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Introduction to Construction Management

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Construction Economics
A new approach
Danny Myers
FOURTH EDITION
SECOND EDITION
MANAGEMENT OF CONSTRUCTION PROJECTS
A Constructor's Perspective
John E. Schaufelberger and Len Holm
DUNCAN CARTLIDGE
Quantity Surveyor's Pocket Book
THIRD EDITION
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Estimating and Tendering for Construction Work
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Building Measurement
NEW RULES OF MEASUREMENT
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TOTAL CONSTRUCTION MANAGEMENT
Lean Quality in Construction Project Delivery
John S. Oakland and Marton Marosszeky

Introduction

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CHAPTER 1

01: Construction Economics Chapter: An Introduction to the Basic Concepts

1 An Introduction to the Basic Concepts

This book is written for students from many backgrounds: architecture, surveying, civil engineering, mechanical engineering, structural engineering, construction, project or estate management, property development, conservation and, even, economics. Economics students may find it possible to skip over some of the standard analysis, but should be forewarned that in many ways construction is quite distinct from other sectors of the economy. An important aim of this text is to draw out these distinctions and clarify the unique nature of the industry. In this first chapter we begin to outline the main characteristics of firms involved in construction markets, introducing the complexity of the construction process and diversity of activities. As the chapter develops you will sense that there are a number of possible ways to describe the construction industry. Table 1.1 identifies a range of activities that can be included in a broad definition of the industry. By contrast, Table 1.2 (see page 11) divides the construction process into a number of professional stages and Table 1.3 (see page 19) outlines a simple classification system that narrowly defines the industry as firms that just construct and maintain various types of buildings and infrastructure.

Table 1.1 The construction industry – broadly defined

	The key actors include:
✓	Suppliers of basic materials, e.g. sand, cement, aggregate and bricks
✓	Manufacturers of site equipment, such as cranes and bulldozers
✓	Manufacturers of building components, e.g. windows, doors, pipes and radiators
✓	Site operatives who bring together components and materials
✓	Project managers and surveyors who co-ordinate the overall assembly
✓	Architects and engineers who design new buildings and infrastructure
✓	Facility managers who manage and maintain property
✓	Property developers who initiate new projects
✓	Providers of complementary services, such as demolition, disposal and clean-up

The aim of the text is to demonstrate that underlying the construction process, from conception to demolition, is a lot of useful economics. As suggested in the preface, economics should not be regarded as solely related to the appraisal of costs. The subject matter is far broader, and this text introduces a number of branches of economic theory. These have been selected to provide fresh insights into the performance of construction firms and a greater understanding of the need for a more holistic approach if the industry is to contribute to an efficient and sustainable economy in the future. These economic ideas should inform the work of all professionals concerned with the construction and maintenance of buildings and infrastructure – and, in particular, the way that they think.

The next section explains some of the key concepts used by economists. Further clarification is provided in the glossary at the back of the book, where all the economic terms highlighted in the text and other concepts and ideas relevant to construction economics are defined.

INTRODUCING CONSTRUCTION ECONOMICS

Construction economics – like pure economics, its mainstream equivalent – is concerned with the allocation of scarce resources. This is far more complex than it at first appears. Many of the world's resources (factors of production such as land, labour, capital and enterprise) are finite, yet people have infinite wants. We are, therefore, faced with a two-pronged problem: at any point in time there is a fixed stock of resources, set against many wants. This problem is formally referred to as **scarcity**. In an attempt to reconcile this problem, economists argue that people must make careful choices – choices about what is made, how it is made and for whom it is made; or in terms of construction, choices about what investments are made, how these are constructed and on whose behalf. Indeed, at its very simplest level, **economics** is 'the science of choice'.

When a choice is made, therefore, some other thing that is also desired has to be forgone. In other words, in a world of scarcity, for every want that is satisfied, some other want, or wants, remain unsatisfied. Choosing one thing inevitably requires giving up something else. An opportunity has been missed or forgone. To highlight this dilemma, economists refer to the concept of **opportunity cost**. One definition of opportunity cost is:

the value of the alternative forgone by choosing a particular activity.

Once you have grasped this basic economic concept, you will begin to understand how economists think – how they think about children allocating their time between different games; governments determining what their budgets will be spent on; and construction firms deciding which projects to proceed with. In short, opportunity costs enable relative values to be placed on all employed resources.

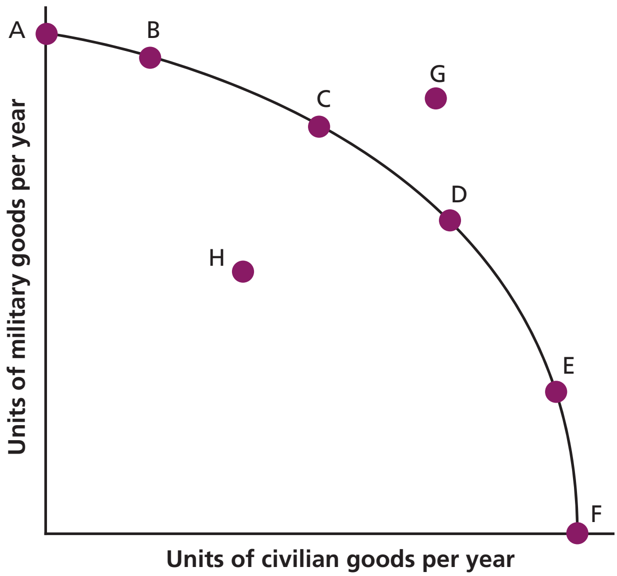
This way of thinking emphasises that whenever an economic decision is made there is a **trade-off** between the use of one resource for one or more alternative uses. From an economic viewpoint the value of a trade-off is the 'real cost' – or opportunity cost – of the decision. This can be demonstrated by examining the opportunity cost of reading this book. Let us assume that you have a maximum of four hours each week to spend studying just two topics – construction economics and construction technology. The more you study construction economics, the higher will be your expected grade; the more you study construction technology, the higher will be your expected grade in that subject. There is a trade-off, between spending one more hour reading this book and spending that hour studying technology. In this example there is fixed trade-off ratio. In practice, however, some people are better suited to some subjects than others and the same thing can be applied to resources. As a general rule, therefore, resources are rarely equally adaptable to alternative projects.

In construction, or any other economic sector, it is rare to experience a constant opportunity-cost ratio, in which each unit of production can be directly adapted to an alternative use. It is far more usual in business trade-off decisions to see each additional unit of production cost more in forgone alternatives than the previously produced unit. This rule is formally referred to as the **law of increasing opportunity costs**. This can be illustrated with the 'guns or butter' argument – this states that, at any point in time, a nation can have either more military goods (guns) or civilian goods (butter) – but not in equal proportions. For example, consider the hypothetical position in which all resources in the first instance are devoted to making civilian goods, and the production of military goods is zero. If we begin production of military goods, at first production will increase relatively quickly, as we might find some engineers who could easily produce military goods and their productivity might be roughly the same in either sector. Eventually, however, as we run out of talent, it may become necessary to transfer manual agricultural labour used to harvesting potatoes to produce military goods – and their talents will be relatively ill-suited to these new tasks. We may find it necessary to use fifty manual labourers to obtain the same increment in military goods output that we achieved when we hired one sophisticated engineer for the first units of military goods. Thus the opportunity cost of an additional unit of military goods will be higher when we use resources that are inappropriate to the task. By using poorly suited resources, the cost increases as we attempt to produce more and more military goods and fewer and fewer civilian goods.

The law of increasing opportunity costs is easier to explain using a **production possibility curve**. Using these curves, it is possible to show the maximum amount of output that can be produced from a fixed amount of resources. In Figure 1.1 (see page 4) we show a hypothetical trade-off between units of military goods and civilian goods produced per year. If no civilian goods are produced, all resources would be used in the production of military goods and, at the other extreme, if no military goods are produced, all resources would be used to produce civilian goods. Points A and F in Figure 1.1 represent these two extreme positions. Points B, C, D and E represent various other combinations that are possible. If these points are connected with a smooth curve, society's production possibilities curve is obtained, and it demonstrates the trade-off between the production of military and civilian goods. These trade-offs occur on the production possibility curve. The curve is bowed outwards to reflect the law of increasing opportunity cost. If the trade-off is equal, unit for unit, the curve would not bow out, it would simply be a straight line. Other interesting observations arising from the production possibility curve are shown by points G and H. Point G lies outside the production possibility curve and is unattainable at the present point in time, but it does represent a target for the future. Point H, on the other hand, lies inside the production possibility curve and is, therefore, achievable, but it represents an inefficient use of available resources.

