PART 1

Measurement in Construction

Part 1

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

Chapter 1
The Role and Purpose of Measurement

Part 1

Think of a number. Double it. Add 175. Double it again. Subtract 21.5. And the answer is… Who cares? Just fill in any number you like. If this sounds a bit like how you fill in your annual tax return, you might just have the makings of a career in quantity surveying.

The way that quantity surveyors can get away with getting it so wrong is an art form in itself.

John Crace, *The Guardian*, Saturday, 25 February 2006[1]

Perhaps Wembley Stadium is not the greatest endorsement of the quantity surveyor's skills, at least to 'outsiders', but it is more than likely that the project quantity surveyors had little control over this grotesque cost overrun.

Quantity surveyors work with information provided by others – clients, architects, engineers and so on – but it is probably true to say that the results they achieve often belie the paucity of the information they are provided with. The quantity surveyor's skill, attention to detail and ability to 'read between the lines' give the profession its individuality and special value.

1.1 Measurement

Part of the professional armoury of the quantity surveyor is the ability to measure.

Since its origins in the latter part of the nineteenth century, the quantity surveying profession has developed and grown and, as the years have rolled by, measurement has become pretty much the sole province of the quantity surveyor in the construction world.

Not everyone values what the quantity surveyor does (certainly not the *Guardian* reporter!), but this is more evident when it comes to the skill of measurement. Measurement lacks the esteem that it once had. Even some quantity surveyor academics, of the author's acquaintance, look down on measurement as being the province of 'technicians' and one eminent academic once told me that "you can teach monkeys to take-off quantities!".

This is not true, of course, and those who sneer at measurement are usually those who have been unable to master the subject themselves.

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It is true that, measurement, once the 'be-all and end-all' of the quantity surveyor's work, is now very much the 'Cinderella' of the profession having been overtaken by sexier and more lucrative pursuits such as procurement advice, whole life costing and value management.

However, whilst the focus on measurement and bills of quantities is apparently waning, especially in higher education courses, Ashworth et al. (2013) observe that *instead of preparing bills of quantities for clients, quantity surveyors are preparing bills for contractors*.

1.1.1 Counting bricks

Many QSs must have had a similar experience to the author – in my case it was a conversation with a typical tennis club 'Hooray Henry'! When I was asked "and what do you do for a living?", the retort to "quantity surveyor" was:

"Ah … one of those chaps that counts the bricks?"

Quantity surveyors don't count bricks; of course, they measure the area of brickwork so that someone else can work out how many bricks are needed. For a m^2 of half brick thick wall in stretcher bond, this is 59 bricks, but no one actually counts them, do they?

- Builders need to know how many bricks are required, but they order by the 100.
- The contractor's buyer? No, they order by the 1000 and they arrive in pallets of 400/500 give or take.
- Bricklayers? No, they count the number of courses to work out how many bricks they have laid and they are paid by the 1000.

All these people are measuring the same thing but in a different way. The thing that distinguishes quantity surveyors is, firstly, that they habitually measure accurately and, secondly, usually do so following a code, or method of measurement, using well-established conventions for recording their work.

1.1.2 Definition

The noun 'measurement' is so much part of everyday life that most people would not bother to find out what it actually means. A number of definitions may be found:

The Oxford English Dictionary:

- *The action or an act of measuring or calculating a length, quantity, value, etc.*

Collins Dictionary:

- *The act or process of measuring.*
- *An amount, extent, or size determined by measuring.*
- *A system of measures based on a particular standard.*

Wikipedia:

- From the Old French word – *mesurement.*
- Represents the assignment of numbers to objects or events.
- All measurements consist of three parts: magnitude, dimensions (units) and uncertainty.[2]

1.1.3 Who measures?

Measurement is most commonly associated with the quantity surveyor, and the quantity surveyor is, in turn, normally thought of as a construction economist associated with 'working out costs', 'counting bricks (!)' and producing 'bills of quantities'. Whilst there is a lot more to the profession than this, measurement is the basis of much that the quantity surveyor does.

In the construction industry, however, measurement is conducted by all sorts of participants:

- Surveyors for conducting site surveys.
- Professional quantity surveyors for producing bills of quantities for tendering purposes.
- Main contractors for calculating a tender price for a design and build project.
- Main contractors pricing partial contractor design in traditional contracts.
- Subcontractors tendering for work on a drawings and specification basis.
- Buyers for calculating the quantity of materials to be ordered.
- Bonus surveyors for calculating incentive payments.
- Planning engineers for deciding on production outputs in order to arrive at the duration of activities on a construction programme.
- Engineers for setting out buildings and engineering structures.
- Construction workers as part of their trade.

In fact, it would be interesting to discover just how many retractable measuring tapes may be found on a typical construction site!

Individuals approach measurement in different ways:

- Work on-site may be measured with a tape or with digital surveying equipment.
- Quantities may be produced by hand using traditional procedures or various sorts of software may be employed.
- On-screen measurement may be done with 'high-end' library-based systems or with software that allows the measurer to create the descriptions.
- Item descriptions may be non-standard, bespoke, quasi-formal or formal SMM based.

