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AN INTRODUCTION TO TAKING OFF BUILDING QUANTITIES – AN IRISH APPROACH

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Construction professionals are involved in procuring building work on a daily basis. Effective procurement aims to provide construction clients with projects which achieve good value for money. Key objectives include ensuring that accurate budgets are prepared before work commences and that the correct price is eventually paid for the completed work. Measurement and valuation are essential processes underpinning these activities and together they form the central link between design and cost. On commercial projects these tasks are usually carried out by quantity surveyors. On smaller projects, however, clients, architects, managers and builders may receive quotations and/or accounts containing building measurements. In these situations it is very beneficial to understand how these measurements have been made and how they are presented so that they can be checked and verified.

Measurement is used by various stakeholders and construction professionals throughout the development process to calculate the quantity of work to be done. For example:

- A project manager may require the gross floor area of a proposed office block to establish a building budget at the initial stages of a contract.
- A quantity surveyor may calculate the approximate quantities of work during the design development stage to produce a cost plan to check the adequacy of the building budget.
- A quantity surveyor may take off quantities from detail drawings to produce a bill of quantities for tendering purposes.
- On smaller projects an estimator may need to measure the quantities from the tender drawings and specifications as part of a tender submission.
- A contractor will present measured variations as part of a final account settlement.

The purpose of measuring any building work is to establish the correct amount of work to be done. This involves producing accurate quantities in a way which is comprehensive, technically accurate and clear in its approach and presentation.

Measurements must be carefully made regardless of whether the measurer is sitting comfortably at an office desk or is on site up a scaffold in the rain, other people's money depends on it and so does the measurer's reputation. They are spending employer's money every time a dimension is entered. It is assumed they are conscious of the responsibility and are worthy of it.

Measurement has two basic essential activities; description and quantification.

Description usually involves 'translating' information contained on drawings, specifications and technical reports and communicating that information accurately and concisely so that another person will completely understand the writer's intentions. The measurer must be able to describe concisely what the designer has drawn or the builder has built. In practical terms this means that the description must

be clear enough to enable an estimator or valuer to visualise the detail without having to refer to the drawing. The description will only be adequate if the estimator is capable of fully pricing the original detail. Designers and quantity surveyors must be aware that others will rely on their descriptions when pricing building works. Descriptions must therefore be accurate, clear, concise and unambiguous.

Quantification on the other hand is reasonably straightforward. Accuracy, again, is the objective, however the level of accuracy which is to be expected depends on the degree to which the design has been developed and the purpose for which the measurements have been taken. The accuracy required usually increases in tandem with the detail of the design. It would not be intended that an undimensioned 1:1000 block layout produced during the initial phase of the design process would be used to measure lengths of walls to the millimetre. It may be perfectly acceptable to measure outline drawing to a lesser degree of accuracy to generate approximate quantities as part of a preliminary budget cost estimate.

This paper is presents an approach to taking off quantities based on the author's personal experience of working as a quantity surveyor in four consultant quantity surveying practices in Ireland over the course of nearly twenty years. The author notes that while each of these practices had their own particular approach to taking off, the differences between them were very minor are usually reflected differences in style rather than process. This paper comments on, and demonstrates how, measurements may be recorded and processed in writing, and sets out to lead the reader step-by-step through the process.

Quantity surveying practices now produce bills of quantities using various software packages, each of which has its own techniques for entering dimensions and composing descriptions. However, it is often uneconomic and unnecessary, particularly for other construction professionals, to purchase these packages and other approaches must therefore be considered. The traditional method of teaching building measurement through hand written worked examples is considered by this author to be an effective approach to developing a sound understanding of, and ability in measurement procedure and the potential problems which may be encountered. The author believes that the pen-and-paper approach to measurement has served the profession well, and should remain the necessary and pragmatic first steps in mastering the basic principles on which digital measurement is founded.

Introduction to Taking Off Quantities

The quantification process involves recording dimensions and is referred to as *taking off* because it involves reading or scaling (taking off) dimensions from a drawing and entering this information in a standard manner on purpose ruled paper called *dimension paper* or *take off* paper.