Figure 1.1 The trade-off between military goods and civilian goods

Points A to F represent the various combinations of military and civilian goods that can be achieved. Connecting the points with a smooth line creates the production possibility curve. Point G lies outside the production possibility curve and is unattainable at the present time; point H represents an inefficient use of resources at the present time.



There are a number of assumptions underlying the production possibility curve. The first relates to the fact that we are referring to the output possible on a yearly basis. In other words, we have specified a time period during which production takes place. Second, we are assuming that resources are fixed throughout this time period. To understand fully what is meant by a fixed amount of resources, consider the two lists that follow, showing (a) factors that influence labour hours available for work and (b) factors that influence productivity, or the output per unit of input.

FACTORS INFLUENCING LABOUR HOURS AVAILABLE FOR WORK

The number of labour hours available for work depends on the nature of human resources in society. This is determined by three factors:

- the number of economically active people that make up the labour force – this depends on the size of the population and its age structure, as children and retired persons will be economically inactive
- the percentage of the labour force who then choose to work
- prevailing customs and traditions (such as typical length of the working week, number of bank holidays, etc.).

FACTORS INFLUENCING PRODUCTIVITY

There are a number of factors influencing the productivity of an economy or sector of the economy:

- the quantity and quality of natural and man-made resources
- the quality and extent of the education and training of the labour force
- the levels of expectation, motivation and wellbeing
- the commitment to research and development.

The third and final assumption that is made when we draw the production possibility curve is that efficient use is being made of all available resources. In other words, society cannot for the moment be more productive with the present quantity and quality of its resources. (The concept of efficiency is examined more closely in Chapters 2, 5, 6, 7 and 8.)

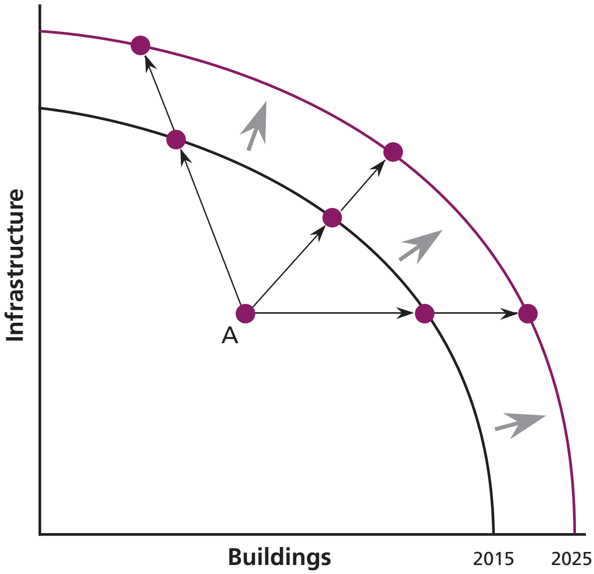
According to several government reports (Egan 1998; NAO 2001, 2005 and 2007; IPA 2016), given the existing level of resources in construction it should be possible to increase productivity by at least 10 per cent. In other words, a production possibility curve representing all construction activities could be pushed out to the right, as shown in Figure 1.2 (see page 6). Several common sets of problem are identified as the root cause of this inefficiency. First, the industry demonstrates a poor safety record and an inability to recruit good staff. Second, there appears to be no real culture of learning from previous projects, and no organised career structure to develop supervisory and management grades. Third, concern is expressed about the poor level of investment into research and development that restricts the industry's ability to innovate and learn from best practice. The fourth, and possibly most worrying, problem is the fact that technology (in the sense of innovation, information modelling and off-site assembly) is not used widely enough across the construction sector.

Another plausible scenario suggested by the production possibility curve approach is that the construction industry may at present be working within the boundary of its production curve (say, point A in Figure 1.2). In which case, an increase in output could be simply achieved by greater efficiency. Supply constraints need to be reduced, the problems identified by the government reports resolved, and the factors generally acknowledged to increase productivity (listed above) must be addressed to achieve the full potential of the industry. Both these scenarios are shown in Figure 1.2 and they support the idea that the level of productivity in the construction industry needs to improve.

In very general terms, therefore, the study of economics is concerned with making efficient use of limited resources to maximise output and satisfy the greatest possible number of wants. In short, the basis of the subject rotates around the concepts of choice, scarcity and opportunity cost.

Figure 1.2 Increasing output and the production possibility curve

In this diagram we show two scenarios: (a) improved productivity shifts the entire production possibility curve outwards over time; (b) output can be achieved more efficiently by moving to a position of full potential on the actual production possibility curve.



In modern society, economics is involved in all activities leading to the production of goods and services. Consequently a range of specialisms have evolved out of mainstream economics, such as transport economics, health economics, business economics, financial economics, agricultural economics, labour economics, international economics and, even, ecological economics. Hence it is not particularly surprising that many students in the twenty-first century are expected to read something called construction economics as part of their degree course. What is surprising, however, is that other vocationally oriented degrees do not have a similarly developed economics specialism. For example, students reading for degrees in catering, sports and leisure, publishing, retailing or computing do not benefit from a range of specialised literature in economics.

The reasons usually stated for construction warranting its own specialised economics is accounted for by the sheer size of the industry, its profound contribution to a nation's standard of living and its products' unique characteristics. Put very simply, the industry has five distinct qualities.

- The physical nature of the product is large, heavy and expensive.
- The construction industry is dominated by a large number of relatively small firms, spread over a vast geographical area.
- Demand for activity within the industry is directly determined by the general state of the economy as a whole.

- The method of price determination is unusually complex due to the tendering process used at various stages.
- Most projects can be considered as a 'one-off', as there is usually some defining quality that make them in some ways unique.

These qualities alone have justified a number of dedicated academic publications. The first edition of these was Patricia Hillebrandt's *Economic Theory and the Construction Industry*, published in 1974 (with new editions in 1985 and 2000). Subsequently several other titles followed, in particular the two-part text co-authored by Ive and Gruneberg (2000) and the edited volume by Gerard de Valence (2011). In 1982, *Construction Management and Economics*, a specialist refereed journal, began to report on research contributing to the new subject specialism. The journal continues to be published monthly and several papers have been selected as exemplary readings to consolidate the three sections of this textbook. Another relevant academic journal is *Building Research and Information*. This has an interdisciplinary focus, with linkages made between the built, natural, social and economic environments. Consequently many of the papers in this journal contribute to our understanding of how buildings and infrastructure impact on ecology, resources, climate change and sustainable development; appropriately several examples are cited as references.

Alongside these academic developments, there has also been a steady stream of government reports investigating the problems of the construction industry (for example, see Latham 1994; Egan 1998; National Audit Office 2001; Fairclough 2002; HM Government 2008; BIS 2013). These reports have highlighted the inefficiency caused by the sheer scale and complexity of the construction industry. A recurring recommendation is the need for the construction process to be viewed in a holistic way by a multidisciplinary team. This reflects the fact that construction draws knowledge from many areas, and an important but undervalued area is economics. Indeed, it is commonly observed that far too many projects run over budget and are delivered late, with a general disrespect for the client. Clearly it should not be acceptable for construction projects to fail cost-wise, time-wise or client-wise. A classic study by Professor Flyvbjerg (2003: 16–26) of 258 major public transport infrastructure projects constructed across Europe, USA, Japan and developing countries between 1927 and 1998 suggests that on average costs overrun by approximately 30 per cent, deadlines are missed by as much as ten years and the expected level of demand fails to meet targets by around 40 per cent. Worryingly, the cost, time and quality dimensions continue to be problematic right up to the current day.

Each of the construction economics texts that have been published to date conveys a slightly different emphasis. For example, Hillebrandt (1974: 3) defines construction economics as the application of economics to the study of the construction firm, the construction process and the construction industry. Whereas the preference of Ive and Gruneberg (2000: xxiii) is for a slightly less orthodox approach, adapting traditional economic models to capture 'local' [construction] circumstances even if that means losing the ability to generalise about the economy at large. As a result, there is no coherent conceptual consensus about what constitutes the precise nature of construction economics. As George Ofori (1994: 304) bluntly concluded in his seminal review of the subject: 'Construction economics cannot be regarded as a bona-fide academic discipline. It lacks a clear indication of its main concerns and content.' A situation that reviews by de Valence (2011: 1) and Chang (2015: 102) suggest is still problematic today.

The purpose of this text is to address this lack of consensus and make the case for a coherent economic vocabulary. The crux of the argument for this new approach is the increasing importance of strategies aimed at achieving **sustainable construction**. In other words, there is clear recognition that the construction industry makes a significant contribution to a country's economic, social and environmental wellbeing.

