Introduction 1

Quantity Surveying

Quantity surveyors are said to have emerged in response to the need for cost planning and for measurement and valuation of work in progress. Hudson gives a definition of a quantity surveyor as below (Hudson, 1994):

> *whose business consists in taking out in detail the measurements and quantities from plans prepared by an architect for the purpose of enabling builders to calculate the amounts for which they would execute the plans.*

The above description portrays a simple but clear picture of the most representative work performed by a quantity surveyor – to carry out estimating and measurement of construction works. With the growth complexity of construction technologies and designs, quantity surveyors are capable of providing advice and services related to a wide range of aspects, including contract administration, financial advice, dispute resolution and contractual advice. Estimating and measurement are the primary skills possessed by quantity surveyors to provide the contract and financial services to project owners.

Estimating and Measurement

Once an organisation has an idea to construct something, many questions related to project cost have to be answered: Is the project financially feasible? How much does the project cost? Are there any alternative proposals which cost less? How much is the life-cycle cost of the project? These questions are answered by a quantity surveyor during the estimating and measurement processes.

Estimating is the process of calculating the likely cost of a project (or items of work) to be incurred. Agreement of the estimated cost with the actual cost depends on the availability and understanding of project details, and the use of appropriate estimating methods.

Measurement is the process of calculating the quantities of work to be required for various trades or items of work such as from drawings, sketches and specifications prepared by designers, principally architects and engineers. Accurate measurement of the work enables realistic cost estimates and cost control to be carried out.

From the project owner's perspective, a quantity surveying consultant is employed to act as a project adviser. As shown in **Figure 1.1**, the quantity surveyor reports to the project developer and advises the estimated project cost from inception to completion. Besides, a quantity surveyor manages the tendering process, contract award and commercial interfaces. He/she measures the work in accordance with a standard method of measurement and prepares the bills of quantities for tender and evaluates the tenders received. During the construction period, a quantity

surveyor continues to review and control the project cost and prepare necessary measurements and estimates for monthly payments to the contractors. When the project completes, the quantity surveyor prepares measurements for the final accounts and claims.

On the contractor side, a contractor's quantity surveyor uses his/her expertise to bid a contract and secure reasonable profit if the contract is awarded. A quantity surveyor, usually employed in the position of an estimator, prepares estimate (or price) for each BQ item based on his/her expert knowledge of costs of work, labour, materials and plant required, and an understanding of the implications of project conditions and designs. A base estimate, which represents all the likely direct costs will be worked out by the estimator. The figure will be presented to the management to decide on the allocation of profit and overheads in order to work out the tender bid. If the contract is awarded to the contractor, the contractor's QS(s) will be recruited as core member(s) of the project team to handle the procurement and cost control activities. Quantities of work will be measured for materials ordering. To assess subcontractors' payments and prepare interim payment applications, measurement of work quantities and cost estimating are also performed at regular intervals. These tasks contribute to the integral components, the project expenses and income, of a project cost control system. **Figure 1.1** illustrates the estimating and measurement work performed by the contractor's QS at various stages.

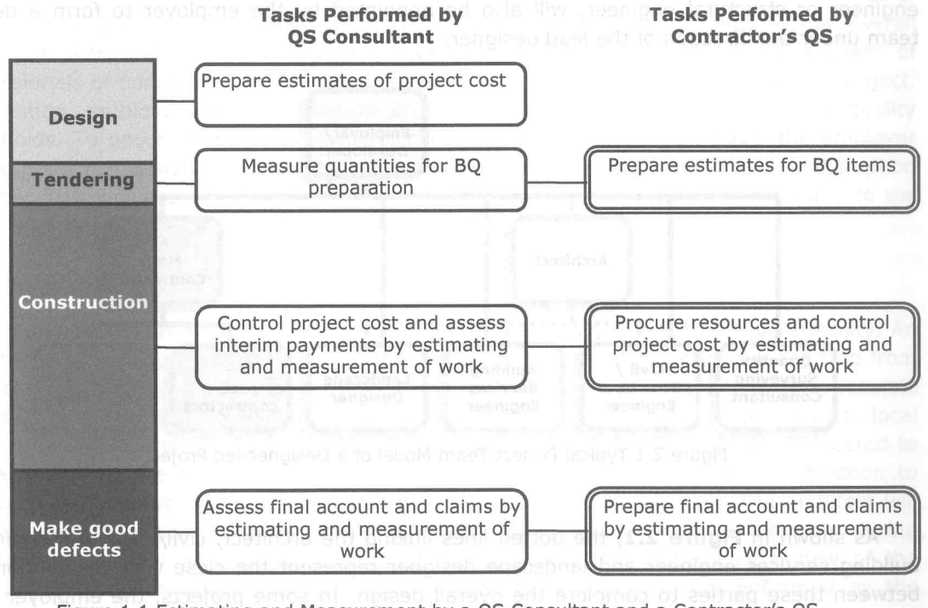

Figure 1.1 Estimating and Measurement by a QS Consultant and a Contractor's QS

Principal Parties in a Project 2

Introduction

Construction projects are intricate and fragmented in nature. A diverse group of companies are invited to collaborate at different stages to complete the project in a timely and cost effective manner. These companies form an integrated 'team', with each of them playing specific roles. It is only through the concerted effort and contribution of all team members that the project completes.

In a traditional designer-led project, an employer (or developer) will engage a lead designer (or design leader) to direct and coordinate the work of all consultants and monitor compliance with design and schedule. The lead designer is usually an architectural consultant or engineering consultant. Various design consultants like building services engineer, civil engineer or structural engineer, will also be appointed by the employer to form a design team under the direction of the lead designer.