Dimension Paper

An example of traditional dimension paper is illustrated at Figure 1 overleaf. These sheets are normally printed in A4 portrait format.[1]

[1] Other rulings are used in practice, many Irish practices use a variety of estimating paper which combines the left side rulings of dimension paper with a wider central description column and right side cash rulings.

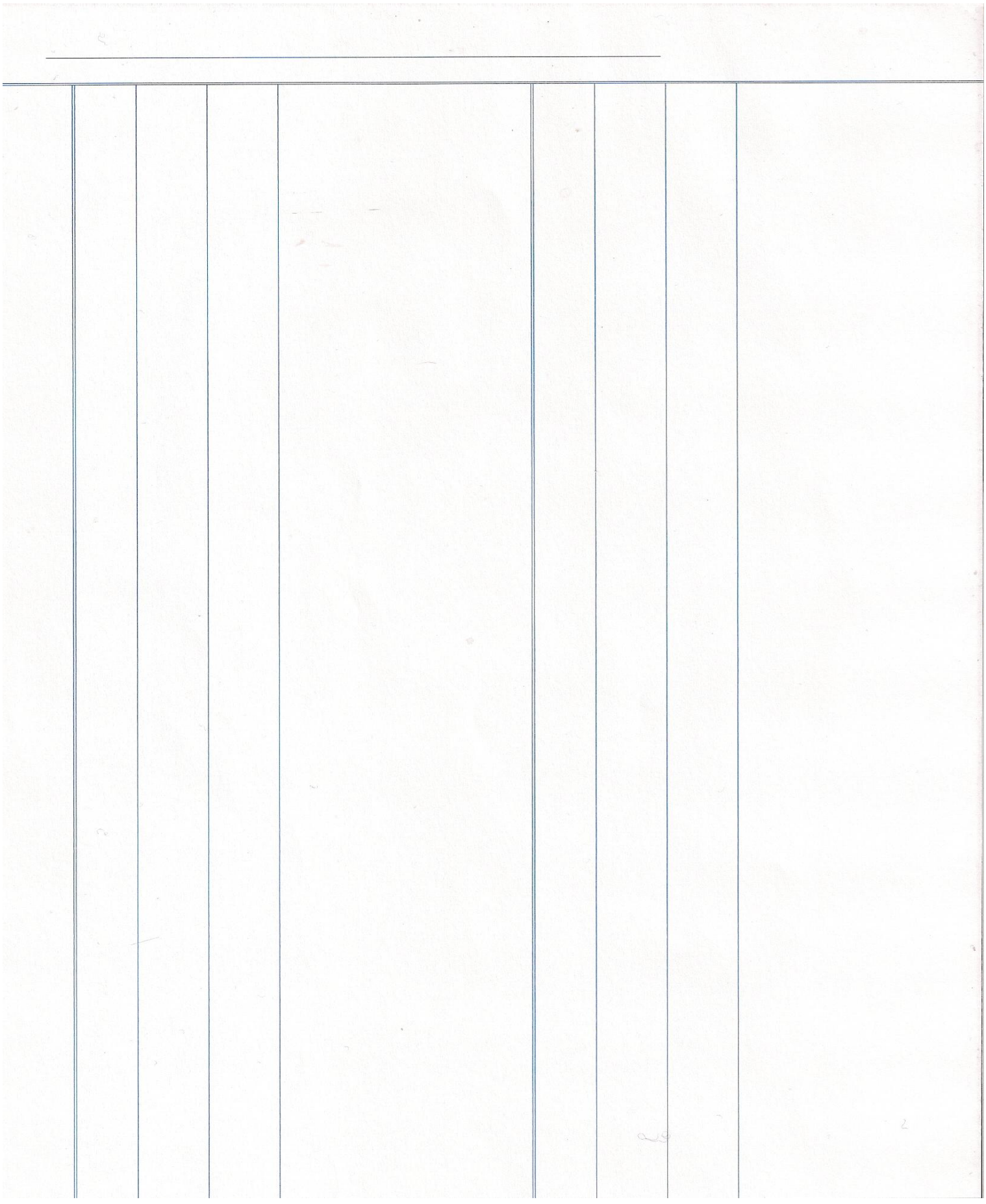


Figure 1 A Blank Sheet of Typical Dimension Paper

The traditional dimension sheet is divided vertically into two identical halves each comprising a set of four columns. In effect, the rulings on the right half of the sheet may be considered to be a continuation of those on the left side of the sheet.