INTRODUCING SUSTAINABLE CONSTRUCTION

The UK government published its first strategy for sustainable construction, *Building a Better Quality of Life*, in April 2000. This document aimed to provide a catalyst for change in the approach to construction processes. Subsequently it has been revised and extended, and the *Strategy for Sustainable Construction* published in June 2008 states the current UK position. Similar agendas have emerged in Europe, North America and some developing countries (see Chapter 15 for further discussion). Sustainable construction can be described in simple terms as comprising:

- efficient use of resources
- effective protection of the environment
- economic growth
- social progress that meets the needs of everyone.

Each of these strands is underpinned by economic concepts, which provide the rationale for this book.

Part A   Effective use of resources

This deals with microeconomics, and outlines the various ways of efficiently allocating resources between competing ends. In this section the prime focus is concerned with the determinants of demand and supply for infrastructure, housing, industrial buildings, commercial property, and repair and maintenance.

Part B   Protection and enhancement of the environment

This section considers failures of the market system, drawing upon various environmental economic concepts and tools to encourage future members of the construction industry to evaluate projects by more than just financial criteria.

Part C   Economic growth that meets the needs of everyone

This section incorporates coverage of the broader macroeconomic scene. It outlines the various government objectives that need to be achieved alongside sustainable construction. It highlights the difficulty of managing an economy and the need for professionals working in the construction industry to acquire an economic vocabulary.

Key Points 1.1

- The construction industry can be described in a number of ways – for example, review the broad range of activities listed in Table 1.1 (page 1).
- Construction has five distinguishing characteristics: (a) each project is regarded as a unique one-off product; (b) the industry is dominated by a large number of relatively small firms; (c) the general state of the economy influences demand; (d) prices are determined by tendering; and (e) projects are characterised by their 'lumpiness' in terms of their scale and expense.
- The basis of economics rotates around the concepts of choice, scarcity and opportunity cost. Hence, economics is the study of how we make choices.
- Any use of a resource involves an opportunity cost because an alternative use is sacrificed.
- The graphic representation of the trade-offs that must be made can be displayed in a production possibility curve.
- Sustainable construction is a strategy aimed to encourage the industry to (a) use resources more efficiently, (b) limit the environmental impact of its activities, and (c) produce buildings and infrastructure that benefit everyone.

INTRODUCING ECONOMIC VOCABULARY

The discipline of economics employs its own particular methodology and language. Consequently for the complete beginner it is necessary at the outset to clarify a few meanings.

Resources

Resources can be defined as the inputs used in the production of those things that we desire. Economists tend to refer to these resources as **factors of production** to highlight the fact that only by combining various factors can goods and services be produced. The factors of production are usually categorised into three general groups; namely, land, capital and labour – and sometimes the entrepreneur is specifically identified as a fourth entity. The point is that quantities of each factor are needed to make any good or service. To construct buildings or infrastructure, for example, labour is required to develop a plot of land, and plant and equipment, which may be hired or bought, is required to facilitate the process. To put it another way, land and labour are always combined with manufactured resources in order to produce the things that we desire. The manufactured resources are called **capital**, or more precisely physical capital, and consist of machines and tools.

The contribution of labour to the production process can be increased. Whenever potential labourers undergo training and learn new skills, their contribution to productive output will increase. When there is this improvement in human resources, we say that **human capital** has been improved. A relevant example is the effect that good trained management can have on the efficiency of a whole project. Indeed, according to Hillebrandt (2000: 104) management expertise is one of the scarcest resources of the construction industry throughout the world.

With each new construction project there is a choice to be made about the materials that will be used and the proportion of labour, plant and equipment required. In most instances, construction tends to be dominated by input costs relating to materials, components and labour. The importance, however, of the entrepreneur should not be overlooked, as without a dedicated resource managing and co-ordinating the other factors of production, virtually no business organisation could operate. In other words, an entrepreneur is sometimes regarded as a special type of human resource associated with the ability to make business decisions, take risks and foster innovation. In a small construction firm the manager-proprietor would be the entrepreneur; in a joint stock company the shareholders would take on that responsibility. (For further discussion about the role of the entrepreneur see Chapter 7.)

Each factor of production can be regarded as receiving a specific form of income. A landlord providing the use of land receives rent. Owners of physical (and monetary) capital are rewarded, directly or indirectly, and earn some form of interest payment to cover credit arrangements. Workers receive wages (salaries), and entrepreneurs gain profit. The distribution of these factor rewards (factor incomes) formed an important point of focus for the classical economists. Ricardo's work (1817) suggested that the rewards paid to the agricultural landlord determined all other payments and this inevitably led to a tension between the interests of the landlord and those of the consumer and manufacturer. Equally Marx (1844) was concerned about the inequalities that were rewarded to labour as he claimed that they were exploited by the owners of capital and land, as he observed: a worker cannot supplement his income with ground rent or interest on capital. For general introductory purposes, however, the significance of dividing income payments into four sets of factor rewards will become evident when we consider the measurement of **national income** in Chapter 13.

Market Systems

The concept of the **market** is rather abstract in the sense that it encompasses the exchange arrangements of both buyers and sellers for a particular good or service. Consequently, we can envisage many markets for specific building materials, housing, professional services, etc. The recurrent feature of any market is the exchange of information about factors such as price, quality and quantity. The difference, however, between one market and the next is the degree of formality in which it functions. The stock market in any Western economy, for example, provides instant information worldwide about the prices and quantities of shares being bought and sold during the current trading period. By contrast, construction markets are less structured and more informal, and they are usually determined by geographical location.

The construction industry is concerned with producing and maintaining a wide variety of durable buildings and structures, and as a consequence, there are many construction markets. As Drew and Skitmore (1997: 470) concluded in their analysis of the competitive markets for construction: 'The construction industry is highly fragmented, with the dominant firm being the small contractor.' The type of construction – particularly in terms of its size and complexity, its geographical location, and the nature of the client – will define the market in each case.

Let us consider in a little more detail what traditionally happens when a new project begins. Usually a contractor undertakes to organise, move and assemble the various inputs, and as such provides a service – a service of preparing the site before work commences, and assembling and managing the process thereafter. Subsequently, various subcontractors add their services – such as plumbing, painting, plastering, glazing, roofing, or whatever the specific job requires. As a result the typical project process can easily become a series of 'separate' operations undertaken by various parties as set out in Table 1.2.

Table 1.2 Parties traditionally supplying a construction project

Parties Involved in Supply	Responsibilities
Architects and Designers	Provide specialist advice concerning structural, electrical, mechanical and landscape details. Identify key specifications.
Project Manager	Manages project in detail. Liaises between the client and the construction team.
Cost Consultant	Prepares bills of quantities, cost plans, etc.
Main Contractor	Manages work on site.
Subcontractors	Supply specialist skills.
Suppliers	Provide building materials and components.

The level of competition for all this work depends upon the complexity of the construction (which to some extent will be reflected in the cost per square metre). The idea of complexity is particularly important in construction markets as it determines the number of businesses interested in competing for the work. In most cases, firms will not bid for work beyond their local district as the costs of transporting materials, plant and labour is relatively expensive. Travelling is unnecessary when the same type of work is available in the firm's own neighbourhood or catchment area. If, however, the construction project is very complex and/or very large, the costs per square metre are likely to increase and the relative costs of transport in relation to the total costs will decrease. The market catchment area for this highly specialised work will broaden. The following formula may make this clearer:

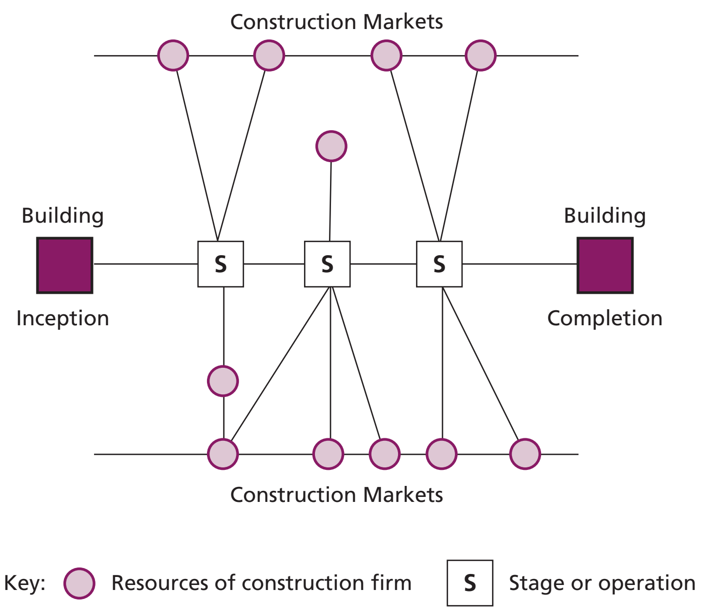
complexity + large size = competing firms from a wider geographical area

The converse of this rule explains why construction markets are so often dominated by small local firms subcontracting for work in or near their home towns. Indeed, it is only the biggest firms that can manage to compete on a national or international basis. Markets in the construction industry should, therefore, be defined as comprising those firms that are willing and able to compete for a contract in a specific geographical area. In other words, the total number of firms interested in work of a particular type can be referred to as comprising the local market.