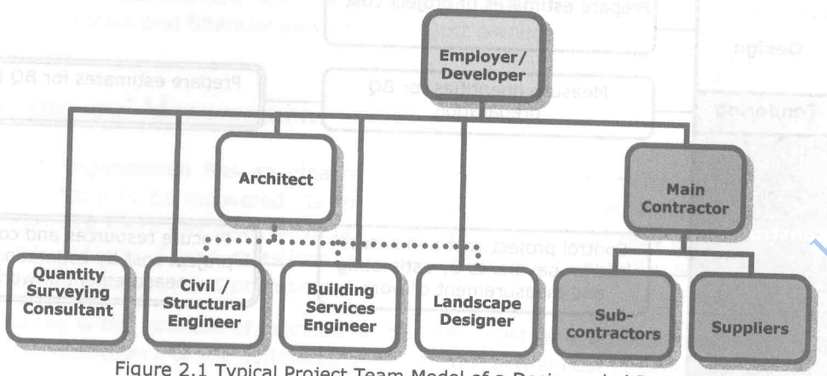

Figure 2.1 Typical Project Team Model of a Designer-led Project

As shown in **Figure 2.1**, the dotted lines linking the architect, civil/structural engineer, building services engineer and landscape designer represent the close working relationship between these parties to complete the overall design. In some projects, the employer may engage a multi-disciplinary design consultant to prepare the full range of design services including architectural, structural and building services design. A quantity surveying consultant and a main contractor are also employed by the employer at appropriate time for the execution of project work.

Points to note

Every project is unique and may have different team models based on the project nature, scope and delivery method. For instance, in a project delivered by design-and-build approach, no separate architect will be employed by the developer. In a tunnel project, a civil engineer instead of an architect will be the lead designer. Details of the project team set-up under different project delivery methods will be further discussed in **Chapter 3**. For illustration purpose, the major roles of each project party are explained with reference to a traditional designer-led project.

Principal Project Parties

The Employer

An employer (or developer), is an organisation that initiates the project. Examples are the Government, Hospital Authority, Swire Properties, MTRC etc. Commission for Architecture and the Built Environment, U.K. (2013) provides a detailed guide on the roles of employer throughout the project life cycle. To summarise, an employer is the overall decision-maker and coordinator of a project. An employer has to recruit a team of professionals or consultants, give clear directions and set operational criteria for the project. In addition, employers will also decide on budget, project completion date and quality thresholds. To ensure that various project parties play their respective roles, the employer has to grant possession of site to the contractor on the agreed date and minimise disruption to work. This includes but is not limited to supplying necessary information promptly to the various parties and making timely payments for design and construction.

The Architect

An architect is an organisation or individual whose primary role is to design a facility. An architect is usually the lead designer in the project team of building projects. Starting from project initiation, an architect must collaborate with other team members to develop feasible and satisfactory designs and specifications that meet the employer's requirements, local codes and regulations. In most projects, construction administration duties are delegated to the architect by the employer. In this case, an architect has to oversee construction to ensure meeting of specifications as laid down in construction documents. The architect will prepare written assessments/approvals of contractor's work at regular intervals during construction as well as after completion of the project. Other duties like review of the contractors' shop drawings and acquisition of permits are likely to be performed by the architect.

Other Design Consultants

An employer often appoints other specialist consultants to prepare designs and computations for a project. Design consultants may include structural engineers, civil

engineers, geotechnical engineers, building services engineers, acoustic engineers and landscape architects or interior designers. In civil engineering contracts, civil engineers assume the leadership role in the design team.

The design consultants will cooperate with each other to produce the design information for production. With the growing maturity of building information modelling (BIM) in the industry, design consultants may be required to prepare design modelling outputs using BIM softwares. The tasks of design consultants also include monitoring, organising, commissioning and assessing the contractor's work to ensure satisfactory completion.

The Quantity Surveying Consultant

A quantity surveying consultant is usually appointed at an early stage of design to provide financial and contractual advice or services for projects. They provide expert advice on the selection of procurement route, contract type and tendering procedures. Quantity surveying consultants have to coordinate the tender process, including preparation of the tender and contract documentation. One of the main duties of the QS consultant is to estimate the likely project cost for the employer. This estimate continues to change when the design is evolving and refining. It is the responsibility of the quantity surveying consultant to adjust and update the cost estimates and inform the employer and lead designer regularly. Should the cost requirement reach the budgetary limit, the quantity surveying consultant has to alert the architect or other design consultants to consider alternative solutions so as to lower the cost requirement. Quantity surveying consultants should assist the design team with life-cycle cost analysis.

During the construction stage, quantity surveying consultants are responsible for the valuation of contractors' work and assessment of variations and financial claims. Contractual advice is also provided by them in cases where disputes arise between the contractor and employer. Upon project completion, quantity surveying consultants will prepare the final account for agreement.

The Main Contractor

Here, a main contractor is the company that has signed a direct contract with the employer for construction of a project. For example, in case of a school project, the contractor responsible for the construction of the school building is considered as the main contractor. In many cases, employers appoint only a single contractor to carry out all the construction work of a project so as to save coordination effort. We often describe this contractor as the general or main contractor. However, some employers also choose to employ several independent contractors to carry out different portions of the project work simultaneously. This can allow the employer to have direct control over the performance of contractors and therefore, the quality of work. However, the burden of coordinating these independent contractors rests on the employer.

Once a main contractor is engaged in a direct contract with the employer, it is responsible for the performance of all work in accordance with the contract documents. The contractor must plan and coordinate all necessary resources for production, and establish an effective control system to meet the time, cost, quality, safety and environmental requirements.

The Subcontractors and Suppliers

Labour, materials and equipment are the three main types of resources required for construction. General contractors, especially the large ones, normally outsource most of these components. It is an economical strategy to use outsourcing because construction projects involve too many made-to-order or engineered-to-order components. If a general contractor has to employ direct labour and equipment to carry out all these tailored operations, a wide range of specialties have to be maintained at all times (O'Brien et al., 2010). Therefore, a general contractor usually employs multiple subcontractors and suppliers to provide the necessary products and services for different portions of work.

A subcontractor is usually a firm specialised in specific aspect of a project, for instance painting, plumbing or plastering. A subcontractor has a duty to carry out his work diligently with no or minimal supervision. Depending on the agreement with the main contractor, the subcontractor may provide both labour and materials or just labour to complete the work. The firm which provides only materials are the suppliers. The suppliers have the duty to deliver the specified materials/products according to the agreed schedule.

PART 2

Deciding the Procurement Strategy

Project Delivery Methods 3

Introduction

We have reviewed the various project parties in **Chapter 2**, but how does the employer procure the contractor(s) and consultants to carry out the project work? This chapter illustrates the various routes to procure these parties to complete the project.

