurate in making calculations, have a systematic and orderly mind, and be able to visualise the drawings and details.

## Divisions of bill preparation

The traditional preparation of a bill of quantities divides itself into two distinct stages:

- 1) The measurement of the dimensions and the compilation of the descriptions from the drawings and specification. This process is commonly known as *taking-off*.

- 2) The preparation of the bill. This involves the calculation of volumes, areas, etc. (*extending or squaring the dimensions*). Traditionally, this was followed by entering the descriptions and the squared dimensions on an abstract (*abstracting*) to collect similar items together and present them in a recognised bill order. From this abstract, the draft bill was written (*billing*).

Through the utilisation of computerised systems, the various stages have become more integrated. The facility now exists for direct input of quantities and formulation of descriptions through the use of standard libraries of descriptions, and the lengthy collating and bill preparation processes are carried out automatically. It should be noted that there is often still the need to produce preliminaries and preambles separately and to input uncommon items (*rogue* items) that are peculiar to the particular project. Checking total quantities and careful editing of the bill are still required to identify any data entry errors.

## Quantities as part of the contract

Where a contract with quantities is used for a project, the bill of quantities forms one of the contract documents, with the contract providing that the quantity of work comprised in the contract shall be that set out in the bill of quantities. The contract will also stipulate the measurement rules that were used to prepare the bill of quantities. In such a case, the contractor is expected to carry out and the employer to pay for neither more nor less than the quantities given, an arrangement that is fair to both parties. Thus, it will be seen how important accuracy is in the preparation of the bill, and how a substantial error might lead an employer to enter into a contract that involved a sum considerably beyond that contemplated.

For contractors to appreciate how the quantities have been prepared and what is included in each item, the quantity surveyor uses the rules from a standard method of measurement. In the UK, the current standard method used for measuring building works is NRM2. A bill of quantities will be interpreted by a number of contractors in competition, and it must therefore be complete and a suitable basis for a contract.

## Contractor-produced quantities and estimates

The subject of measurement by a quantity surveyor is dealt with in this book chiefly from the point of view of preparing a bill of quantities, but the ability to prepare quantities is also vital to the contractor for the compilation of tenders where quantities are not supplied, which is common in design and build and small contracts. A contractor may well produce quantities for an estimate including only the main items of work and not all of the items that would have been measured using NRM2. The descriptions would be shorter and usually the pricing is worked out alongside the quantities, thus avoiding abstracting and billing. The contractor's estimate is solely for internal pricing. If mistakes are made or shortcuts are taken which lead to errors, the contractor alone suffers. The contractor is free to adapt the general principles of measurement to the company's needs and the specifics of an individual project.

Nevertheless, the contractor's surveyor must be able to check a bill of quantities and measure variations on the basis of that bill. It is therefore essential that the contractor's surveyor should understand how the bill is prepared, and there should be no difficulty in adapting this knowledge to suit the somewhat different requirements when preparing quantities for a contractor's estimate.

## **Differences of custom**

It must be understood that, as a good deal of the subject matter of this book is concerned with method and procedure, suggestions made must not be taken as invariable rules. Surveyors will have, in many cases, their own customs and methods of working which may differ from those given here, and which may be equally good or, in their view, better. The procedure advocated is put forward as being reasonable and based on practice. Furthermore, all rules must be adapted to suit any particular circumstances of the project to be measured.



## 3

# The Use of the RICS *New Rules of Measurement* (NRM)

## Background

The *New Rules of Measurement* (NRM) Project was arguably one of the most significant developments in quantity surveying practice since the publication of the SMM7 in 1988. The intention of the Royal Institution of Chartered Surveyors (RICS) with this suite of documents is to create a set of common rules that provide a consistent approach to measurement through the various stages of a project, from initial cost estimate to detailed quantification of the construction work. Whilst the NRM is based on UK practice, it is nevertheless intended to have worldwide application.

This chapter therefore looks at the key features of the NRM in order to explain how it relates to the measurement covered in this text.

Historically, surveyors would approach the measurement of approximate quantities in different ways: for example, the area of external walls might be measured over windows and doors (i.e. gross measurement) by one surveyor, whilst another might deduct the area of the windows and doors (i.e. net measurement). The method of measurement would be closely related to the way in which the rates were to be applied. This variation in practice then resulted in an inconsistent approach to early estimates and cost planning, which then led to further problems when cost plans were used instead of bills of quantities as the basis of tender negotiations. Cost plans would then be analysed and used as benchmarks for further cost plans, thus creating an unreliable database and potentially inaccurate estimates. There was also a lack of continuity in cost data between cost plans and bills of quantities, making it almost impossible to reconcile the cost plan with the priced bill of quantities or pre-tender estimate.