In construction the services of one firm are often easy to substitute by contracting another firm with the same type of expertise. To the extent that prices in construction markets often find their own level, the theory behind this behaviour is examined in Chapters 3 to 8. For the moment, it will suffice to understand that the market for construction refers to a diverse and broad range of activities made up of many markets. To emphasise this point, consider the flow diagram set out in Figure 1.3.

Figure 1.3 A complex set of markets for one building project

In the flow diagram a building project is represented as a sequence of stages. Each stage is completed by a number of firms supplying their services.



THE EXAMPLE OF ONE BUILDING PROJECT

In Figure 1.3 we represent a set of markets that could be involved in the construction of a small commercial building. The construction process from inception to completion is shown to comprise a number of separate markets. The completion of each operation, or stage, is the concern of several construction firms competing to supply materials, components, labour, etc. Figure 1.3 highlights the number of fragmented activities involved in completing just one small building. Each independent firm, in effect, is more concerned with its specific contribution than the project as a whole. In many ways, the next project in a firm's market sector may well be competing for its attention while it is still finishing the present project.

We discuss the characteristics of fragmentation and the resulting poor flow of information in Chapters 6 and 9 respectively. We also identify these issues as a problem to resolve in Chapter 15, where we analyse loosely connected activities as a barrier to achieving sustainable construction.

METHODOLOGY

This introductory chapter aims to explain what construction economics is all about. Apart from identifying the central concepts, we need to consider the methods employed by economists, as the approach taken to a discipline helps to specify the nature of the subject. In general terms, economics is a social science and it attempts to make use of the same kinds of methods as other sciences, such as biology, physics and chemistry. Like these other sciences, economics uses models or theories.

Economic models are simplified representations of the real world that we use to understand, explain and predict economic phenomena.

These models may take on various forms such as verbal statements, numerical tables and graphs – and, at the more advanced level, mathematical equations. For the most part, the models presented in this text consist of verbal statements and graphs.

A particular challenge faced by students of construction economics is that many of the processes in the industry do not lend themselves easily to generalisations and models. First, the construction industry involves a large variety of interests and parties that makes the process rather complex and plagued with unwarranted assumptions about what is possible. Second, economic analysis is only one of the disciplines contributing to the process as a whole. And, third, there is a distinct lack of vision about the role of construction in society and how it could better serve its clients. As Professor Duccio Turin poetically observed:

> [T]he building process is a world of 'as if'. It is 'as if' the client knew what he wanted when he commissioned the building from a designer; it is 'as if' the designer was in a position to advise the client on the best value-for-money he could obtain in the market; it is 'as if' contractual procedures were devised to ensure that the client would get the best possible deal from the profession and from the market place; it is 'as if' the manufacturer of building materials and components knew in advance what is expected of him and geared his production to such expectation; it is 'as if' the contractor

> knew how his resources were used, was in a position to control them, and was able to use this experience on his next job.
>
> (Turin 1975: xi)

Although this summary of the industry was expressed over 40 years ago, as the text unfolds you will realise the striking similarities between then and now. It is this complex, fragmented and conservative nature that gives the subject matter of construction economics its appeal – as economists seek to unravel these seemingly unconnected threads of random behaviour. Economic models seek to identify the interrelationship between the key variables and simplify what is happening in the sector. So although some economic models may at first appear abstract, they do have practical applications. The important point we are trying to clarify is that an economic model cannot be criticised as unrealistic merely because it does not represent every last detail of the real world that it is seeking to analyse. If the model elucidates the central issues being studied, then it is worthwhile. For example, students may be expected to commence their course by completing an assignment based on a theoretical economic model of competition in the marketplace. This provides a simple introduction to the economic framework and the opportunity to demonstrate how construction deviates from or reflects this reference point. In short, the model provides a starting point – it enables us to proceed.

Following the recommendations of several government reports (Fairclough 2002: 34; BIS 2013: 18; IPA 2016: 5–11) the construction industry should favour models that prioritise strategies aimed to improve sustainability, competitiveness, productivity, value for money and use of technology. In Part A, we present models of market behaviour that encourage a far better grasp of the meaning and purpose of efficiency, competition and profit. In Part C, we introduce a model of aggregation to study the operation of the whole economy that brings a fresh dimension to productivity by reviewing the total output of construction and reflecting on its contribution to the total output of an economy. In Part B, we bring the environment into the traditional model as a key variable for construction and the economy to consider. When the whole book has been studied, we identify a significant number of concepts that underpin an understanding of sustainability.

This leaves the precise nature and details of the models to emerge as the book unfolds and their purpose should become self-evident. Once we have determined that a model does predict real-world phenomena, then the scientific approach requires that we consider evidence to test the usefulness of a model. This is why economics is referred to as an empirical science – empirical meaning that real data is gathered to confirm that our assumptions are right.

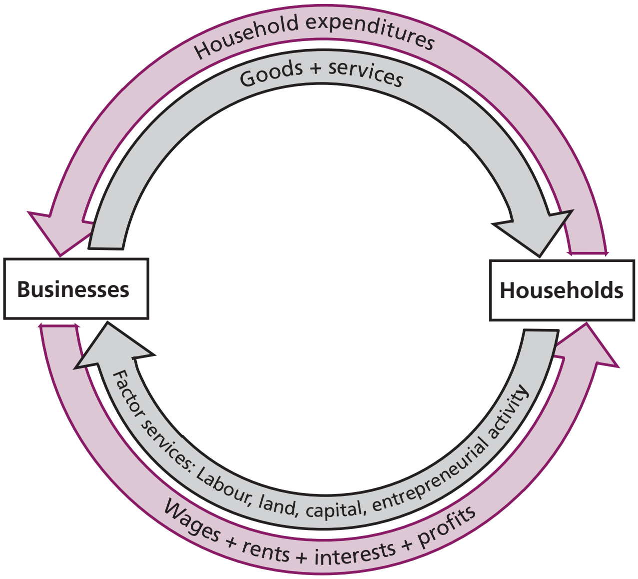
An Example of an Economic Model

Before closing this section on models, we review one specific example to analyse and explain how income flows around an economy. Economists begin their explanation by ignoring the government sector, the financial sector and the overseas sector – that is, the **circular flow model** represents a simplified, scaled-down economy in which relationships are assumed to exist only between households and businesses.

To make the model effective, it is assumed that households sell factors of production to businesses and in return receive income in the form of wages, interest, rents and profits. This is shown in the bottom loop in Figure 1.4. The businesses sell finished goods and services to households in exchange for household expenditure. This is shown in the top loop in Figure 1.4. These assumptions are reasonably realistic. Businesses will only make what they can sell. Production will necessitate buying in land, labour, capital and enterprise, and the monies paid for these factors of production will generate respective income payments.

Figure 1.4 The circular flow model: a two sector economy

In this simplified model there are only households and businesses. Goods and services flow in one direction in return for money. This exchange can be thought of as a circular flow.



Already, without building in any of the complications of the real world, we begin to sense several insights or starting points. Clearly there is a close relationship between the income of a nation, its output and the level of expenditure, and we shall investigate this further in Chapter 13. Also, we can see how money enables households to ‘vote’ for the goods and services desired, and this will be developed further in Chapters 2 to 5. The perceptive reader will note that the model fails to include any reference to the environment and, as we explained above, this represents the contents of Part B. The model also explicitly excludes reference to the role of governments, overseas economies and financial institutions and these aspects are included in Part C. Again we can see how the model enables us to progress into the subject.

THE ROLE OF GOVERNMENTS AND FINANCIAL INSTITUTIONS

The importance of the construction industry to the overall wellbeing of the economy means that most governments are concerned that it becomes a highly efficient sector. As a consequence, the government's role as a client, regulator, policy-maker and a sponsor of change is raised at several points throughout the text. Equally the role of the financial sector makes a significant contribution to the effective management of the economy and the funding of construction projects. As indicated in the preface, any self-respecting text on economics must make some reference to the financial crisis sparked by the 2007 credit crunch, especially as it continues to trouble economies around the world. At the start of 2016 the UK construction sector had still not got back to is pre-recession level of output (see trend in Figure 2.4, page 38). These themes are discussed throughout Part C of the text.