Measurement is used by many people, in different ways, using different standards, and this book tries to reflect this by broadening the traditional approach taken by measurement books to include consideration of:

- The identification of risk in standard methods of measurement.
- The identification of risk in the measurement process.
- The production of 'formal' and 'informal' bills of quantities.
- The production of 'informal' schedules of quantities of different sorts.
- The physical measurement of completed or partially completed work on-site.
- The valuation of work in progress.
- The valuation of variations to the contract.
- The measurement of work in connection with provisional sums.
- The remeasurement of approximate quantities.
- Post-contract measurement and physical measurement on-site.
- The measurement aspects of claims and final accounts.

1.2 The end of measurement or a new beginning?

The construction industry, irrespective of country or culture, is, of course, a paradox, and any discussion about it is likely to polarise opinion.

Crotty (2012), in his excellent and thought-provoking book, considers the industry to be locked into *a craft-based mode of operation* despite the extent of factory-based production preferred in some countries.

The obverse side of this argument is put eloquently by Radosavljevic and Bennett (2012), who identify that construction is an industry capable of delivering buildings and infrastructure that *are the most complex things produced by* humans.

The anachronistic face of the industry is exemplified by the almost medieval construction crafts still practised, and yet this may be contrasted with leading edge Building Information Modelling (BIM)-based architectural and engineering design and construction, such as Renzo Piano's 1016 foot skyscraper – The Shard at London Bridge Quarter. The industry has a fabled history of disputes and litigation and yet is capable of the highest standards of collaborative working, a shining example being the Llanelli Scarlets Rugby Stadium project (Eastman et al., 2011) in South Wales, United Kingdom.

The industry is changing slowly. In some cases, old-fashioned 'data-poor' documentation, such as paper-based drawings and bills of quantities, are being replaced by 'data-rich' models that can be shared interactively by all members of the design and construction team. This is a gradual process but it is gaining momentum. BIM in construction is being incrementally adopted – and not just on signature projects – but will this signal the end of measurement? No, BIM is not a threat; it just poses a different question – 'how will measurement be done in the future?'.

The RICS has taken a step in this direction by publishing the New Rules of Measurement suite of documents, and traditional practices are being challenged by new technology in both the design and construction of projects.

1.2.1 Anyone can measure

On the face of it, measurement is pretty straightforward; most people can measure physical things, whether by using a ruler, a measuring tape, a digital measuring device or by physically pacing out.

As far as construction work is concerned, anyone could take an intelligent guess as to how such things might be measured – it's fairly obvious:

- Rainwater pipes and gutters, drain pipes – linear metre, linear foot.
- Brickwork, plastering, painting – square metre, square foot, square yard.
- Excavation, concrete – cubic metre, cubic foot, cubic yard.

Measuring from drawings is more complex – far more complex than measurement textbooks imply. Drawings – being a less than full size representation – introduce the idea of scale. Consequently, unless the drawing is fully dimensioned, a measuring device is required that will measure to the appropriate scale – traditionally, a scale rule.

The modern day equivalent to this is the digitiser tablet which facilitates tracing a line, or shape, with an electronic device which then conveys the measurements taken to a personal computer.

Currently, measurements may be taken from scaled drawings that have been converted into a digital file by using on-screen measurement software and a computer mouse.

1.2.2 Measurement in the lecture theatre

Over the last 20 years, measurement has assumed less and less importance in academic circles, and many university courses now place significantly more emphasis on procurement and risk management topics to the exclusion of measurement.

The reasons for this trend reflect changes in the quantity surveying profession – Wikipedia provides a long list of services that quantity surveyors provide[3] – and it is certainly a fact that the subject of measurement is not regarded as sufficiently challenging academically.

The result of all this is a much more superficial coverage of the subject in quantity surveying degree courses such that employers frequently complain that sandwich course students and graduates cannot measure, never mind do so with any degree of competence. This is a real shame because 'measurement' is central to the quantity surveyor's skill base and it is a subject that ties all the other subjects in the syllabus together. Measurement is, after all, the basis of virtually everything that the quantity surveyor is about, and it is a transferable skill that is jealously coveted by other professions.

McDonnell (2010), who observes that *measurement of quantities is a core skill which must be inherent in all graduates from Quantity Surveying courses*, also considers that students find measurement difficult to understand and that they lack the basic knowledge of construction technology in order to be able to measure competently. These frailties are often exposed when students and graduates enter the industry and have to measure 'for real' – they struggle and disappointed employers complain that they are unable to 'hit the ground running' as far as measurement goes.

Paradoxically, McDonnell (2010) reports that students recognise the importance of measurement in their studies and also that they consider traditional 'paper-based' methods of teaching measurement as still having an important role to play despite the attractions of the 'computer-based' measurement software packages that are used both in teaching and in the industry generally.

Other commentators agree with the students, and Lee et al. (2014), amongst others, suggest that mastery of traditional paper-based taking-off is the key to being able to measure competently and confidently. A counterargument to this is that measurement from 3D models is simpler than from paper drawings because models can be 'delayered' to show only those items being measured and this, with the benefit of 3D perspective, is easier for students to comprehend.

It is often argued that measurement smacks of 'training' rather than 'education', and there may be some truth in this point of view, but measurement, when considered in its broadest context, draws together many complex legal, financial and technical issues sufficient to challenge the most experienced practitioners, never mind undergraduates.