In the *Construct for Excellence Report* (Construction Industry Review Committee, 2001), the Committee recommended that the employers of local construction projects should adopt alternative procurement methods (which means methods other than the conventional designer-led approach) to achieve better value for money in the projects. Since then, the Environment, Transport and Works Bureau of the Hong Kong Special Administrative Region (HKSAR) has seriously investigated the various project delivery methods and made attempts to increase the adoption of alternative procurement methods in government projects. The initiative was then spread to the private sector.

Project Delivery Options

Project delivery options are differentiated by describing the responsibilities allocated to the construction contractor. In general, we can broadly classify them into five approaches:

- Designer-led
- Construction management
- Design and build
- Design, build and operate
- Design, build, finance and operate

Each delivery method has its own benefits and drawbacks. Some methods are better suited for certain types of projects or project constraints and will be further discussed hereafter.

Designer-led

A designer-led method is also known as Design-bid-build method in other countries such as Australia. This project delivery method was first introduced to Hong Kong a hundred years ago and is still the most popular approach in the construction industry (Environment, Transport and Works Bureau, 2004a).

The designer-led method is characterised by the separation of design and construction responsibilities. As shown in **Figure 3.1**, the lead designer, usually an architect or an engineer, prepares the design, which is then given to the contractor to construct. A QS consultant is appointed to administer the project cost and contracts. Therefore, the design and construction of works are carried out separately in identifiable stages.

Principles and Rules of Taking-off 9

What is Quantity Takeoff?

As mentioned in **Part 3**, bills of quantities are usually prepared by QS consultant for contractors to price in the tender period. This document is set in a standardised format, consists of a list of items providing description and quantities of work to be performed by the contractor. To prepare this document, a QS consultant has to measure the dimensions and quantities of works from drawings and specifications in accordance with predefined rules laid down in the Hong Kong Standard Method of Measurement (HKSMM). We describe this process of measurement as 'taking-off'.

Quantity takeoff is essential as measurement of work is not only required during the tender stage for preparation of BQ, but also during the contract period for materials ordering, preparation of interim valuations and final accounts. Both the QS consultant and the contractor's QS have to perform quantity takeoff frequently throughout the project period.

Rules of Taking-Off

Measurement or takeoff of quantities has to follow a set of predefined rules in order to produce a list of work which can be understood by all parties. The rules covered below are widely used by quantity surveyors in other countries as well.

Use of Dimension Paper

When preparing measurement of works, dimension paper which is formatted as **Figure 9.1** is used.

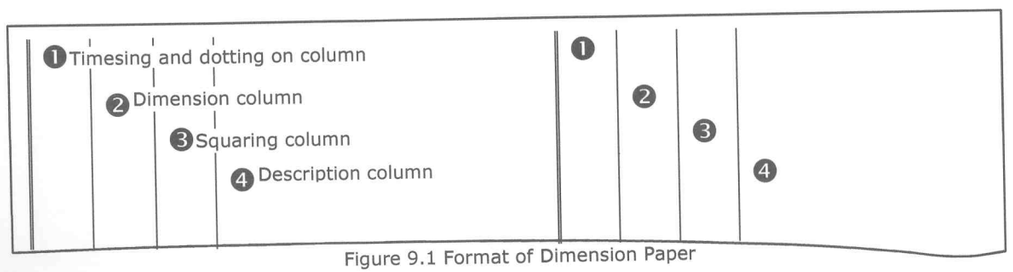

Figure 9.1 Format of Dimension Paper

The dimension paper is divided into two halves, each with four columns. Column 1 is the timesing and dotting-on column in which the factors of multiplication are entered when there are repeated items. 'Dotting-on' allows the factors of multiplication to be added. Column 2 is

the dimension column for recording the dimensions taken from drawings. Column 3 is the squaring column; figures in column 1 and column 2 will be multiplied and recorded here for transfer to the bill. Column 4 is the description column where the description of measured item is entered. This description will also be shown in the bills of quantities. Further details of the use of dimension paper will be illustrated in the following sections.

Entering Measurements in Dimension Paper

General Format

It is always a good practice to write down the project name and referenced drawing number at the head of each page (as shown in **Figure 9.2**), and each page should be numbered consecutively.

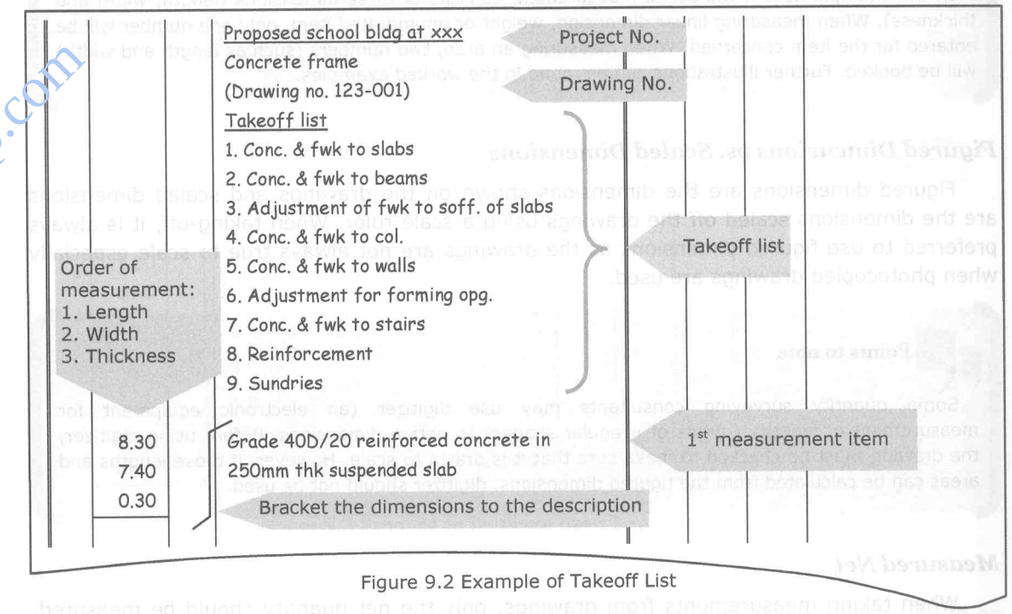

Figure 9.2 Example of Takeoff List

Takeoff List

A takeoff list should be given to provide a logical sequence of all items to be measured. The takeoff list can act as a checklist to avoid missing items. This is usually listed at the very beginning, as shown in **Figure 9.2**.