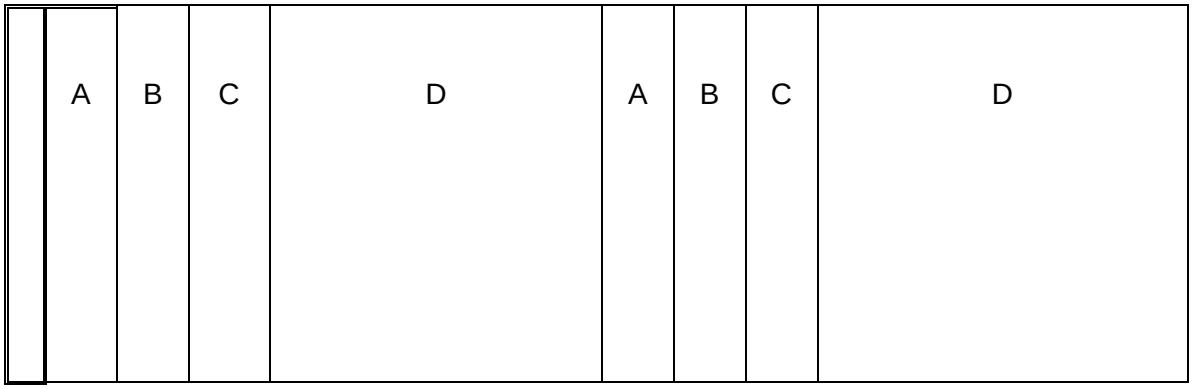


Figure 2 Rulings of Traditional Dimension Paper

Columns A – are the *timesing columns;* these columns are used to enter multipliers when there is more than one of the particular item being measured.

Columns B – are the *dimension columns;* where the dimensions of the item being measured are recorded.

Columns C – are the *squaring columns;* these columns are used to calculate the quantities which are produced by multiplying the timesing factor in column A by the dimensions in column B. The results are then totalled to derive the final quantity of work.

Columns D – are the *description columns*; these wider columns are used for descriptive content such as location references and explanatory notes called *annotations.* Preliminary calculations, called *waste calculations* may also be carried out in these columns. In the UK these columns contain the written description, often abbreviated, of the item being measured.

The double lined column on the extreme left of the sheet is a binding margin and it is not used in the taking off process. The division of the dimension paper into two halves permits a number of items to be measured on a single sheet. This author, however, recommends that plenty of space be left between items on the dimension sheet. Cramped work is often difficult to follow and there may be instances where work is missed if it appears to be a continuation of the previous item being measured; both will result in the loss of marks in examinations and project work.

Entering Dimensions

The four principal units of measurement encountered on introductory measurement courses are number, length, area, and volume. Occasionally standard methods of measurement require the insertion of an ‘item’. This is an item of work without a measured quantity, for example disposing of surface water in excavation work, labours on brickwork, testing the drainage system, and so on. Figure 3 illustrates the process for entering dimensions for various work items.

838 x 1981 x 44 mm thick flush door

6
3

215 mm thick solid concrete block wall.

5.16
2.40

4.00
1.23

100 mm diameter upvc drain pipe

7.20
11.90

3.45

Grade 20N concrete in foundations

11.34
0.90
0.30

2.15
0.90
0.15

Figure 3 Entering Dimensions

A particular focus of this paper is to explain how measurements are prepared for inclusion in bills of quantities compiled in accordance with standard methods of measurement. These stipulate that '*Work shall be measured as net as fixed in position and each measurement shall be taken to the nearest 10mm (i.e. 5mm and over shall be regarded as 10mm, and less than 5mm shall be disregarded).*'(ARM4 Rule A5) This rule requires measurements to be entered in the dimension column in metres to *two places of decimals* with the decimal point between the metres and fractions. For example, where the length of a skirting is 5994mm it would be entered as 5.99m. If, however the length is 5995mm it would be entered as 6.00m.

Note that dimensions are always entered to two places of decimals even where it may not appear to be entirely necessary. For example if the length of the first pipe in Figure 3 above was 7000mm precisely, it would still be entered as 7.00m. rather than just 7! Figured dimensions should always be used in preference to scaled dimensions, which should only be used as a last resort.