1.3 How's your Latin?

> Cash flow is the lifeblood of the construction trade.
>
> Lord Denning
> Former Master of the Rolls

Some people would argue that 'information' should have equivalent status in our thoughts:

> Bringing together the right information with the right people will dramatically improve a company's ability to develop and act on strategic business opportunities.
>
> The most meaningful way to differentiate your company from your competition … is to do an outstanding job with information. How you gather, manage, and use information will determine whether you win or lose.
>
> Being flooded with information doesn't mean we have the right information or that we're in touch with the right people.
>
> Bill Gates

1.3.1 Information

Information is all about communication, the Latin word for which – *commūnicāre* – means to share.

Sharing – of information – is how the construction industry communicates with itself. Drawings beget specifications, which together beget bills of quantities, and all this information is passed on down the line, via a complex system of contracts and subcontracts, with the final result being the completed building, bridge or tunnel.

There is no shortage of information in construction, but whether this is the information needed by the recipient is questionable and whether the correct information gets to those doing the work is even more doubtful. BIM responds to this challenge as it is capable of modelling exactly what has to be fabricated off-site, and assembled on-site, to pinpoint precision, with quantities already determined.

However, the construction industry has special characteristics which create a complex communication environment. Being of a project-based nature, the industry is fragmented and dynamic with many stakeholders operating in frequently changing sets of relationships which are contractually driven (Hoezen, 2006).

The system has its critics, and Crotty (2012) describes it as *a way of doing business that would be quite recognisable to medieval builders and their clients*. They might struggle with the mobile technology and with the finer points of *e-tendering*, but Latham (1994) and Egan (1998) would no doubt agree!

Speaking of which, the UK construction industry has been the subject of seemingly innumerable official and semi-official reports. This started with the Simon Report – no, not the 1930 study of potential constitutional reform in India – the 1944 Simon Committee Report on *The Placing and Management of Building Contracts*!

This report was followed by lots of others, including the Emmerson, Banwell and Wood reports. In more recent times, there have been the Latham (1994) and Egan (1998) reports and finally, for now at least, the Wolstenholme Report (2009), inspired by Constructing Excellence which was set up post-Egan (originally named the Movement for Innovation). This report concentrated on the impact of the Egan Report with particular regard to the performance targets set for the industry by Egan.

Murray and Langford (2003) usefully summarise the important issues raised in the 1944–98 reports.

They note that the principal driving force behind these government-initiated reports was two groups of powerful clients who had their own agendas for wanting change in the way that the construction industry operated. Pre-1980, it was largely government and parastatal clients driving the desire for change, and post-1980, it was influential private clients and construction employers who wished to conduct their business with the state in a different way.

1.3.2 The Tavistock Report

Murray and Langford observed that the desire to change the relationships of the participants in the construction process, with a view to improving industry performance, was a consistent theme in all of the reports. A recurring theme in the most influential reports was that of procurement and, more particularly, the inefficiencies generated by the separation of design and construction in the industry.

Procurement is especially important in the context of the subject matter of this book, with particular regard to the quality of project information and the negative impact on industry performance of:

- The lack of integration within design teams.
- The disconnect between designers and constructors.
- The incomplete and uncoordinated design information that results.

This was the theme of the so-called Tavistock Report (there have been several), written by Higgin and Jessop (1965), which concerned organisational structures and the exchange of information in the construction industry. The report was published independently by the Tavistock Institute of Human Relations in 1965, a not-for-profit organisation that carries out, *inter alia*, research work in the social sciences, and was not government sponsored.

The significance of the Higgin and Jessop report may not be fully understood for some time yet, but some observers consider that the successful adoption of BIM in the UK construction industry will be dependent on the industry's ability to embrace a new era of cooperative working, driven by high-quality intelligent information.

There may be a need for new methods of procurement and conditions of contract in order to do this, but there will certainly have to be a lot of 'head scratching' about how measurement fits into the BIM-scene *vis-a-vis* current methods of measurement.

1.3.3 A new business model?

> This Government's four year strategy for BIM implementation will change the dynamics and behaviours of the construction supply chain, unlocking new, more efficient and collaborative ways of working. This whole sector adoption of BIM will put us at the vanguard of a new digital construction era and position the UK to become the world leaders in BIM.
>
> Francis Maude
> Minister for the Cabinet Office

The Government Construction Strategy, published by the Cabinet Office on 31 May 2011, announced the Government's intention to require collaborative 3D BIM on its projects by 2016, with all project and asset information, documentation and data being electronic.[4]

This is an enormous challenge to the current business models employed in construction, but if it can be achieved, the BIM revolution promises to fundamentally change current practice.

At the risk of wearing out the Bill Gates quotes:

> This is a fantastic time to be entering the business world, because business is going to change more in the next 10 years than it has in the last 50.

There are two key challenges:

- Firstly, to coalesce the various design inputs involved in construction projects.
- Secondly, to harmonise the inputs of all contributors to the construction process – clients, designers, contractors and users – so that the final outcome is smarter and more predictable.

There is nothing new about this 'model' of the construction industry, of course, and in many respects, this is how construction work was organised for many centuries.

The client or architect would hire individuals or teams of craftsmen, organise the work, control the money and supervise work on-site. It is a system that worked well and led to the sort of harmony between designers and constructors that present-day BIM methodologies seek to create; the architect produced the drawings and the craftsman added final details as 'designer of last resort'. In some cases, craftsmen also created models or prototypes prior to actual construction.