Booking Dimensions/Measurements

Metric system is used for measurements according to HKSMM. Units of measurement used in taking-off include:

- Linear (run): m

- Area (super): m^2
- Volume (cube): m^3
- Weight: kg
- Enumerated: Nr (number) or Set, as applicable
- Time: Days or Hours

Dimensions must be entered in the order of length, breadth (or width) and depth (or height) as shown in **Figure 9.2**. All dimensions should be recorded in metre to two decimal places. A line should be drawn across the dimension column under each set of measurements (see **Figure 9.2**).

Points to note

In the example above, the set of measurement consists of three dimensions (length, width and thickness). When measuring linear dimension, weight or enumerated item, only one number will be entered for the item concerned. When measuring an area, two numbers (such as length and width) will be booked. Further illustrations can be found in the worked examples.

Figured Dimensions vs. Scaled Dimensions

Figured dimensions are the dimensions shown on the drawings and scaled dimensions are the dimensions scaled off the drawings using a scale ruler. When taking-off, it is always preferred to use figured dimensions as the drawings are not always true to scale especially when photocopied drawings are used.

Points to note

Some quantity surveying consultants may use digitizer (an electronic equipment for measurement of lengths / areas of irregular shapes) to obtain dimensions. Before using digitizer, the drawing must be checked to make sure that it is drawn to scale. However, if those lengths and areas can be calculated from the figured dimensions, digitizer should not be used.

Measured Net

When taking measurements from drawings, only the net quantity should be measured. No adjustment will be made for the waste factors and the like. All voids, unless otherwise stated in the standard method of measurement, should be deducted. Minimum deductions of voids as stated in the standard method of measurement shall refer only to openings or wants which are within the boundaries of the measured areas. Openings or wants which are at the boundaries of the measured areas shall always be deducted irrespective of size.

Use of Hyphen

In the item description, the use of hyphen between two dimensions shall mean a range of dimensions exceeding the first dimension stated but not exceeding the second. For instance, '200–300mm thick slab' means that the thickness of slab exceeds 200mm but not

exceeding 300mm. Alternatively, the range can be written as 'exceeding 200mm but not exceeding 300mm thick'.

Annotating Dimensions – Signposting, Waste Calculation

One of the most important disciplines for a quantity surveyor to develop is to annotate the measurements so that others can understand. There are many chances when the measurements prepared by a quantity surveyor have to be cross-checked by someone else, for instance, when settling the valuation of variations and final accounts. Signposting at the right-hand side of the dimension column (as shown in **Figure 9.3)** is useful to allow the readers to know where the dimensions have been taken.

To record the measurements clearly in the dimension paper, waste calculation and explanatory notes can be entered into the description column, usually at the right-hand side of the column. As indicated in **Figure 9.3**, all steps taken to arrive at the dimensions should be written.

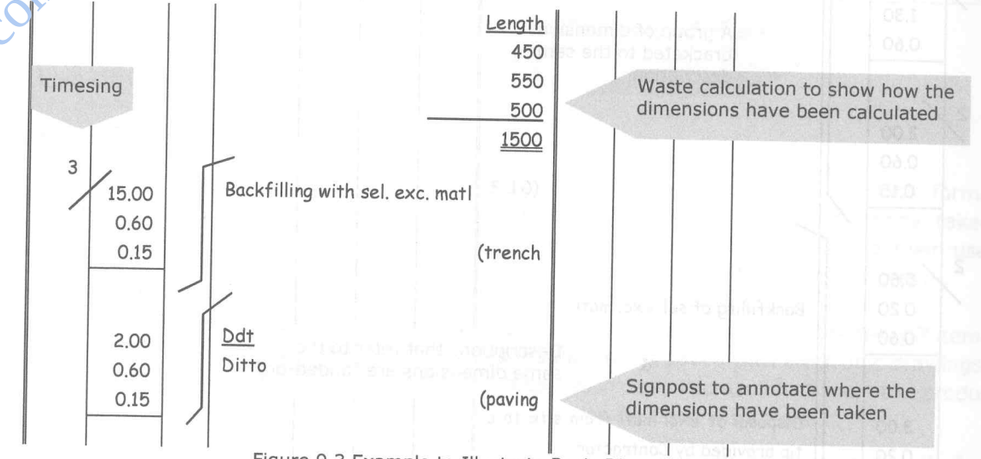

Figure 9.3 Example to Illustrate Basic Dimensions Entry

Timesing

This is used where dimensions are repeated. As in **Figure 9.3**, three trenches are to be excavated and therefore the dimensions are multiplied by three in the timesing column.

Dotting-on

If two factors of multiplication are to be added, dotting-on can be used. As shown in **Figure 9.4**, the first measurement entry means: (3 + 2) × 10 × 1.30 × 0.60. Although the dotting-on practice is customary, care should be taken when using dotting-on to avoid people mistaking the dot for a decimal point.

Deductions and Anding-on

Sometimes, we may prefer to take an overall measurement and deduct the part which is not required (for instance, deduct the void after the overall volume measurement). In this case, we can enter the dimensions to be deducted in the dimension column under the heading 'Ddt' which means deductions (as in **Figure 9.3**).

All dimensions should be suitably bracketed with the corresponding description. Quite often, several sets of dimensions are corresponded to the same description and the bracket is useful to indicate the grouping (as in **Figure 9.4**). In some situations, more than one item has the same set of dimensions. To avoid repetition, 'anding-on' can be used (**Figure 9.4**).