ENVIRONMENTAL ECONOMICS

Effective protection of the environment forms a key part of any text concerning sustainability. **Environmental economics** is important for several reasons: first, because the environment has an intrinsic value that must not be overlooked; second, because the sustainability agenda extends the time horizon of any analysis to assure equity between generations; and, third, demands must be viewed on a whole-life basis and this is particularly important in the context of products that last for more than 30 years. Any model of analysis that seeks to identify general principles of sustainable development must include, at the very least, these three dimensions. We explore these issues and related concepts in Part B and bring them all together in Chapter 15 where we review the possibility of achieving the government's sustainable construction agenda.

Microeconomics and Macroeconomics

Economics is typically divided into two types of analysis: **microeconomics** and **macroeconomics**. Consider the definitions of the two terms.

> **Microeconomics is the study of individual decision-making by both individuals and firms.**
>
> **Macroeconomics is the study of economy-wide phenomena resulting from group decision-making in entire markets. As such, it deals with the economy as a whole.**

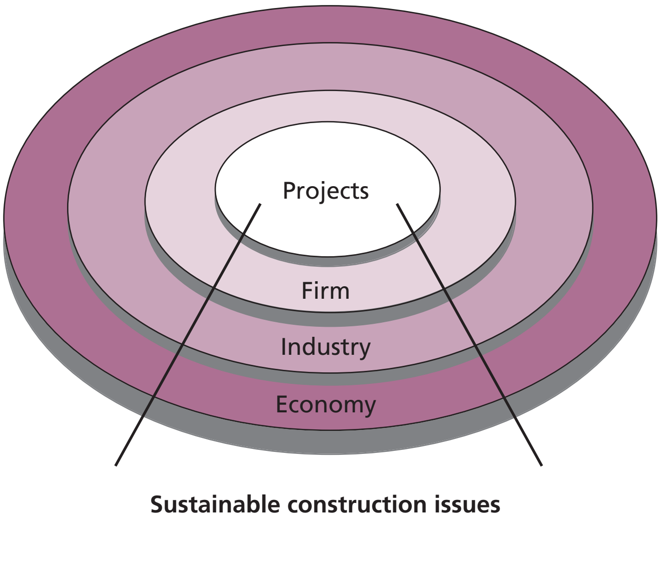
One way to understand the distinction between these two approaches is to consider some generalised examples. Microeconomics is concerned with determining how prices emerge and change, and how firms respond. It involves the examination of the effects of new taxes, the determination of a firm's profit-maximising level of production, and so on. It concerns the economic behaviour of individuals – such as clients, contractors, surveyors and engineers – in various markets. We study this type of analysis in Part A. In contrast, questions relating to the rate of inflation, the amount of national unemployment, and the growth rate of the whole economy fall in the realm of macroeconomic analysis. In other words, macroeconomics deals with aggregates or totals, and this forms the basis of the chapters in Part C.

You should be aware, however, of the blending together of microeconomics and macroeconomics in modern economic theory. Modern economists are increasingly using microeconomic analysis – the study of decision-making by individuals and by firms – as the basis for macroeconomic analysis. They do this because, even though aggregates are being examined in macroeconomic analysis, those aggregates are made up of the actions of individuals and firms. The study of any specific industry involves both microeconomic and macroeconomic approaches; particularly when the industry is multi-product, and has national and international significance.

Throughout this text the interaction between the construction sector and the other sectors of the economy is a constant reference point. In some texts a sectoral approach is referred to as **mesoeconomics**, derived from the Greek word *mesos* meaning intermediate. This is done to make it clear that the study of any specific sector or industry inevitably falls between the conventional microeconomic and macroeconomic categories. (These two terms are also of Greek derivation: *macros* meaning large and *micros* small.)

Consequently, to gain a comprehensive understanding of construction activity, it is advisable to embrace three perspectives – a broad macro overview of the economy, a specific sectoral study of the industry, and a detailed microanalysis of the individual markets in which construction firms operate. Studying the complete text, therefore, should provide a greater understanding of winning and completing projects in an efficient and sustainable manner. Figure 1.5 summarises how these three elements contribute to a fuller understanding of a project. In many ways, it models the overall approach of the text.

Figure 1.5 A model for construction economics: a new approach



Key Points 1.2

- We need to use scarce resources, such as land, labour, capital and entrepreneurship, to produce any economic good or service.
- The exchange of information between buyers and sellers about factors such as price, quality and quantity happens in a market. Construction is made up of a diverse range of markets, as the industry comprises a large number of relatively small firms.
- Every economic model, or theory, is based on a set of assumptions. How realistic these assumptions are is not as important as how effective they make the model or theory.
- Microeconomics involves the study of individual decision-making. Macroeconomics involves the study of aggregates. Mesoeconomics combines the territory shared by microeconomics and macroeconomics to study a specific sector such as construction.

INTRODUCING CONSTRUCTION INDUSTRY ACTIVITY

The system of industrial classification used for statistical and government purposes favours a narrow definition of the construction industry that includes only firms that are involved with building and civil engineering. This categorisation is derived from the United Nations International Standard of Industrial Classification (ISIC). There are also American and European equivalents: the North American Industry Classification System (NAICS) and the General Industrial Classification of Economic Activities – otherwise known as NACE. In other words, firms generally recognised as officially comprising the construction sector tend to embrace a range of 'on-site' activities including those relating to infrastructure, new construction, repair, maintenance and (eventually) demolition. Table 1.3 shows the type of work that is classified into these various sectors and Table 1.4 gives some indication of the monetary value of these different activities in Great Britain.

As Table 1.4 (on page 20) shows, repair and maintenance are of major importance and comprise nearly 40 per cent of the total annual activity – this includes all public and private sector work carried out on houses, infrastructure and commercial buildings. It is also evident that government departments and their agencies are significant clients of the construction industry. As both Tables 1.3 and 1.4 suggest, official statistics often draw a distinction between public and private sector activity. The public sector includes everything that is owned and/or funded by national or local governments such as roads, schools, the National Health Service, and local council leisure centres. In fact, a close examination of output tables reveals that approximately 30 per cent of construction industry turnover relates to public sector clients. Obviously this includes a vast range of contracts, varying in size from £10,000 for a small flood defence scheme to £14.8 billion for the infrastructure required for London's newest railway line, Crossrail.

Table 1.3 The construction industry – narrowly defined

Areas of Construction	Examples of type of work
Infrastructure	Water and sewerage Energy Gas and electricity Roads Airports, harbours, railways
Housing	Public sector (e.g. housing associations) Private sector (e.g. new estates)
Public non-residential	Schools, colleges, universities Health facilities Sports and leisure facilities Police and fire stations
Private industrial	Factories Warehouses Oil refineries
Private commercial	PFI (and similar public private partnerships) Schools/hospitals (where privately funded) Restaurants, hotels, bars Retail (outlets and shops) Offices
Repair and maintenance	Extensions and conversions Renovations and refurbishment Planned maintenance

The percentage of public sector construction work in the UK has fallen considerably since 1980, as many of the activities traditionally in the public domain have been privatised. Utilities and services such as gas, electricity, water supply, telecommunications and railways were previously 'pure' state owned activities; today they are quasi-public – privately owned but 'regulated' and controlled by specific government agencies. This means that there is a new expanding sector of 'regulated' private sector work that is reliant on public sector decisions before it can be executed. More recently, the private sector has also been given a greater role in the funding, building and maintenance of public facilities such as hospitals, schools, prisons and roads. In these **public private partnerships**, the private sector organises the funds and manages the risks, while the public sector specifies the level of service required and ultimately owns the assets – as they are commonly returned to public ownership after 10, 15 or 25 years. These 'regulated' and 'partnership' arrangements are explained further in Chapters 2 and 6 respectively. The important point for our purposes is that expenditure on the construction of public facilities is increasingly classified as private sector expenditure in the official data. (Figure 2.4 on page 38 shows the distribution of work across the public and private sector divide over the last 10 years.)

Table 1.4 Value of construction output in current prices, Great Britain

Types of work	Value of Output (£million)		
	2005	2010	2014
Infrastructure	7,702	12,660	15,267
Housing – public	2,207	4,770	5,757
private	20,112	14,281	23,408
Public non-residential	8,279	14,204	10,330
Private industrial	5,293	3,573	4,145
Private commercial	26,064	23,312	25,836
Repair and maintenance	39,427	41,630	50,403
Total (of all work)	**109,084**	**114,430**	**135,146**

Source: Construction Statistics Annual (ONS 2011: Table 2.1 and ONS 2015: Table 2.8)

Sources of International Data

A *narrow definition* of the construction industry confines official statistical data to the 'site-based' activities of firms involved with buildings and infrastructure. As Table 1.3 shows, this data is typically disaggregated into house building, private commercial and industrial building (that is, non-residential), infrastructure (civil engineering), repair and maintenance, so on. Across Europe, therefore, it is possible to see some common trends. Aggregating figures cross 27 European countries, 28 per cent of construction output is repair and maintenance, 19 per cent is house building, 21 per cent is infrastructure and 32 per cent is non-residential (FIEC 2015).