The construction boom in the mid-nineteenth century changed all this, largely driven by the Industrial Revolution and the need to improve public health and sanitation. Many clients demanded market prices for their projects, and this gave rise to the idea of competitive tendering that has been the mainstay of the industry for over a century.

At the same time, the structure of the industry was changing, and the concept of the general contractor was established. It was the general contractor that organised the work according to the architect's or engineer's design, and the designer's role became one of the monitoring standards and certification of payment, thereby driving a wedge between design and construction that hitherto did not exist.

The system of competitive tendering in the late nineteenth century, with general contractors such as William Joliffe, Sir Edward Banks and Thomas Cubitt competing for work, was originally based on architect/engineer design with quantities prepared by each tendering contractor. This business model led to such wildly inconsistent tender prices that tendering contractors eventually contributed to the cost of preparing a single set of quantities upon which their tenders could be based.

A natural extension to this model was for the client to engage a quantity surveyor, both to produce the quantities needed for tendering and to provide other professional services. Lack of clarity in the documentation led, as a natural consequence, to the need for standardisation of the way that this documentation was presented. The concept of the standard method of measurement was born.

Over the years, the main focus of measurement has been on the production of bills of quantities – an aspect of quantity surveying pretty much dominated by the professional quantity surveyor (PQS) – but nothing major has changed in relation to the measurement of quantities since standardised measurement was first introduced:

- Standard methods of measurement have become more sophisticated, and different versions have been developed for use in different industry sectors.
- More attention has been paid to the value of quantities, and the way they are measured and presented, as a means of communication.
- The role of measurement in the cost management of buildings has become prominent since the early 1950s.
- Measurement techniques and conventions have developed over time.
- The introduction of computerised and on-screen measurement has transformed quantity surveying from a paper-based to a technology-based profession.

However, none of these developments has fundamentally changed the way that quantities are measured or the role that measurement plays in the procurement of construction work.

1.4 Standardised measurement

Formalised measurement has a long history dating back to the Middle Ages. Records exist of Royal expenditure on building work at the time of Henry II (1154–1189), and detailed accounts may be found from the monarchy of Henry III (1216–1272).

It is likely that we would call these documents 'final accounts' rather than bills of quantities.

Records of what appear to resemble bills of quantities appeared in Ireland in 1750, but Seeley and Winfield (2009) point out that the first method of measurement was produced in Scotland in 1802. There appears to be no evidence, however, that this method of measurement was in widespread use, or that bills of quantities were prepared to any extent, but there are firm indications that the system of measure and value on completion was used for most of the nineteenth century.

Towards the end of the nineteenth century, the practice of employing one surveyor to measure the quantities developed, due to the growth of competitive tendering, but this only brought uniformity to tendering and tender prices and not to the measurement process.

Standardised measurement is a more recent, twentieth-century phenomenon, which differs from formalised measurement in the sense that the latter is 'measurement written down' but standardised measurement is 'measurement written down according to a set of rules'.

The industry has a variety of standard methods or rules of measurement to suit different circumstances, but they each take a different approach to measuring the same thing, as illustrated in Table 1.1.

The item descriptions in Table 1.1 impact on how the work item is communicated to the tenderer/contractor and how the estimator goes about pricing the work. Whether, and to what

Table 1.1 Comparison of standard methods of measurement.

NRM2	**Excavating and filling** Excavations **Excavation** Bulk excavation; not exceeding 2 m deep	• Clear description • No precise sense of how deep the excavation is • Masks the fact that this could equally be an excavation to reduce levels or a basement excavation
CEMM4	**Earthworks** General excavation **Material other than topsoil, rock or artificial material** maximum depth: 1–2 m	• Clear description of what is to be excavated and the type of excavation it is • Depth is calculated from the commencing level and is therefore between 1 m and 2 m deep
MMHW	**600:Earthworks** Excavation Excavation of acceptable material excluding Class 5A in cutting or other excavation	• No depth category • The excavation could be in cuttings or elsewhere on-site • The term 'acceptable' means that it could be reused on-site if required
POM(I)	Excavation Generally Reduce levels any depth	• The type of excavation is clear • No depth category is stated • Additional description may be advisable

extent, ancillary items such as working space and earthwork support are measured, together with the precision of the description, impact on the balance of risk in the item.

1.4.1 Non-UK standard methods of measurement

Many countries of the world have their own standard methods or codes of measurement. Some such as Australia and South Africa have more than one and the United Kingdom has several different methods of measurement in use at any one time for different purposes.

In a survey of 64 countries including the United Kingdom, the RICS (Building Cost Information Service, 2003) found that 14 of the 32 countries that responded had their own standard method or code of measurement and 5 countries used at least one UK standard method of measurement.

Clearly, in any book, it would be unrealistic to include coverage of all standard methods and codes of measurement, particularly as some standard methods of measurement used around the world, such as the Malaysian Standard Method of Measurement of Building Works and the Agreed Rules of Measurement (ARM4) in the Republic of Ireland, are, at least to some extent, modelled on UK standard methods and others bear a close resemblance to the Principles of Measurement (International) (POM(I)). In some cases, inclusion would be impractical due to the language barrier.

In Australia, the Australian Standard Method of Measurement (currently Fifth Edition), published by the AIQS, is widely used, but the Australian Standard AS 1181–1982 method of measurement of civil engineering works and associated building works is seemingly less popular.