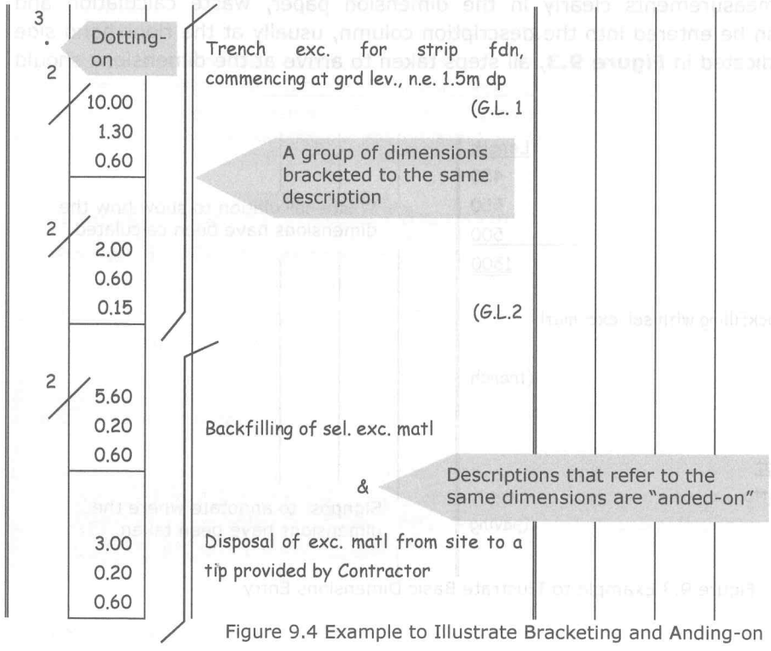

Figure 9.4 Example to Illustrate Bracketing and Anding-on

Writing Descriptions

To save long descriptions in measurement, abbreviations which have been listed separately in the Appendix are often used. Information which is 'deemed to be included' in the item as stated in the standard method of measurement, is not required to be mentioned specifically. For instance, reinforced concrete measurement is deemed to include for vibration and is therefore, not necessary to mention in the description of concrete items.

Use of Schedules

Sometimes, when measuring a number of items of similar characteristics (for instance doors, windows, ironmongeries, reinforcement and finishes), schedule can effectively assist the taking-off process. This is particularly the case when there are a large number of similar

items to be measured. It will be more efficient and tidy to measure the quantities in a schedule rather than on a dimension paper. The format of schedule is highly flexible and expandable depending on the variety and nature of items to be measured. A blank schedule for measuring finishes is shown in **Figure 9.5**.

Location	F1		S1	F2		S2	W1		W2		C1		C2	
	timber flooring		timber skirting	quarry tiles		coved skirting tile	emulsion wall paint		ceramic wall tiles		emulsion ceiling paint		aluminium strip ceiling	
	L	W	L	L	W	L	L	H	L	H	L	W	L	W

Note: L: length; W: width; H: height

Figure 9.5 Example of Schedule (For Taking-off Finishes)

Use of Computers

Takeoff by Commercial Software Packages

Design and contract documents in most projects are now prepared in electronic format, facilitating electronic data transfer and processing. To ride on the trend, many takeoff softwares such as Cost X and Blue Beam, have been developed emphasizing their user-friendliness and efficiency. Most of them are characterised with the following features:

- Allow on-screen takeoff from pdf drawings or images using the mouse.
- Enable user to select and fill colours to lines and areas to differentiate takeoff items.
- Enable audit trail since the quantities measured are saved with electronic drawings.
- Integrate with spreadsheet softwares such as Microsoft® Excel to produce customised templates to sum up the quantities for each work item.

Some softwares also link with digitiser to allow users to obtain dimensions directly from paper drawings using a digitiser tablet. Very often, quantity surveyors in QS consultants and contractors use the measurement softwares to extract quantities quickly for data checking purpose or to obtain floor areas and CFA.

Some softwares work with CAD file format (such as .dwg). However, using editable file format to prepare on-screen measurement may have the risk of modifying the drawing details unintentionally. CAD softwares such as AutoCAD or BIM tools such as Revit can also provide quantities of work. However, without any established standards, the way that the drawing data are input and filtered does not match with the rules in HKSMM. As a result, the use of CAD/BIM softwares to prepare measurements is much discouraged. These design softwares are usually used for estimating approximate quantities in early estimates or to obtain quantities from extremely complex layouts where dimensions cannot be obtained accurately from known equations (such as measuring the quantity of excavation from 3D images).

As mentioned before, most of the QS firms emphasize the use of figured dimensions in taking-off, and therefore, the said benefits of the above softwares may not be highly-valued. Although measurement softwares are convenient for QS to obtain quantities of work, manual taking-off is still indispensable in the current market.

Takeoff by Computerised Spreadsheets

Taking-off is only the first step to prepare measurement for work. After taking-off, the dimensions have to be squared to produce BQ or cost reports (processing of measurements will be further elaborated in **Chapter 20**). Calculating the totals manually from traditional dimension papers is tedious and error-prone. The use of computer spreadsheet has contributed significantly to simplify the work. The format of a schedule in **Figure 9.5** is primarily the same as a computerised spreadsheet. Without any sophisticated softwares required, computerised spreadsheets such as Microsoft® Excel already have strong ability to manipulate data by the use of formulae. By carefully design the spreadsheet template, takeoff schedule can be transformed to an electronic format ready for measurement. Many quantity surveyors like to use templates with preset format and formulae to measure different trades.

Designing a suitable template may take some time but once it is created, all takeoff for the same trade can be done quickly. As shown in **Figure 9.6**, quantities can be automatically extended and totals calculated when appropriate formulae are set. Unintentional changes to the formulae or description can be restricted by protecting the relevant cells.

There are no rules for the design of a takeoff template. However, there are some suggestions for better designs:

- Provide clear details of the project, drawings and takeoff.
- Provide complete description of the items.
- Follow the sequence of length, width and height (or depth).
- Remember to incorporate the factor column for timesing.
- Protect the cells to restrict changes of cell contents by mistake.
- Make good use of the 'link' function to cross-reference the cell contents so that changes made in a cell can be automatically updated in other related cells/spreadsheets.