Number / Enumeration

Many items in building work are counted, for example precast concrete lintels and sills, prefabricated roof trusses, joinery items such as doors, and windows, electrical and mechanical fittings such as lights, radiators and pumps, sanitary fittings such as baths and so on. Where items are counted they are entered as *whole numbers* in the dimension column with a line drawn horizontally across the dimension column below each entry. For example in Figure 3 above, six flush doors have been counted in one particular location and another three are located elsewhere. The whole numbers 6 and 3 have been entered in the dimension column with a horizontal line across the column below each entry. Note that the actual dimensions of enumerated items are stated in millimetres in the description. This identifies the door's width, height and thickness.

Lengths

Linear measurements (lengths) are taken for items such damp proof courses, details such as bands and cappings on brickwork, carcassing and first fix timbers, runs of pipe, etc. Linear measurements usually state the cross section size of the item in the description.

Figure 3 above enters the measurements for three drain pipes in metres to two places of decimals in the dimension column; these are: 7.20, 11.90 and 3.45 metres long respectively. A line is drawn across the dimension column under each length to indicate that it is a linear measurement.

Areas

Items such as walls, roof coverings, floor boarding, and most finishes are measured by area. These are sometimes referred to as *superficial measurements*. The description usually states the thickness of the item of the work. The measurements comprise two dimensions; a length and width when the item is on plan, or a length and a height where it is vertical. Dimensions are arranged in pairs in the dimension column with the horizontal line appearing under the second dimension. Figure 3 above shows the measurements of two block walls. The dimensions read as 5.16 m long by 2.40 m high and 4.00m long by 1.23m high respectively.

Volumes

Excavation, earthwork and concrete work are typically measured by volume. These items contain three dimensions which ideally are arranged in the order of length by

width by depth. Again, the sets of three dimensions are identified by the horizontal line under the third dimension of the set. The concrete foundations in Figure 3 identify two separate trenches where the longer trench is 900mm wide and the shorter trench is 1200mm wide.

The convention of underlining indicates which unit of measurement is being used and removes the need to stipulate whether the measurements are lengths, areas, volumes or numbers. Where each dimension is underlined the unit of billing is the metre, where the second dimension in a pair is underlined the unit is square metres, and where the third dimension in a set is underlined the unit is cubic metres.

Timesing

Quantity surveyors use the term ‘timesing’ rather than ‘multiplication’ to refer to the number of times a particular item occurs in the course of measurement. The timesing factor is entered in the timesing column and is registered by a backslash mark across the border between the timesing and dimension columns.

Figure 4 shows various timesing techniques which can be used to speed up the measurement process by avoiding the needless repetition of identical dimensions.

The second entry in the door measurement indicates that there are three separate groups of three doors.

The measurement of the drain pipes show that there are two runs of 7.20m and 11.90m pipe and three 3.45m lengths of pipe.

The measurement of the block walls demonstrates that timesing can be repeated where similar designs are located in different parts of the project. Example 4 shows that there are two instances of the first type of wall in two separate parts of the project. This entry reads twice times twice times 5.16m long by 2.40m high walls - i.e. there are four walls with these dimensions. Likewise the second entry shows that there are six (three times twice) walls that are 4.00m long by 1.23m high. This technique is particularly useful when measuring work of a repetitive nature such as housing schemes and hotels or multi-storey buildings with repetitive floor layouts.

The measurement of the concrete foundations demonstrates a technique called *dotting on*. This technique is not encountered frequently in practice, but there may be occasions where a further item or items have been discovered after similar work has already been measured. The process is signified by inserting a conspicuous large ‘dot’ behind and above the timesing factor while entering the number of the additional items. In the concrete work in Figure 4 the multiplier for the first set of dimensions reads (three plus one) times, i.e 4 times. Likewise the second entry reads twice times three times (two plus one) i.e six times the dimensions..

838 x 1981 x 44 mm thick flush door

6
3/ 3

215 mm thick solid conc-rete block wall.