An alternative, however, is to widen the statistical definition and go beyond the narrow boundaries created by the international classification to include the whole life cycle of construction: design, production, use, facility management, demolition, etc. This debate was initially triggered by the Pearce Report (2003), which argued that to fully understand the extent of what is meant by a sustainable industry required data relating to the broad scope of construction productivity including its environmental and social impacts. (The new approach adopted in this text clarifies the contributions that the sector makes to these wider concerns.) Pearce (2003: 24) argued for a *broad definition* that includes the mining and quarrying of raw materials, the manufacture and sale of construction products, and the related professional services such as those of architects, engineers and facilities managers. For example, a detailed analysis of current available data in Great Britain indicates that in addition to the 1,500,000 workers employed in the traditional construction sector, there are approximately 450,000 engineers, architects, facilities managers and chartered surveyors supplying professional services relating to construction and property, about 650,000 employed in the manufacture of building products and equipment, 25,000 involved in mining and quarrying construction materials and a further 100,000 workers selling building materials. In effect this broad approach increases the significance of construction; the size of the industry virtually doubles in terms of employment and output. The implications of the contrast between the narrow and broad definitions will be reviewed further in Chapter 13 and in Reading 6. In Chapter 13 we explain the measurement of economic industry activity in more detail, and in Reading 6 we review Squicciarini and Asikainen (2011) paper that addresses the inability of statistical analyses to capture fully the true scope and impact of construction.

The broad system approach has been tested in nine countries: Australia, Canada, Denmark, France, Germany, Lithuania, Portugal, Sweden and the United Kingdom. In each case the statistics confirmed that the construction system as a whole appears to be roughly twice the size that conventional construction sector statistics imply (Carassus 2004).

Few academic researchers have made comparisons of broad construction data. This is largely due to the different institutional arrangements and processes used to record official statistics in each country. Government sources of construction data are usually limited to the established narrow definition, as collated and presented by the European Construction Industry Federation (FIEC). Hence access and symmetry are lacking when attempts are made to measure the size of the industry using the broader construction system approach. Inconsistencies would be uncovered if you follow the links detailed in Table 1.5, as in some instances one series of data cannot be precisely compared to another across national boundaries.

Table 1.5 Sources of international data

The European Construction Industry Federation (FIEC)	www.fiec.eu
FIEC was created in 1905 to specifically promote the interests of the construction industry across Europe. The current membership is made up of 29 countries and 33 national federations. They represent 3 million construction enterprises employing a total of more than 14 million people. Publications include *Construction Activity in Europe*.	
United Nations Statistical Division	http://unstats.un.org/unsd/default.htm
This organisation is committed to the advancement of a global statistical system. It develops standards and norms designed to strengthen each country's official statistical output. It collates data on international trade, national accounts, energy and industry.	
Organisation for Economic Co-operation and Development (OECD)	www.oecd.org
The OECD comprises 34 member countries sharing a commitment to the market economy (in some quarters the group is referred to as the rich countries club). Its publications include *The Economic Outlook,* and a detailed series of *Main Economic Indicators*, and forecasts divided by subject (including construction) and by country.	
Eurostat	www.ec.europa.eu/eurostat
Eurostat provides the European Union with a high quality statistical information service, and co-operates closely with other international data organisations (such as the UN and OECD). *The Eurostat Yearbook* presents a comprehensive selection of statistical data covering labour markets, economy, international trade, industry and construction.	

Sources of UK Data

In the UK, economic and construction data is collected and published by the **Office for National Statistics** (commonly referred to as **ONS**). Its website (www.ons.gov.uk) provides a comprehensive range of statistical indicators and it is the starting point to search for most data relating to UK society, demography and the economy. The ONS is free from political influence and its role is to provide an evidence base for policy and decision making. The Bank of England and the Treasury are also responsible for a significant number of statistical releases relating to finance and the current economic climate, and this output is often supported by commentary from government economists. Some sources of data are detailed in Table 1.6.

Table 1.6 A brief guide to official sources of UK statistics

UK National Accounts
This publication is normally referred to simply by the colour of its cover as the Blue Book. It is published annually in the autumn by the ONS, and is considered to be a most important source of data for the UK macroeconomy, since it provides a comprehensive breakdown of GDP. As with other ONS publications, recent editions have become more user friendly, with a useful explanatory and a glossary of terms.
The Pocket Databank
This is a monthly statistical publication produced by HM Treasury providing a summary of important economic indicators, including housing. It contains data for the UK and the global economy.
Financial Statistics
The Bank of England compiles and publishes a range of financial statistics. These include domestic banking statistics, external finance statistics and international banking statistics. An interesting example is the monthly collection informally referred to as 'Bankstats'.
Bank of England Inflation Report
This is published quarterly with the Bank of England's *Quarterly Bulletin*. The *Inflation Report* serves a dual purpose. First, it provides a comprehensive review of specialised indices and a detailed commentary. Second, it is the official publication of the minutes of the monetary policy committee (referred to in Chapter 12).

For specific information relating to construction, a key source in the UK is the *Construction Statistics Annual*. A new edition is published each year in August, and the data tables are available to download from the ONS website. The publication amalgamates all construction statistics produced by central and local government, together with data from a monthly survey of private sector construction firms. It also carries appendices with detailed notes on methodology and definitions to clarify the data. Overall it provides a comprehensive picture of the UK construction industry through the last decade. (For example, the references to industry sectors in Table 1.3 and data on the value of output shown in Table 1.4 are derived from *Construction Statistics Annual*.) As with most economic data there is always a time lag, so the 2015 edition only presents data up until 2014. Consequently, data quoted in this text can appear out of date before the book even goes to print. It is important, therefore, that you have the confidence to research data for yourself.

RESEARCHING DATA

When using official national statistics, from the Internet, or in hard copy, it is useful to be aware of the way is collected, calculated and presented. First, some statistical series do not have sufficiently consistent data to refer to the United Kingdom as a whole, and only refer to Great Britain or are restricted simply to England, Wales, Scotland or Northern Ireland. For example, official statistics relating to the size and output of the construction industry tend to be specific to Great Britain. To highlight the possible confusion, the statistics shown in Table 1.7 include data published by the Northern Ireland Statistics and Research Agency (NISRA) to complete a picture for the United Kingdom.

Table 1.7 Number of businesses classified to construction, 2014

Great Britain	251,647
Northern Ireland	9,170
United Kingdom	260,817

Source: ONS, 2015: Table 3.1 and NISRA, 2015, Table 1.10

Second, figures relating to money can be expressed in several ways. The most straightforward is to represent economic activity in 'face value' terms; or put more simply, in the prices used for everyday transactions. Such measurements are referred to as **current prices**; an example is shown in Table 1.4. A more sophisticated option, however, is to adjust figures to allow for monetary inflation or deflation as this makes comparisons across time more meaningful; these adjustments are referred to as **constant prices** or a **chained volume measure (CVM)**. Traditional constant price data is expressed in terms of a specific base year, so that all prices in the base period form a reference point of the relative worth of different commodities at that specific point in time (It is usual to revise – or rebase – the data every five years.) A constant price estimate provides a measure of value which only varies with changes in the quantities produced or sold. This is achieved by removing the direct effect of changes in the prices of commodities over time. A similar but more contemporary approach is the chained volume measure in which the reference period – the base year – is updated on an annual basis. This maximises the number of commodities common to both periods and enables more accurate value comparisons to be made. Both methods are used to calculate changes in volume over time and they enable economists to analyse data in 'real terms'; at the introductory level, this is more important to grasp than the subtle technical differences between ways of calculating inflation adjusted data. For an example of chained volume measure data scan forward to Figure 2.4, where levels of construction activity from 2005 to 2015 are compared without the effects of price inflation and deflation complicating the analysis.

A further way of presenting data relating to the value of money is to use **index numbers**. The starting point (or base year) is given the value of 100, which allows subsequent percentage changes to be quickly identified. Index numbers and examples of their use are the subject of Chapter 14.