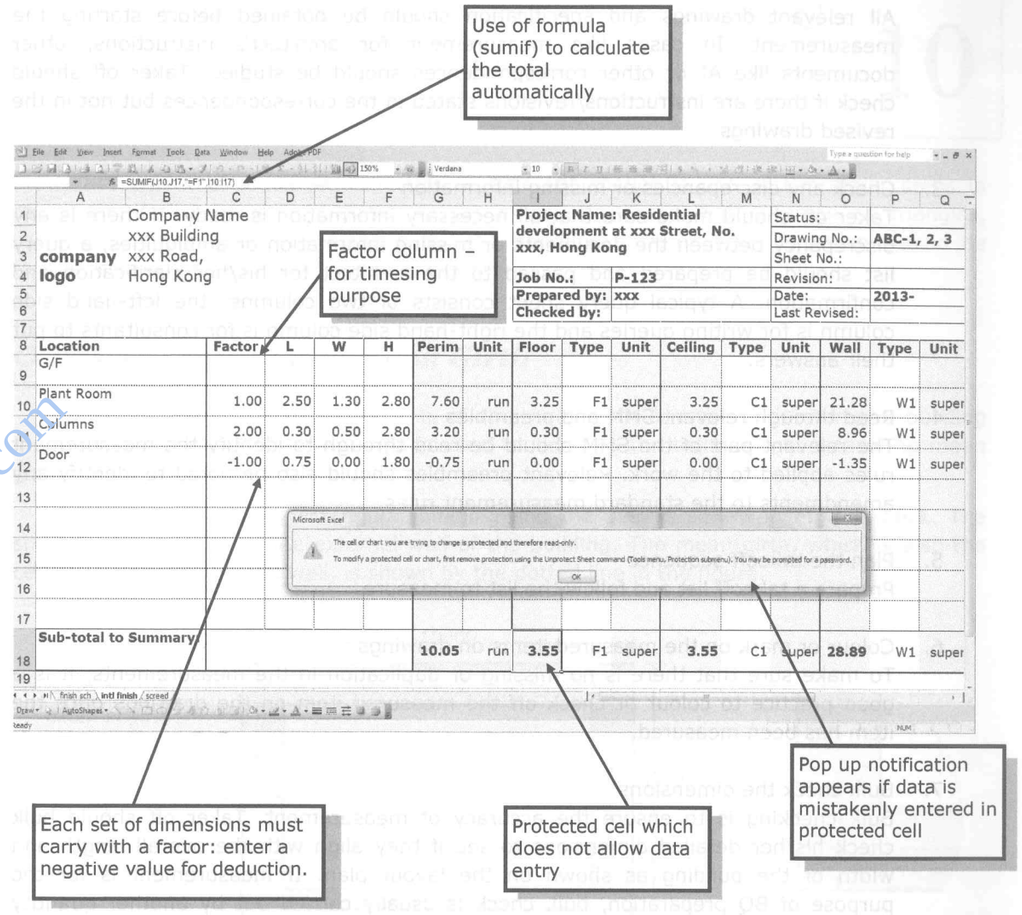

Figure 9.6 Spreadsheet Template for Measuring Finishes

Taking-off Procedures

To maintain clarity and accuracy in the taking-off process, the following procedures are recommended, irrespective of whether computer-aided measurement is used or not:

1. Identify the subject of measurement
   Taking-off can be done for different purposes such as BQ preparation, materials procurement, valuation of Architect's Instruction (AI) or interim payments and final account measurement. The same area or work item may be measured at different stages for different purposes. To avoid confusion, the subject of measurement should be stated clearly at the beginning of measurement.

PART 5
Estimating Unit Rates

21 Pricing in General

Factors of Production

In **Part 4**, we have reviewed the basic method to measure the quantities of work for BQ preparation (or for other contract administration functions such as procurement and valuation of payment). With the quantities of work ready, the contractor has to price each item to arrive at the total cost for work. The pricing process is easier to understand when considering the production process of a contractor as below:

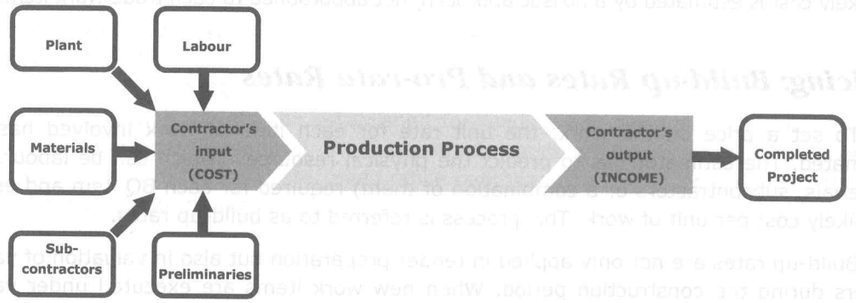

Figure 21.1 Production Process – Changing Input (Resources) into Output (Completed Project)

As shown in **Figure 21.1**, there are five categories of resource inputs provided by a contractor to complete a project:

- Labour
  Direct labour employed by the contractor.
- Plant (or equipment)
  Mechanical plant, equipment and tools owned or hired by the contractor to carry out specific trade work, such as roller or compactor for soil.
- Materials
  Materials procured for the project.
- Subcontractors
  Subcontractors hired for the project.
- Preliminaries
  Also known as project overheads. Site-based facilities and staff provided to the project as a whole. Examples include site management staff, insurance, electricity and water supply for the site and so forth.

Points to note

Besides the five categories of input required for the production process, a contractor also provides head office support to each project. This is regarded as the indirect cost of a project (as such expense is to keep the business running and will be expended even without the project). However, when we estimate the unit rate or price for each BQ item, we will not consider the head office overheads at this point or otherwise, the estimating task will become very complicated. The head office overheads (together with the profit margin) will be considered by management in the tender adjudication process (see **Chapter 6** for further details).

All the above categories contribute to the direct cost of a contractor. When pricing the trade items, the first four categories will be ascertained accordingly. The last category, preliminaries, usually appears as a separate section in the bills of quantities as discussed in **Chapters 6 and 7.** Its likely cost is estimated by a holistic approach, not apportioned to each trade work item.

Pricing: Build-up Rates and Pro-rata Rates

To set a price on the work, the unit rate for each item of work involved has to be estimated. The estimator has to predict the physical resources (which can be labour, plant, materials, subcontractors or a combination of them) required for each BQ item and estimate the likely cost per unit of work. This process is referred to as build-up rates.

Build-up rates are not only applied in tender preparation but also in valuation of variation orders during the construction period. When new work items are executed under variation orders, new rates (usually called star rates) are built up pending further negotiation between the parties. Sometimes, the new work items in a variation order only differ slightly from the BQ items in terms of material quality or output. In that case, a pro-rata rate can be applied (subject to agreement between the parties) instead of building up a new rate. The pro-rata rate is established by making adjustment to existing BQ rates on a pro-rata basis.