2/2/ 5.16
2.40
3/2/ 4.00
1.23

100 mm diameter upvc drain pipe

2/ 7.20
2/ 11.90
3/ 3.45

Grade 20N concrete in foundations

1.
3/ 11.34
0.90
0.30
2/2/ 2.15
0.90
0.15

Figure 4 Use of the Timesing Column

Squaring the Dimensions

The squaring column is used to calculate the quantities of work and represents the products of the timesing and dimension columns. The *squaring* process figures out the quantities of work by multiplying the dimensions by the timesing factor. Figure 5 shows how the works measured in Figure 4 would be squared. There are a number of conventions to note:

- In situations where there are multiple dimensions for enumerated items or linear dimensions which are not timesed, these may be totalled and the result entered in the squaring column to the right of the final number / dimension. For example the measurements relating to the doors and drainage pipes in *Figure 3* (The example before squaring was put in) would total 9 and 22.55m respectively. There would be no need to insert each dimension in the squaring column.
- Where enumerated items or dimensions are timesed each calculation should be entered separately in the squaring column - as occurs throughout in Figure 5
- Enumerated items are entered or totalled as whole numbers in the squaring column.
- Squared dimensions are entered in the squaring column to two places of decimals and are totalled alongside or below the final dimension entry. Note that there is no underlining in the squaring column until the totalling process is carried out. Totalling is usually signified by double underlining.
- Totals are usually rounded off to the nearest full unit and transferred to the right hand side of the description column immediately below the description. This accords with standard practice – ARM4 rule A10 stipulates: '*Where the unit of billing is the metre, quantities shall be billed to the nearest whole unit. Fractions of a whole unit less than a half shall be disregarded and all other fractions shall be regarded as a whole unit.*'

The quantities are transferred either directly to the measurement document or to an abstract as part of the billing process.

Use of the Description Column

As its name suggests, this is where descriptive information is entered.

Typical taking off procedure in Ireland differs from UK practice in the way in which descriptions are presented on the dimension sheets and how the measurement process is organised. The differences between the two approaches become most obvious in the way the description column is used.

In Ireland the description of the items to be measured is typically located at the top of the sheet and is *written in full* across the timesing, dimension, squaring ***and*** the description column. The *complete set of dimensions* relating to the item are presented directly below the description before starting to measure the next item. This approach is referred to as '*direct billing*'.

838 x 1981 x 44 mm thick flush door

15 Nr.

	6	6
3/	3	9
		15

215 mm thick solid conc-rete block wall.

79 sq.m

2/2/	5.16	
	2.40	49.54
3/2/	4.00	
	1.23	29.52
		79.06

100 mm diameter upvc drain pipe

49 m

2/	7.20	1440
2/	11.90	2380
3/	3.45	1035
		4855

Grade 20N concrete in foundations

1.

14 cu m

3/	11.34	
	0.90	
	0.30	12.25
2/2/1	2.15	
	0.90	
	0.15	1.74
		13.99

Figure 5 Squaring the Dimensions

Practices in the UK, however, often use a system called the '*group method or London method*' of taking off. This system is demonstrated in a number of textbooks published in the UK including Packer (1996) Seeley and Winfield (1999) Lee et al (2005) and Cartlidge (2013).

The *group method* groups related work items with common dimensions, such as blockwork plaster and paint, and measures them together simultaneously using brackets and a technique called '*anding on*'. Measurements and adjustments relating to the particular work items are gathered from the various sections of the take off and aggregated in an abstract to produce the final quantities prior to final billing.

Work descriptions in the 'group' approach are *contained within the description column* and are heavily abbreviated and copied using the word '*ditto*' to save time and space. This allows a number of descriptions to be written in the description column. The full descriptions of the work items are only produced at the final billing stage.

Despite the fact that the Irish direct billing approach does not use 'anding-on', bracketing and abbreviated descriptions, there are two techniques which are common to the UK approaches: the use of *annotations* and the facility of calculating dimensions called *waste calculations*.

Annotations

Taking off building work can be a lengthy process and it is common for a team of surveyors to take off the work when producing a bill of quantities. It is essential that the take off notes can be understood and followed by others, such as the project quantity surveyor, during the construction and final account stages of the project. If the take off cannot be followed it becomes useless, and the effort spent in trying to figure it out can, in effect, be a further waste of time. It is important, therefore, that the quantity surveyor *annotates* the dimensions to show where and how they have been made and calculated. A well signposted set of dimensions ultimately saves time and money in the event that the take off has to be referred to, such as where the final account has to be adjusted as a result of variations.