New Zealand has a number of standards, Standard NZS4202 being a standard method of measurement of building works, but there is reportedly a trend away from using it. The New Zealand Standard NZS4224: 1983 Code of practice for measurement of civil engineering quantities is apparently not widely used. In the NZ building industry, bills of quantities are referred to as 'schedules of quantities'.

South Africa has a strong quantity surveying heritage, and the ASAQS publishes a Standard System of Measuring Building Work. This is not a national standard but it is very widely used.

In civil engineering, there are two national standards, SABS120 and SABS1200, for measurement of civil engineering works. These standards are very comprehensive compared with the Australian and NZ equivalents.

1.4.2 The Standard Method of Measurement of Building Works

The *Standard Method of Measurement of Building Works: Seventh Edition* is part of a long history of such documents stretching back to 1922 when the first edition was published. The aim of the SMM has always been to introduce uniformity into the production of bills of quantities which were, hitherto, prepared on an *ad hoc* basis variously by quantity surveyors engaged by the employer or jointly by contractors keen to reduce the costs of tendering.

Consequently, the early years of the twentieth century witnessed the two surveyors' bodies at the time – The Surveyors' Institution and the Quantity Surveyors' Association – cooperating in an endeavour to create a standard set of measurement rules in conjunction with representatives of the contractors' organisations (the NFBTE and the Institute of Builders).

The new SMM created a 'level playing field' for tenderers and ensured consistency in the preparation of bills of quantities which were previously conditioned by *local custom* and *the idiosyncrasies of individual surveyors*.

SMM7 was first published in 1988, with minor amendments being made in 1988, 1989 and 1992 as a result experience and use of the document in practice. Three further amendments were made in 2000 (amendments 1 and 2) and in 2009 (amendment 3), and this is why the latest version is sometimes referred to as SMM7C.

SMM7 heralded two further benefits of standardisation in the shape of two major changes from the previous SMM6:

- The adoption of a measurement system based on classification tables, as opposed to prose, which has the advantage of being more closely aligned with the use of standard phraseology and computerised measurement.
- The restructuring of the SMM into the Common Arrangement of Work Sections (CAWS) developed by the Co-ordinating Committee for Project Information (CCPI) in order to promote the standardisation and coordination of bills of quantities, drawings and specifications.

The benefits of coordinated project information propounded at the time SMM7 was introduced were that obvious omissions in the design would be picked up in the specification and billing of the work (e.g. builders' work in connection with mechanical and electrical services that might otherwise be overlooked). Anecdotal evidence suggests, however, that such benefits did not materialise in practice.

1.4.3 Common arrangement of work sections

Construction projects are complex entities that rely on lots of information of different sorts including product information and specifications, as well as the usual drawings and bills of quantities. This information needs to be classified so as to be available and accessible to a variety of users, just like *Yellow Pages*, and bill compilers need access to this information so that they can describe as well as measure work. This is the role of classification systems.

There is no one classification system in use in construction, and many countries have their own ways of specifying construction products and construction work.

Prior to the publication of SMM7, the CI/SfB system was in common use, and many architectural libraries still use it. However, a new classification system was introduced in 1987 by the CCPI which was formed as a result of a 1970s coordinated project information initiative. This led to the formation of the Construction Industry Project Information Committee (CPIC), which led in turn to the introduction of SMM7 in 1988.

As a consequence, the structure and layout of SMM7 was based on the Common Arrangement of Work Sections (CAWS), and it is CAWS which is responsible for the SMM7 alphanumeric numbering system. For instance, reinforcement for in situ concrete (reference E30) is to be found in Work Section E: *In situ concrete/Large precast concrete*.

UK construction industry classification systems have moved on since 1988, although the CAWS classification is still around. Uniclass, a new classification scheme for the construction industry, which was introduced in 1997 to implement BS ISO 12006-2 in the United Kingdom, incorporates the CAWS amongst its 15 classification tables – Table J (Work Sections for buildings).

However, due to deficiencies in its structuring and classification of information for BIM, Uniclass is not now considered fit for purpose and this has led to the development of Uniclass2, a fully searchable albeit not yet fully developed system.

1.4.4 RICS new rules of measurement

Since the 1 January 2013, SMM7 has been superseded by NRM2 and all indications are that this should now be used from this date on.

NRM2 has been issued as a guidance note, and as such, there is no compulsion to use it but not to do so may be considered to be contrary to good practice, and this may have implications as regards professional competence and professional negligence.

The JCT has issued an update to those of its 2011 contracts where measurement is relevant, including the SBC/Q, SBC/AQ and SBC/XQ, and this suggests that NRM2 *should be used instead of SMM7* for all relevant contracts entered into after the 1 January 2013. The RICS subscription online information portal, *isurv*,[5] also states that NRM2 has now replaced SMM7.

As part of the suite of documents that make up the RICS New Rules of Measurement, NRM1 was introduced a set of measurement rules for use during the design process. Its full title is *NRM1: Order of cost estimating and cost planning for capital building works*. It was first published in 2009 as NRM1: *Order of cost estimating and elemental cost planning* and is now in its second edition which became operative on 1 January 2013.