Build-up Rates

Many publications, including the Code of Estimating Practice (The Chartered Institute of Building, 2009), give detailed illustration on the calculation of unit rates. Although the principles of estimating are easy to understand, an accurate estimation of unit rates demands a thorough understanding of the construction method and sequence, as well as the capacity of resources to be hired or used. Take excavation as an example. The operation can be executed by using a hand-dug or machine-dug method. If the machine-dug method is chosen, the use of equipment such as large tractors, scrapers or draglines can affect the cost significantly. The type of equipment, model, maintenance condition, skill level of operator, etc. all have an impact on the productivity of work. That is why an estimating team comprising an estimator, a project planner and a project manager is required to prepare a bid. Readers should therefore appreciate the diversity of construction operations and conditions and understand the necessity of making relevant adjustments when tackling estimating problems.

Having established the physical resources required for a work item, a unit rate (for the work item) will be estimated for entering in the final bid. It should consist of head office overheads, profit, and one or a combination of the following components:

- labour
- plant
- materials
- subcontractors

Alternatively, a unit rate can be represented by:

$$U_x = (C_l + C_p + C_m + C_s)(1 + p\%)$$

Where U_x = unit rate of work item x
C_l = labour cost per unit of item x
C_p = plant cost per unit of item x
C_m = material cost per unit of item x
C_s = subcontractor cost per unit of item x
p = markup percentage for head office overheads and profit

As in **Figure 21.2**, cost per unit for any required resource will be calculated to establish the unit rate. The all-in hourly rates for labour and plant will be converted to the labour and plant rates (per unit of BQ item) based on the respective productivities. All-in rate for material (if applicable) will also be established for feeding into the unit rate calculation. If input from subcontractor is required, the subcontractor price will be obtained, with necessary markup for inclusion in the unit rate. Head office overheads and profit are added to the unit rate at a later stage during tender adjudication.

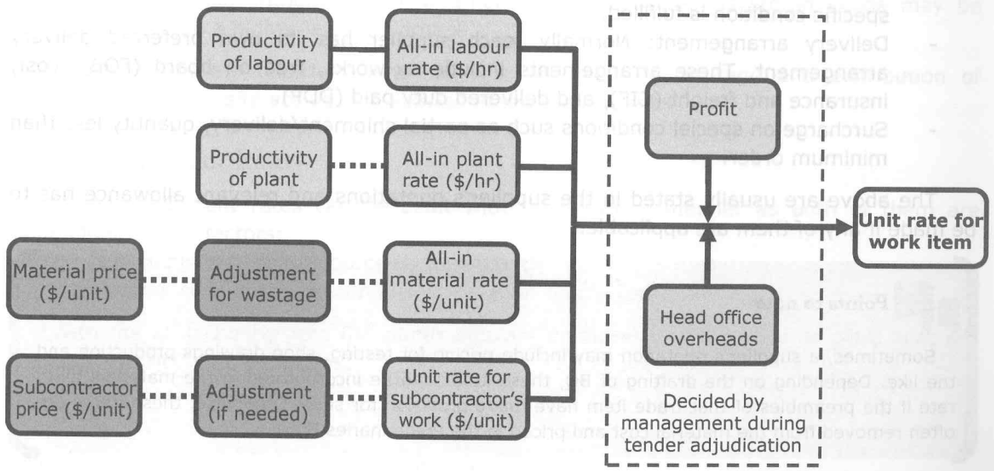

Figure 21.2 Building Up of a Unit Rate in Bills of Quantities

Subcontractor Rate

There are two main types of subcontractors: domestic subcontractors and nominated subcontractors. In terms of the subcontract work nature, it can be a labour and materials subcontract or a labour only subcontract.

The subcontractor rate is comparatively easier to tackle in the unit rate calculation. Nominated subcontractor cost will not be involved in unit rate building as it is included in the BQ separately in the form of a PC sum. The estimator only needs to estimate the markup percentage for profit and attendance to the PC Sum (more details can be referred to **Chapter 7**). For domestic subcontractor costs, normally material and labour components are covered. Assuming exact and complete tender information has been given to the subcontractors, the estimator only needs to choose the most competitive bid (usually the lowest bid) and applies markup for profit and overheads. Although the risk of underestimation lies with the subcontractor, estimator should make sure that the subcontractors have full understanding of the scope of work to avoid future disputes. As shown in **Figure 21.2**, in case if there are any non-priced items or qualifications in a subcontractor's bid, an appropriate cost adjustment should be made before finalising the unit cost for pricing. If the subcontract work covers the labour component only, the relevant material rate and/or plant rate will be added with the subcontractor rate to build up the unit rate.

Material Rate

If material cost has to be estimated for unit rate pricing, the cost information is usually collected from suppliers in the form quotations or from company's records if the material is generally used in most sites. When using the quotations for building up rates, the estimator has to watch out for several aspects:

- Discounts: Discounts can be in the form of bulk purchase discounts, discount for prompt payment or cash payment, which means the cost per unit can be reduced if specific condition is fulfilled.
- Delivery arrangement: Normally, each supplier has its own preferred delivery arrangement. These arrangements include ex-works, free on board (FOB), cost, insurance and freight (CIF), and delivered duty paid (DDP).
- Surcharge on special conditions such as partial shipment/delivery, quantity less than minimum order.

The above are usually stated in the supplier's quotations and relevant allowance has to be made if any of them are applicable.

Points to note

Sometimes, a supplier's quotation may include pricing for testing, shop drawings production and the like. Depending on the drafting of BQ, these items can be incorporated in the materials all-in rate if the preambles of that trade item have made provision for such. Otherwise, these items are often removed from the material cost and priced in the Preliminaries Bill.

Besides the supplier's quoted price, material wastage should also be included in the all-in material rate. The quantities in BQ are measured net in accordance with HKSMM4 and the estimator has to estimate the likely wastage (usually in the form of percentage) based on

his/her experience. For instance, 1 m^3 concrete to wall will require more than 1 m^3 ready-mixed concrete as there will be spillage and wastage. Besides, many trade work items like ceramic tiles require materials to be sold in specific packaging unit (in this case, boxes or pieces), which is different from the unit of measurement in SMM. Therefore, conversion with consideration of wastage has to be made when calculating the all-in rate for materials.