Annotations should be kept as brief as necessary; and often a single syllable can identify the measurement logic or an item's location on the drawings. It is common practice to align the annotations on the left hand side of the description column beside the dimensions to which they refer. Figure 6 illustrates how the various measured items may be annotated. It is not necessary to annotate something that is obvious.

Waste Calculations

Ideally dimensions can be read directly from the drawings and entered directly into the dimension column. However, direct transfers are not always possible as some calculation or adjustment may be required to the dimensions on the drawing before they can be correctly booked.

838 x 1981 x 44 mm thick flush door

15 Nr.

	6	6	Rooms 1-6
3/	3	9	21-3 121-3 221-3
		15	

215 mm thick solid concrete block wall.

79 sq.m

2/	2/	5.16	End Elevs.	1680
		2.40	49.54	1800
				1680
				5160
3/	2/	4.00	Gardens	
		1.23	29.52	
			79.06	

100 mm diameter upvc drain pipe

49 m

2/	7.20	1440	GT 1, 2 – MH-1 → 2
2/	11.90	2380	GT 3-4 – MH 2-3
3/	3.45	1035	GT 5-6 – MH 3-4
			SV 1 – MH 3-4
		4855	

Grade 20N concrete in foundations

1.

14 cu m

3/	11.34		Zone A
	0.90		
	0.30	12.25	
2/1/2/	2.15		Drg F' 2750
	0.90		proj -2/300 - 600
			2150
	0.15	1.74	Zone B
		13.99	

Figure 6 Annotations and Waste Calculations

*****Note these annotations are for demonstration purposes only and are intended to illustrate how notes may be written on a dimension sheet

The right hand side of the description column is commonly referred to as the *waste*. The waste is used to build up dimensions and to carry out other preliminary calculations. Quantity surveyors call these '*waste calculations*' or '*side-casts*' and they are worked out in millimetres alongside the item to which they relate. Once the dimension is calculated, it is transferred into the dimension column in metres to two decimal places.

A key principle of taking off is the elimination of mental arithmetic. All steps that have been taken in arriving at a dimension should be included in the waste calculation. This enables the dimensions to be checked and will reduce doubts and misunderstandings. There may be a temptation to scribble these or carry out simple arithmetic in the head. Both should be avoided as it is important to be able to identify the process by which the dimensions were established. Double underlining in a waste calculation usually indicates that the result has been transferred to the dimension column.

Figure 6 shows two waste calculations, the notes indicate that:

- The lengths of the first block walls, 5.16, have been derived from a string of dimensions indicated on a drawing (1680+1800+1680) relating to an end elevation.
- The length of the second set of concrete foundations are based on a wall dimension of 2750mm shown in 'drawing F' relating to Zone B: this dimension has been adjusted for the projecting overlap of the foundations at both ends these trenches – giving a net length of 2150mm.

Deductions

After measuring an item it is sometimes necessary to deduct for voids and/or openings. Standard methods of measurement such as ARM 4 set out rules governing the deduction of openings within the boundary of the work. Openings or wants at the boundaries of the work are deducted irrespective of their size. Openings and wants are shown in Figure 7.



Figure 7 Openings and Wants (Courtesy Fiacra McDonnell)

Deductions are generally entered as shown in Figure 8. This example shows the measurement of the internal block walls in a small cottage in which there are five internal doors. The letters Ddt in the squaring column stand for the word '*deduct*'. The net total of the blockwork has been labelled TOT A as it will be reused during the later stages of the take off (discussed below).

One of the key techniques used by surveyors in measuring work '*the golden rule of measurement*' is to measure in full in the first instance and subsequently adjust for the detail; this process frequently involves deduction.

DEDUCTIONS AND CORRECTIONS

Solid blockwork; I.S. 20

Walls

100 mm thick.

32 M²

7650 5400
-2/300 -600 -600
7050 4800
overlap -100
4700

7.05
2.50 17.63

2/4.70 'ribs'
2.50 23.50
41.13

Ddt

5/0.90
2.10 9.45 doors
TOT A 31.68 TOT A

Concrete; Grade 35

Foundations

poured on earth.