1.4.5 Civil Engineering Standard Method of Measurement

Standardised measurement of civil engineering work has a long history dating back to 1933 when the Institution of Civil Engineers published a report which provided, for the first time, a standard procedure for the drafting of bills of quantities for civil engineering work (Seeley and Murray, 2001).

This was revised in 1953 when the *Standard Method of Measurement of Civil Engineering Quantities* was published which, itself, was amended in 1963 and 1968 (metric version). In 1964, the ICE set up a committee to look into revising the existing standard method, and research work was initiated by the Construction Industry Research and Information Association (CIRIA). This culminated in Report No. 34 which was published in 1971 (Barnes and Thompson, 1971).

The work which led to the publication of the Civil Engineering Standard Method of Measurement (CESMM) was conducted for the ICE by Dr Martin Barnes under the guidance of a steering group of the Institution. Dr Barnes acknowledges the contribution of the CIRIA research, and the involvement of P. A. Thompson of the University of Manchester Institute of Science and Technology (UMIST), in the eventual successful launch of CESMM in 1976 (Barnes, 1977).

When the CESMM was first published, it represented a major shift away from the previous codes for measuring civil engineering works. The principal characteristics that made CESMM different included:

- A classification system for developing item descriptions.
- An item coding system to assist in sorting bills of quantities and for cost analysis.
- Greater standardisation of measured items and descriptions leading to more clarity and less need for interpretation of item descriptions.
- Greater pricing certainty and less confusion for tenderers.
- The recognition that method and time were determining factors in the pricing of civil engineering work and that these should be separated from the measured work items in the form of method-related charges so that construction method could be more accurately reflected in the contractor's prices.
- A method of measurement that enabled bills of quantities to be better used for programming, site management and post-contract control.

1.4.6 Method of Measurement for Highway Works

Since the dawn of formalised measurement in the early 1920s, a distinction has been made between the measurement rules for building work and those for civil engineering. Some would argue that this is a false distinction in the context of a single construction industry that uses transferable skills, resources and techniques, whilst others would make the point that building work is more detailed and intricate than civil engineering work and that there is therefore merit in the distinction.

Perhaps the wider adoption of BIM will force the industry to adopt a simpler and universal approach to measurement in the future, but in the meantime, the distinction prevails almost to the extent that building and civil engineering are seen as separate industries. The Method of Measurement for Highway Works (MMHW) makes the distinction between these different approaches to measurement even more pronounced in that it creates a distinction between the measurement of different types of work in the same industry sector – civil engineering.

The *MMHW* relates to a specific type of civil engineering work – major roadworks. This type of work involves earthworks, drainage, road pavements, structures – including bridges and associated geotechnical works – road lighting and communications installations, etc.

The origins of this method of measurement date back to 1971 with the introduction of the *Method of Measurement for Road and Bridge Works*. Prior to this, Hunter (1997) records for posterity that *Notes on the Preparation of the Bill of Quantities* were first published in 1951 along with the first edition of the *Specification for Road and Bridge Works*. In their third edition in 1963, the *Notes on the Preparation of the Bill of Quantities* were based on the *ICE Standard Method of Measurement of Civil Engineering Quantities* (1962).

The first edition of the *MMHW*, which, at the time, had the title *Method of Measurement for Road and Bridge Works*, coincided with the UK motorway boom of the 1970s but post-dated the first UK motorways; Preston Bypass and the first section of the M1 were opened in 1958 and 1959, respectively. The 1971, and subsequent, editions of the *Method of Measurement for Road and Bridge Works*, and the accompanying *Specification for Road and Bridge Works*, were printed in small handbooks that could fit in a 'duffle coat' pocket. The first and second editions of the *Method of Measurement for Road and Bridge Works* were grey and green, respectively. The various editions of the Specification were also distinctively coloured.

Despite the MMRB name change in 1987, the *MMHW* was accorded 'Third Edition' status. It was published in ring binders, as was the *Specification for Highway Works* which became known as the 'Brown Book' even though it comprised several booklets. The 'Brown Book' documents were published along with Notes for Guidance, a Library of Standard Item Descriptions and Highway Construction Details which were the forerunners of the current *Manual of Contract Documents for Highway Works* (MCHW), first published in 1991.

The current *MMHW*, notwithstanding amendments over the years, is the Fourth Edition.

The novel part of the *Method of Measurement for Road and Bridge Works*, and the current *MMHW*, is the idea that civil engineering work can be measured simply, with relatively few items, so long as the extent of the work covered by the items is clear and underpinned by an unequivocal specification of the work involved. The central feature of the method of measurement, therefore, is the 'item coverage' rules that accompany the measured work items in the bill of quantities, and these items depend heavily on the *Specification for Highway Works*; the SHW is the 'spine' of the *Manual of Contract Documents* which includes the *MMHW* and other documents.

1.4.7 Principles of Measurement (International)

In 2003, an RICS survey found that the most common standard method of measurement used internationally was POM(I), which was reportedly used in eight countries albeit that its use in the United Kingdom was reported to be 'minimal'. Of the countries where at least one standard method or code existed, 17 reported that their use was recommended or adopted by national bodies, and 15 said that such documents were regularly named in contract conditions. POM(I) was used for some years in the Republic of Ireland before the Agreed Rules of Measurement (ARM) were introduced.