Wastage is often difficult to estimate as it depends on a lot of risk factors including:

- Nature of materials
  Some materials are having a higher risk of damage by their nature. For instance, ceramic tiles, glass and the like are fragile. Cement is moisture-sensitive and must be protected from dampness.
- Design
  Many materials are manufactured in modular sizes to enable easy handling and waste minimisation. However, design may involve irregular sizes or odd sizes which can produce more cutting waste than usual.
- Skill level of operatives
  If the operatives employed are skilful and experienced, waste due to wrong use of material, poor handling, wrong mixing or installation can be much reduced.
- Site management
  Quality of frontline supervision and management on site can also affect the wastage level. Prompt instructions from supervisors to operatives on the proper use and storage of materials can minimise abortive work and production waste. A tidy working environment can also enhance working efficiency and waste control.
- Condition of site store
  The likelihood of theft and vandalism is difficult to predict, but site management can try their best to reduce the loss by proper storage and locking of materials as well as employment of sufficient watchmen. Besides security concern, if the site store is too small or without proper weather protection, materials stored inside may be subject to a higher level of damage.

Other associated material costs such as for unloading, storage and distribution of materials within the site are usually allowed in the Preliminaries.

Labour and Plant Rates

Labour and plant rates can be dealt with in the same manner as both of them are dependent on two factors:

- productivity of the resource (labour/plant)
- hourly 'cost' of the resource (i.e. the all-in hourly rate)

With the all-in hourly rate for labour or plant established, the labour or plant cost per unit can be calculated as follows:

$$C = \frac{R}{p}$$

Where C = labour (or plant) cost per unit of item x
R = all-in hourly rate for labour (or plant) for item x
p = productivity of labour (or plant) (quantity of x completed per hour)

All-in Labour Rate

Labour may be paid on a daily, piecework or monthly basis, depending on the employment contract between the operative and the contractor. In Hong Kong, many large contractors have maintained a certain number of direct labour employed by themselves (instead of employing labour-only subcontractors) to cater for the fluctuating labour market. Although the Hong Kong Construction Industry Employees General Union reviews and suggests wages for different tradesmen on a regular basis, the published wages are not mandatory. Subject to the recruitment policy of individual companies and the market forces, the labour wages vary across different contractors. If workers are employed as full time employees of the contractor, benefits such as leaves, holidays, insurance, mandatory provident fund, overtime payment, bonus, training cost, and other allowances have to be considered when calculating the all-in rate. In other words, all-in rate of labour not only includes the explicit wage received by an operative, but also other fringe benefits. **Table 21.1** illustrates the all-in labour rate calculation in a spreadsheet.

In simple terms, the all-in rate of an operative is:

$$\text{All-in rate of operative} = \frac{\text{Total cost of employing an operative in the wage period}}{\text{Actual hours worked in the wage period}}$$

Table 21.1 Calculation of All-in Rate for Labour

Actual hours worked (wage period = 1 year)		
No. of hours per day*	7.5	
No. of weeks per annum	52	
No. of calendar days per annum	365	365
Less:		
Rest days (once per week)	52	
Statutory holidays	12	
Annual leave (assumed 3 years of service)	8	
	72	-72
Sickness (say 5 days)		-5
Total hours for payment		2,160
Allowance for bad weather in summer		-18
Total productive hours for payment		2,142
Total cost of operative (wage period = 1 year)		
12 month wages	12 × 20,000	240,000
1 month bonus		20,000
		260,000
Central provident fund (5%)	13,000	
Training (safety)**	140	
Training (excl. safety)	700	
Employees' Compensation	Incl. in Prelim.	
	13,840	13,840
Total cost of operative ***		273,840
Operative cost per hour		**127.8**

Note: * Allowance has been made for rest and meal breaks required by the operative. Operatives for different trades/operations and operatives working in different site conditions may require different allowance for rest and meal breaks.

** Assumed zero allowance in Preliminaries Bill.

*** Other possible costs that are not included in the table such as overtime allowance, meal allowance, travel allowance and medical insurance can be allowed where required.

Points to note

When considering the fringe benefits and the like for all-in rate calculation, care should be taken not to duplicate with the preliminaries allowance. For instance, safety training has to be provided to workers. Estimator may allow the training cost in the all-in rate of labour but more often in the Preliminaries Bill (which usually include an item related to safety management). Another example is insurance expenses. Employees' Compensation (EC) is a statutory insurance policy required to be secured by all contractors for their staff and operatives. Normally, this item is also included in the Preliminaries Bill. To avoid double-counting, this item should better be allowed in the Preliminaries Bill.

All-in Plant Rate

There are two main types of plant with different pricing implications: a plant for general use across a wide range of operations and a plant only required for specific operation. Plant and equipment for general use such as tower crane, material hoist, water pump, folk lift and the like are normally priced in the Preliminaries Bill which will be discussed later in **Chapter 23**. Plant and equipment for specific operations such as rollers and backhoes are usually priced with the trade item and is discussed below.

Normally, plant and equipment is either owned by the contractor, purchased for the contract or hired from the plant supplier. In general, when estimating the all-in plant rate, the following items have to be priced:

- Cost of the machine per hour
- Fuel cost
- Sundry consumables such as replacement parts

If the machine is hired, the cost of the machine per hour equals the hiring cost divided by the hiring period. Care has to be taken to check if there are any minimum hire charges. If the machine is purchased for the contract or owned by the contractor, the cost of machine per hour is based on the depreciation cost, financing charge (cost of using the money on plant purchase), maintenance cost and the like. **Table 21.2** illustrates the basic calculation of all-in rate for plant.

Table 21.2 Calculation of All-in Rate for Plant in Spreadsheet

Actual hours operated per year		
Estimated no. of hours operated per year	1,500	
Cost of plant per year		
Expected life of machine	8 years	
Straight line depreciation method is assumed *		
Cost of machine, say	100,000	
Less:		
Scrap value	2,000	
	98,000	
Machine cost (per year)	12,250	
Machine cost (per hour)	8.2	8.2