When reviewing any construction data, it should also be borne in mind that the construction industry (right across Europe) comprises a very large number of small, geographically dispersed firms, and this makes it difficult for government agencies monitoring the industry to compile comprehensive data sets. For example, alongside any official activities 'put through the books' and recorded in national statistics, there may be unofficial work carried out for 'cash in hand'. As a consequence, the data agencies in some countries include an estimated value for 'unrecorded output'. The relationship between the size of the official (formal) economy and its unofficial (informal) equivalent is discussed further in Chapter 13.

To sum up, there are several things to watch out for when researching official national statistics relating to the economy and the construction industry. The headings and footnotes associated with each table should draw your attention to the most important points, so take care to read these most carefully. Official data can never be more than an estimate but governments do their best to correct any errors or omissions as soon as possible, and this is often highlighted in the footnotes where it may be stated that the figures are 'provisional' or 'revised'. It is important to remember the ultimate goal for statistical agencies is to produce data sets that are reliable and robust, and it is the user's responsibility to interpret and understand them correctly.

Key Points 1.3

- The construction industry may be defined in many ways, but its impacts always cut right across the economy.
- A narrow definition of the construction industry includes the erection of buildings, infrastructure work, repair, maintenance and demolition.
- A broad definition of the construction industry adds to the narrow definition by including the mining and quarrying of raw materials, the manufacture and sale of construction products, and related professional services.
- The annual value of construction output (expressed in current prices), in Great Britain, for the decade 2005 to 2014 ranged from £109 billion to £135 billion.

Reading 1

George Ofori's review of construction economics has become a standard reference point for those commencing a study of the subject. In fact, it has been suggested 'that all students of economics in a construction related field should read it at least twice – once before they embark on their studies and once when they are about to complete them' (Cooke, 1996: 13). The following extract provides an opportunity to partly meet this recommendation.

Unfortunately, one of Ofori's main concerns is that there is no real consensus about the exact definition of construction economics. Yet in the 20 years since this paper was written, the aim of sustainable construction has gained momentum and the importance of improving economic efficiency in the industry has been broadly discussed in various government reports (for example, Egan 1998; HM Government 2008; BIS 2013). This raises two related questions that you might consider now and as the text unfolds. First, what seems to have been the main hurdles in defining construction economics and, second, does the development of a sustainability agenda provide the necessary focus to create a more coherent approach?

The questions that relate to each of the readings are set to stimulate debate and further exploration. For example, those interested in pursuing the two questions above should see Chang's (2015) paper where, across ten pages, he manages to discuss the history and development of construction economics, or the chapter by Brochner (2011) that considers the current forces of change within the discipline and where construction economics appears to be heading.

George Ofori (1994) Establishing Construction Economics as an Academic Discipline, *Construction Management and Economics* 12: 295–306

What is construction economics?

Perhaps the most basic feature of a discipline is a clear idea among its practitioners and researchers about what it entails, its aims and its boundaries. In this section, adopting a chronological approach, definitions of construction economics offered by various writers are considered.[1]

Drewer (1978) suggests that Turin was perhaps the first to attempt to impose scientific order on a 'pre-Newtonian' situation. Turin (1975) remarked that '...if economics is concerned with the allocation of scarce resources, it follows that building economics should be concerned with scarce *building* resources' (p. ix). Stone (1976) observes that 'building economics' embraces 'those aspects of design and production, and the related problems of organisation which affect the costs of a building' (p. xi), including forms of construction, methods of production, organisation of the industry and the impact of new methods, materials and forms of organisation and contractual relationships.

Rakhra and Wilson (1982) distinguish between 'building economics' and 'economics of building'. They suggest: 'Building economics takes an aggregate view of the building sub-section of the construction sector' (p. 51), embracing levels of building activity, the industry's contribution to the economy, impact of changes in government's policies and the nature, structure and organisation of the industry. 'Economics of building' was an 'examination at the specific project level of the resource transformation that is known as building' (p. 51), embracing cost-benefit consequences of design alternatives and choice of building components, life-cycle costing, effect of various combinations of labour and plant on site productivity and analysis of project resource requirements. Few writers refer to or adopt Rakhra and Wilson's (1982) distinction, notable exceptions being Bowen and Edwards (1985), Ofori (1990) and Bowen (1993).

Seeley (1983) opted for a very narrow definition, remarking that '...building economics has been widely used ... to describe the investigation of factors influencing building cost, with particular reference to the interaction of building design variables' (p. v). Ahuja and Walsh (1983) define cost engineering, which may be considered a form of construction economics, as '...an active approach in the design, construction and commissioning phases of a project, aimed at extracting the best possible value for money throughout each activity that has cost implications' (p. ix).

Hillebrandt (1985) adopted a broad perspective, defining construction economics as 'the application of the techniques and expertise of economics to the study of the construction firm, the construction process and the construction industry' (p. 1). Similarly, this journal defines construction economics as including design economics, cost planning, estimating and cost control, the economic functioning of firms within the construction sector and the relationship of the sector to national and international economics. Ashworth (1988) considers construction economics as embracing clients' requirements, impact of a development on its surrounding areas, relationship between space and shape, assessment of capital costs, cost control, life-cycle costing and economics of the industry in general.

Bon (1989), whose book was 'to offer a first step toward a theoretical framework for building economics' (p. xiii), suggests that 'building economics is about economising the use of scarce resources throughout the life cycle of a building...' (p. xiii) and concerns the 'application of standard investment decision criteria to buildings as a special class of capital assets' (p. xiii). Johnson (1990) adopts a similar definition, suggesting that '...knowledge of economics can provide a basis for making difficult trade-offs associated with both design and long-term management of buildings' (p. 9).

Ruegg and Marshall (1990) promise to show readers '...how to apply the concepts and methods of economics to decisions about the location, design, engineering, construction, management, operation, rehabilitation and disposition of buildings' (p. xi). Drake and Hartman's (1991) perspective is similarly project oriented, considering construction economics as being concerned with ends and scarce means in the Construction Industry' (p. 1057) and listing the, mainly surveying, techniques it embraces. Raftery (1991) suggests that 'building economics' could be said to be primarily about a combination of technical skills, informal optimisations, cost accounting, cost control, price forecasting and resource allocation. Finally, Bowen (1993) describes 'economics of building' as focusing 'on the application of quantitative techniques using financial criteria for the provision of financial advice to the design team' (p. 4).

From the above discussion, a common definition of construction economics does not exist. The chronological approach adopted helps to show that the issue has not become any clearer over time. For construction economics to develop into a discipline, a common definition is required to set the framework for issues to be considered and methodological approaches to be adopted. The definition should relate to the economic principles of scarcity and choice, refer to what is being studied (projects, practices, organisations and enterprises and industry) and state the overall aim of the discipline.

Segments

Two distinct segments of construction economics emerge from the discussion in the previous section. The first relates to construction projects, whereas the second concerns the industry. Ofori (1990) terms these 'construction project economics' and 'construction industry economics', respectively (these terms are used in the rest of the paper). However, again from the above definitions, some writers consider one or the other of the segments to be the entire field of construction economics or building economics. For example, Bon's (1989), Johnson's (1990) and Ruegg and Marshall's (1990) 'building economics' and Drake and

Hartman's (1991) 'construction economics' relate only to projects and are similar to Rakhra and Wilson's (1982) 'economics of building' and Ofori's (1990) 'construction project economics', respectively. However, Stone's (1976) 'building economics' and Hillebrandt's (1985) 'construction economics' incorporate both segments. The present author prefers and adopts the title construction economics as a perspective encompassing both the project and the industry, as this enables all aspects of the field to be studied.

The project-related segment is basically about techniques (such as cost planning, life-cycle costing and value engineering) – Raftery (1991) likens it to 'cost accounting and management'. It is better known, as it has received greater attention from researchers and in course syllabi (Ofori, 1990). However, even here, there is some confusion. Seeley (1983, p. 1) appears to make 'cost control' synonymous with construction project economics and Kelly (1983), as well as Ferry and Brandon (1991), seem to equate 'cost planning' with construction project economics. Male and Kelly (1991) refer to cost management and define it as 'a synthesis of traditional quantity surveying skills ... with structured cost reduction/cost substitution procedures using the generation of ideas by brainstorming ... in a multidisciplinary team' (p. 25). Finally, Kelly and Male (1993) have combined cost management, which emphasises cost reduction at the design stage, with value management, which focuses on clients' needs prior to design, to obtain the 'comprehensive service' of project economics, which '...seeks to control time, cost, and quality during design and construction within the context of project functionality' (Marshall, 1993, p. 170).

It is necessary to delineate, agree upon and continuously research into and improve its segments and construction economics should be developed as an integrated whole.