7 M³

7650
5400
2/13050
26100

26.10 ↑
0.90 NIL
0.30 ↓

* & adj
-4/300 1200
24900

24.90
0.90
0.30 6.72

Figure 8 – Deductions and Corrections

Alterations to Dimensions

It is sometimes necessary to substitute amended dimensions in place of those, which have already been entered on the dimension sheet. Do not alter the original figures. The better procedure is to write NIL in the squaring column beside the incorrect dimensions and re write the new dimensions immediately above or below depending on the space available.

Figure 8 shows an example where the length of a foundation has originally been incorrectly calculated, and has subsequently been changed to show its correct centreline measurement.

Repeat Dimensions

To save time and reduce the possibility of transcription errors it is good practice to repeat totals from previously measured items. For example block walls are generally plastered and painted on both sides. Figure 9 shows how the total obtained for blockwork in Figure 8 is included in the calculation of the plaster which, in turn, forms the basis for measuring the painting. Some additions and/or adjustments are usually required to the repeated quantity when measuring the subsequent item, therefore, additional care is need when using this technique.

The procedure is to label or tag the total for the blockwork, say TOT ‘A’ and repeat this full quantity to two decimal places in the dimension column of the plaster measurements identifying the unit of measurement used. A side note should be made identifying what the repeat total refers to and the page on which it originates.

This process corresponds to the ‘anding on’ technique demonstrated in the UK textbooks noted above.

Long Calculations

On many occasions it will not be possible to complete the measurement without continuing onto the other side of the sheet or onto a further sheet. In these instances the squared dimensions should be sub-totalled at the bottom of the column and brought forward to the top of the following squaring column, before recommencing the measurement. It is often convenient to start deductions on the right hand side of the sheet where there is not enough room to complete the measurement on the left side.

Numbering and Titles of Dimension Sheets

Each dimension sheet should be suitably headed with the job and page reference at the top of each sheet. A dated and initialled cover sheet identifying the job, stage, element and total number of pages used in the take off is good practice. This cover sheet should also contain a list of drawings used for the take off. The take off should be suitably fastened to prevent loss of sheets.

REPEATING QUANTITIES

Gypsum plaster; 3mm skim coat of finish on blockwork; total 15 mm thick.

Walls

107 M^2

2/ TOT A
31.68
Sq.m 63.36 Internal Walls P 22.1. both sides).

TOT B
41.62
Sq.m 41.62 External Walls P. 21.4.

TOT C
21.00
M
X 0.10 2.10

107.08 TOT PL1.

Three coats emulsion paint on plaster

Walls

102 M^2

TOT PL1
107.08 See plast. P 42.1.
Sq.m 107.08

Ddt

TOT SK1
47.40 Skirting P 43.1.
M
X 0.10 4.74

102.34

Figure 9 Repeating Quantities

Summary

The purpose of measuring building work is to establish the correct amount of work to be executed. Calculating well presented accurate quantities in a clear manner within a logical approach will help to reduce errors and will be very helpful if the notes need to be referred to at a later date. This paper has described an approach to hand-written taking off procedure informed by the techniques adopted by many Irish consulting quantity surveying practices. The paper has also discussed the 'direct billing' system used in Ireland and has contrasted this with the procedures demonstrated in various UK publications, identifying key differences between the two approaches.

Where quantities are being prepared for tender documents governed by standard methods of measurement such as ARM4 the measurements relate to work net as fixed in position and are to be taken to the nearest 10mm, these are then booked in the metres to two places of decimals in the dimensions column. Multipliers are placed in the timesing column and the quantities are computed in the squaring column. Descriptive content and preliminary dimension calculations are performed in the dimension column. Dimensions are ideally entered in the order of length, width and depth, figured dimensions should be used in preference to scaled dimensions.

While accuracy is the primary objective, clarity of presentation and communication remain major priorities. A logical approach in the taking off will greatly assist subsequent understanding. Technical accuracy in booking dimensions should be rigidly observed at all times. Measurements should be made in a logical sequence; for example measuring in a clockwise sequence or following room or door numbers. Dimensions and calculations should be fully annotated. Finally neatness, adequate spacing and grouping of dimensions when combined with technical accuracy will give the notes an authority which will enable those who need to refer to them to do so with a high degree of confidence.

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