In common with other standard methods of measurement in use internationally, such as the South African Standard System of Measuring Building Work (Sixth Edition) 1999, POM(I) is refreshingly simple and easy to follow. The measurement rules hark back to the earlier editions of the *Standard Method of Measurement of Building Work* and the *Standard Method of Measurement of Civil Engineering Quantities* in the United Kingdom in that there are no complex rules, no tables, no coverage rules and the like and there is no tendency to measure to the *n*th degree – thus following the precepts of the Pareto principle (see Chapter 3).

First published in 1979 by the RICS, and not revised since, POM(I) takes a significantly different approach compared to the standard methods commonly used nowadays in the United Kingdom. It is a model of simplicity such that the bill compiler is able to measure in a flexible way, building clear and comprehensive item descriptions but without the constraints of too many rules. Consequently, item descriptions can be developed within a recognisable framework whilst also allowing the skill and experience of the bill compiler to shine through.

To many contractors and subcontractors who are required to prepare bills of quantities for various reasons, POM(I) should be much more attractive than vaguely following a more complex method of measurement because a BQ can be prepared that complies to recognised rules that everyone can understand but also requires less time and resources to prepare the take-off.

1.4.8 Bills of quantities

The RICS Contracts in Use Survey (2011) reveals that the use of bills of quantities has been in decline for some years and that bills of quantities were used in only one in five contracts included in the survey due, in the main, to the growth in popularity of design and build procurement and the increased use of contracts based on drawings and specifications. The RICS Survey does not include the civil engineering sector wherein bills of quantities are still commonly used.

When drawing conclusions about the use of bills of quantities, a distinction needs to be made between bills of quantities prepared as a 'traditional' tender document (formal bills of quantities) and those prepared internally by contractors (informal bills of quantities) as a means of establishing the quantity of work in a project so that a price can be calculated for tendering purposes.

The key difference between the two is that:

- **Formal bills of quantities** are based on standardised measurement rules.
- **Informal bills of quantities** are based on the so-called builders' quantities determined by each of the individual tendering contractors.

Tenders based on builders' quantities introduce an aspect of risk and variability of tender prices that needs to be recognised, and quantities produced in this way have to be prepared in a considered, informed and consistent manner.

Thus, bills of quantities are not 'dead' but have been reinvented in a modern context for a variety of uses according to the procurement and contractual arrangements for any given project. In this regard, it is significant that the need for a more modern approach to measurement and bills of quantities has been recognised in the recent publication of the RICS NRM suite and the contract neutral CESMM4 documents.

1.5 Measurement: skill or art?

If construction measurement was simply concerned with determining lengths, areas and volumes, almost anyone could do it, but it isn't. The ability to measure to a professional standard is not easily acquired, and not all quantity surveyors, even, are competent in measurement or fully understand the subject.

Measurement demands two key skills:

1. The ability to measure construction work, in accordance with generally accepted quantity surveying practice and procedure and in accordance with a specific standard method of measurement.
2. The ability to produce formal bills of quantities with the aim of inviting tenders capable of being converted into a formal contract or subcontract.

To be able to measure to this standard requires an in-depth knowledge of technology and a thorough understanding of how buildings and engineering structures are designed and built. This is underpinned by the ability to set down dimensions in a professional way, thereby creating an audit trail that may be followed by others. Added to these skills is the need for a sound knowledge of procurement and contracts, experience of industry practices, knowledge of standard methods of measurement, reasoning ability and cognitive intuition.

Modern computer software packages have, to some extent, made measurement much less of a chore, but the fact remains that 'skill' is required to obtain accurate results.

The 'art' of measurement is in recognising what is missing from the information provided, whether drawing or model, and making sure that appropriate allowances are made in quantities taken and the documentation produced.

1.5.1 Uses of measurement

There is much more to measurement than how to 'take off' quantities from drawings using a standard method of measurement, and it is a subject that is no longer solely the province of the PQS engaged in producing traditional bills of quantities.

Measurement is used in a variety of ways by many participants in the construction process including:

- Quantity surveyors, engineers, building surveyors and others who are involved in the preparation of pre-contract documentation and post-contract control for main contracts and subcontracts.

- Quantity surveyors, working for contractors and subcontractors, who are involved with interim valuations and payment applications, the handling of subcontract accounts and remeasures and dealing with the internal cost-value reconciliation process.
- Site engineers, trades foremen and the like who are required to record and measure events on-site with a view to establishing entitlement to variations, extras and contractual claims.
- Contractors' planning engineers who need to use measurement when compiling the pre-tender programme, the master programme or short-term programmes, for updating programmes for progress so that projects may be controlled effectively and for determining the causes and effects of delay and disruption to the programme in order that claims for extensions of time and loss and expense may be pursued.
- Quantity surveyors and engineers who need to be able to check that main contractors' payment applications have been submitted in accordance with the contract documents generally and with the appropriate standard method of measurement in particular.
- Those involved in the submission and checking of applications for extensions of time and contractual money entitlements who may need to measure physical and financial progress and interpret this information in relation to the contract documents in general and the contract bills of quantities in particular.
- Those involved with making payment applications on measure and value contracts or where schedules are used or for valuing variations on design and build and other contracts.
- Subcontractors who are not quantity surveyors but nevertheless need to understand a particular method of measurement when pricing tenders, submitting payment applications and dealing with variations, daywork and the like.
- Students of quantity surveying, construction management, civil engineering and related courses who need an understanding of the principles and practice of measurement, an appreciation of various standard methods of measurement and a sound grasp of the role of measurement in construction contracts and its relationship with a variety of procurement methodologies, contractual arrangements and standard forms of contract.