## The NRM volumes

The RICS has published a set of documents in three volumes, for the measurement of building work from the early feasibility stage through to completion, handover, and building occupation. The full NRM comprises:

NRM1 – Order of cost estimating and cost planning for capital building works, covering:

- Estimating – Royal Institute of British Architects (RIBA) Work Stages 0-1; Office of Government Commerce (OGC) Gateways 1 and 2.
- Cost planning – Elements – RIBA Work Stages 2–4; OGC Gateways 3A, 3B, and 3C.

NRM2 – Detailed measurement for building works, covering:

- RIBA Work Stages 4, 5 and 6; OGC Gateway 3C (detailed measurement for tender documentation).

NRM3 – Order of cost estimating and cost planning for building maintenance works, covering:

- RIBA Work Stage 7; OGC Gateways 4 and 5 (life cycle costing).

## Introduction to NRM2

There is still a need for the preparation of bills of quantities following the rules of a standard method of measurement, where detailed information is provided as the basis for the traditional, fixed-price, lump-sum approach to procurement. NRM2 contains the rules for measurement to be used when preparing bills of quantities, and it is therefore used as the basis for explaining how to measure the examples included in this text. Table 4 gives the various work sections that are included in NRM2, and examples of measurement using these rules are included in Chapters 8–19.

**Table 4** Extract from Section 3 of NRM2

---

**Work sections 2–41 comprise the rules of measurement for building components and items. They are as follows:**

---

2	Off-site manufactured materials, components, and buildings
3	Demolitions
4	Alterations, repairs, and conservation
5	Excavating and filling
6	Ground remediation and soil stabilisation
7	Piling
8	Underpinning
9	Diaphragm walls and embedded retaining walls
10	Crib walls, gabions, and reinforced earth
11	In-situ concrete works
12	Precast/composite concrete
13	Precast concrete
14	Masonry
15	Structural metalwork

**Table 4** (Continued)

---

**Work sections 2–41 comprise the rules of measurement for building components and items. They are as follows:**

---

16	Carpentry
17	Sheet roof coverings
18	Tile and slate roof and wall coverings
19	Waterproofing
20	Proprietary linings and partitions
21	Cladding and covering
22	General joinery
23	Windows, screens, and lights
24	Doors, shutters, and hatches
25	Stairs, walkways, and balustrades
26	Metalwork
27	Glazing
28	Floor, wall, ceiling, and roof finishings
29	Decoration
30	Suspended ceilings
31	Insulation, fire stopping, and fire protection
32	Furniture, fittings, and equipment
33	Drainage above ground
34	Drainage below ground
35	Site works
36	Fencing
37	Soft landscaping
38	Mechanical services
39	Electrical services
40	Transportation
41	Builder's work in connection with mechanical, electrical, and transportation installations

---

NRM2 has a detailed section on how to code bills of quantities, but the link between elemental cost plans and bills in trade order can be seen only if bills are accurately coded when produced to enable sorting between the two different formats. Further information on bill preparation is provided in Chapter 21.

PDF copies of the NRM volumes are available as a free download from the RICS website to encourage all to use the guidance.



## 4

### Setting Down Dimensions

The development of computerised measurement and billing systems, each with its own structure for inputting dimensions and calling up descriptions, has made the more traditional, manual procedures less common nowadays. However, it is only by understanding the basic principles of setting down dimensions and descriptions in traditional form, as detailed here, that one can then apply them to whatever measurement process is adopted. It is also essential to understand the measurement of another surveyor so that work can be checked, and it is only by following the approach to setting down dimensions precisely that this can happen.

#### Traditional dimension paper

The dimensions are measured from the drawings by the taker-off, using paper ruled as follows:

1	2	3	4	1	2	3	4
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The columns (not, of course, normally numbered) have been numbered here for identification. Column 1 is called the *timesing column*, and its use will be described later. Column 2 is the *dimension column* in which the measurements are set down as taken from the drawings. Column 3 is the *squaring column* in which are set out the calculated volumes, areas, and so on of the measurements in column 2. Column 4 is the *description column* in which is written the description of the work to which the dimensions apply, and on the extreme right-hand side of which (known as *waste*) preliminary calculations and