It is important to recognise that measurement is used by different people in different ways and is an indispensable facet of many aspects of a construction project; indeed, this book has been specifically designed and written with this fact in mind.

1.5.2 Risk management

Prima facie 'measurement' is concerned with quantifying the work required to realise a proposed construction project with a view to obtaining an acceptable price from a contractor, which will then enable a civil contract to be drawn up so as to facilitate construction and completion of the project.

However, there is much more to the subject of 'measurement' than this:

- Firstly, each standard method of measurement has different measurement and item coverage rules, and this imposes a different balance of risk upon the contracting parties.
- Secondly, such risks will be viewed differently as between client/professional advisers, main contractor and subcontractors, and this will influence their respective attitudes at pre-contract, contract and post-contract stages.
- A third factor is that the extent of risk will be conditioned by the procurement option chosen for a specific project and by the conditions of contract employed for that project.
- The risks posed by the project in question will impact technically, financially and in project management terms, and such risks need to be managed appropriately by each of the participants in the construction process in turn.

Measurement has many uses and applications, and its centrality in the day-to-day management of the construction process is undervalued. There is an important link between methods of measurement, conditions of contract and procurement, and the link is **risk**.

This is a strong theme of this book.

1.5.3 The author's objectives

The objectives of writing this book were:

- To present the subject of measurement in a modern context with a risk management emphasis.
- To recognise the interrelationship of measurement with the complex web of procurement and contractual issues that characterise construction contracting.
- To emphasise the role of measurement in the entirety of the contracting process.
- To convey the basic principles of measurement and to put them in the modern context of on-screen measurement and BIM model quantity take-off.
- To incorporate consideration of five common methods of measurement currently used in construction.
- To widen the accessibility of measurement beyond the province of the professional quantity surveyor.
- To recognise the measurement risk issues facing quantity surveyors, contractors, subcontractors and others in the context of construction work when tendering, applying for payment, controlling cost and value and pursuing legal entitlement.

Much of the above has not been attempted in a measurement book before.

1.5.4 Rationale

The idea behind this book was to write something different and to try, as best as the author is able, to provide a text for practitioners who are able to measure but, perhaps, need a reference to confirm their instincts about measurement issues that are not dealt with in traditional measurement books.

There are many practitioners in the industry who are engaged in both building and civil engineering projects, or have to juggle more than one method of measurement on the same project, and this book is written with them in mind.

The book is structured in four Parts:

Part 1 – Measurement in construction establishes the connection between measurement and design with particular reference to the RIBA Plan of Work 2013 process model that depicts industry procedures. The importance of measurement in a BIM environment is emphasised, and quantity surveying conventions are explained in the context of measurement software applications.

Formal bills of quantities are recognised as only one of many outputs from the measurement process, and the measurement of construction work where no particular standard method of measurement is used is covered in detail.

This includes informal bills of quantities, activity schedules under the EEC and JCT standard forms of contract and schedules of rates and schedules of works for term maintenance and refurbishment contracts.

Part 2 – Measurement risk is a unique feature of the book as it provides a detailed examination of five current, commonly used, standard methods (or rules) of measurement – NRM1, NRM2, CESMM4, MMHW and POM(I).

The theme in Part 2 is the identification of risk, and each method of measurement is examined in detail, both critically and practically. Numerous practical examples of the use and application of each method of measurement are provided. Shortcomings and errors in the documents are highlighted, and there is a comprehensive guide to the transition from CESMM3 to CESMM4.

Part 3 – Measurement risk in contract control deals with measurement risk in the post-contract control of construction work.

This includes coverage of physical measurement and the function of measurement in the valuation of variations and work in progress. Measurement claims and final accounts are considered in the context of the JCT, ECC, ICC and FIDIC forms of contract and with respect to the role that measurement plays in these post-contract processes.

Part 4 – Measurement case studies is devoted to a series of worked examples relating to each of the standard methods of measurement covered in the book and also to the preparation of builders' quantities.

There was never any intention to cover every 'dot and comma' of the methods of measurement referred to in the book nor could it possibly include extensive worked examples of quantity take-off and dimension sheets as is traditional in measurement books. More important than 'how to measure this or that' are the risk issues arising from the methods of measurement we use and the link with the various procurement methods and conditions of contract that are commonly employed in the construction industry.

The aim is to provide sufficient insight and guidance, at a strategic measurement level, such that the reader will be more than capable of delving into whatever corner of any of these documents suits their purpose. If in some small way this helps the reader to feel confident enough to explore the wider issues arising from the measurement and valuation of building and civil engineering work, then the effort writing the book will have been worthwhile.

Notes

1. http://www.theguardian.com/money/2006/feb/25/careers.work1 (accessed 29 March 2015).
2. http://en.wikipedia.org/wiki/Measurement (accessed 29 March 2015).
3. http://en.wikipedia.org/wiki/Quantity_surveyor (accessed 29 March 2015).
4. http://www.bimtaskgroup.org/ (accessed 29 March 2015).
5. http://www.isurv.com/ (accessed 29 March 2015).

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