Conceptual structure

Cole (1983) distinguishes between the core of a discipline, the 'fully evaluated and universally accepted ideas' (p. 111) found in all undergraduate textbooks and the research frontier which includes all on-going studies, most of which eventually turn out to be of little or no significance. Does construction economics have a core of confirmed and accepted concepts?

Some key terms

Precise and common definitions are indispensable building blocks in any discipline, a key base of its conceptual structure. Authors in construction economics often find it necessary to define their main terms (e.g. Batten, 1990; Ive, 1990). Bowen and Edwards (1985) and Bowen (1993) define such basic terms as estimating, forecasting, cost and price. Some construction economics terms, each of which has a clear definition in general economics, are considered in this section.

The industry

There is, as yet, no accepted definition of the construction industry (Ofori, 1990). Some writers consider it as involving only site activity, others include the planning and design functions and yet others extend it to cover the manufacturing and supply of materials and components, finance of projects or management of existing construction items (Turin, 1975; Hillebrandt, 1985). This leads to difficulties. For example, writers' basic data and inferences often differ, simply because they adopted different definitions of 'construction'.

Notes

[1] As you will see in Ofori's search for consensus he was prepared to include other authors references to building economics. He regards this as simply a narrower version of construction economics. As Ofori (1994: 296) explained at the start of the paper, 'of the two commonly used titles, building economics and construction economics, the latter embraces the former, covering also civil engineering and other forms of construction'.

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CHAPTER 2

02: Management of Construction Projects Chapter: Introduction

CHAPTER

1 Introduction

Project management concepts

Project management is the application of knowledge, skills, tools, and techniques to the many activities required to complete a project successfully. In construction, project success generally is defined in terms of document control, safety, quality, cost, and schedule. These project attributes can be visualized as depicted in Figure 1.1. The project manager's challenge is to balance quality, cost, and schedule within the context of a safe project environment while maintaining control of the many construction documents. While cost and schedule may be compromised to produce a quality project, there can be no compromising regarding safety, and proper documentation is required to ensure compliance with contract requirements.

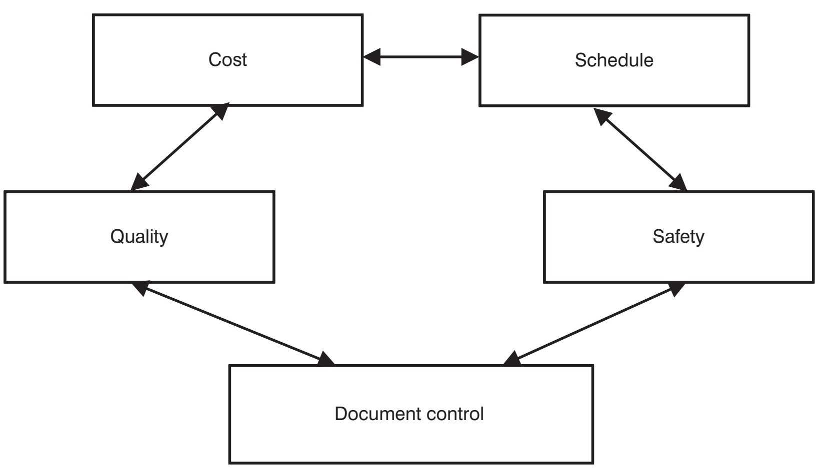


Figure 1.1 Critical project attributes

In this book, we will examine project management from the perspective of the construction contractor. Other project managers typically are involved in a project representing the owner and the designer, but our focus is on the knowledge, skills, tools, and techniques needed to be successful as a project manager for a construction contractor. Our context will be that of a project manager for a commercial general contractor. The principles and techniques discussed, however, are equally applicable on residential, specialty, industrial, and infrastructure or heavy construction projects.

The project manager is the leader of the contractor's project team and is responsible for identifying project requirements and leading the team in ensuring that all are accomplished safely and within the desired budget and time frame. To accomplish this challenging task, the project manager must organize his or her project team, establish a project management system that monitors project execution, and resolve issues that arise during project execution. In successive chapters, we will discuss the many tools that a project manager and superintendent should use in managing a project. Not all may apply to every project, but the project manager and superintendent must select those that are applicable for each project.

The major phases of a construction project

Project planning: involves evaluation of the risks that are associated with the project, particularly those related to safety, cost, quality, or schedule. Risk analysis and risk management are critical skills essential to successful project management. The project manager develops the organizational structure needed to manage the project and the communications strategy to be used within the project management organization and with other project stakeholders. Material procurement and subcontracting strategies also are developed during the planning phase. Topics relating to project planning are discussed in Chapters 3 through 7.

Project start-up: involves mobilizing the project management team, educating them regarding the project and associated risks, and conducting team-building activities. The project management office is established, and project documentation management systems are created. Initial project submittals are provided to the owner or the owner's representative. Vender accounts are established, and materials and subcontract procurement are initiated. Project cost, schedule, and quality control systems are established to manage project execution. Topics relating to project start-up are addressed in Chapters 8 and 9.

Project control: involves controlling the project, interfacing with external members of the project team, anticipating risk by taking measures to mitigate its potential impacts, and adjusting the project schedule to accommodate changing conditions. The project manager monitors the document management system, the quality management system, cost control system, and schedule control system, making adjustments where appropriate. He or she reviews performance reports to look for variances from expected performance and takes action to minimize their impacts. Topics relating to project control are addressed in Chapters 10 through 16.

Project close-out: involves completing the physical construction of the project, submitting all required documentation to the owner, and financially closing out the project. The project manager must pay close attention to detail and motivate the project team to close out the project expeditiously to minimize overhead costs. Project close-out is discussed in Chapter 17.

Post-project analysis: involves reviewing all aspects of the project to determine lessons that can be applied to future projects. Such issues as anticipated cost versus actual cost, anticipated schedule versus actual schedule, quality control, subcontractor performance, material supplier and construction equipment performance, effectiveness of communications systems, and work force productivity should be analyzed. Many contractors skip this phase, and simply go to the next project. Those who conduct post-project analyses learn from their experiences and continually improve their procedures and techniques. Post-project analysis is discussed in Chapter 17.

Project delivery methods

The principal participants in any construction project are the owner or client, the designer (architect or engineer), and the general contractor. The relationships among these participants are defined by the project delivery method used for the project. The choice of delivery method is the owner's, but it has an impact on the scope of responsibility of the contractor's project manager. Owners typically select project delivery methods based on the amount of risk that they are willing to assume and the size and experience of their own contract management staffs. In this section, we will examine the seven most common project delivery methods that are used in the United States.

Traditional project delivery method

The traditional project delivery method is illustrated in Figure 1.2. The owner has separate contracts with both the designer and the general contractor. There is no contractual relationship between the designer and the general contractor, but they must communicate with each other throughout the construction of the project. Typically, the design is completed before the contractor is hired in this delivery method. The contractor's project manager is responsible for obtaining the project plans and specifications, developing a cost estimate and project schedule for construction, establishing a project management system to manage the construction activities, and managing the construction.

Sometimes the project owner has sufficient construction management staff to manage the construction without benefit of a general contractor and chooses to contract directly with all of the specialty contractors. This is known as the multiple prime project delivery method and is a variation on the traditional project delivery method. This approach is illustrated in Figure 1.3. In this delivery method, the owner's project manager creates the project schedule and manages the work of the specialty contractors.

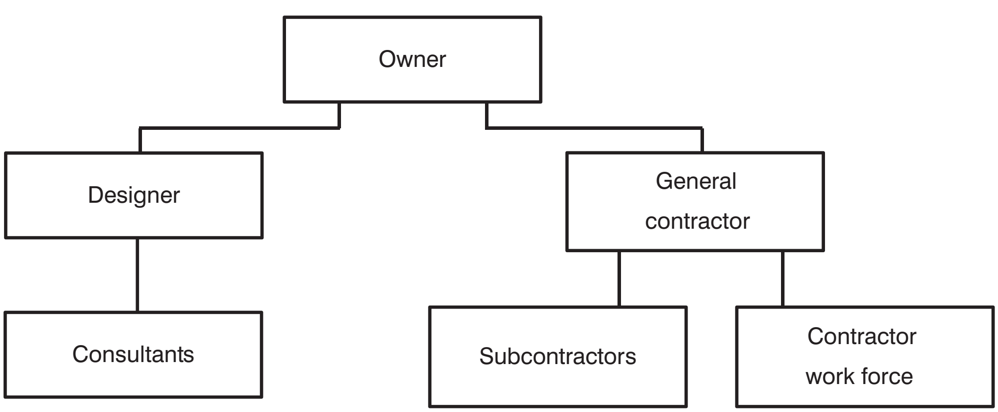


Figure 1.2 Traditional project delivery method

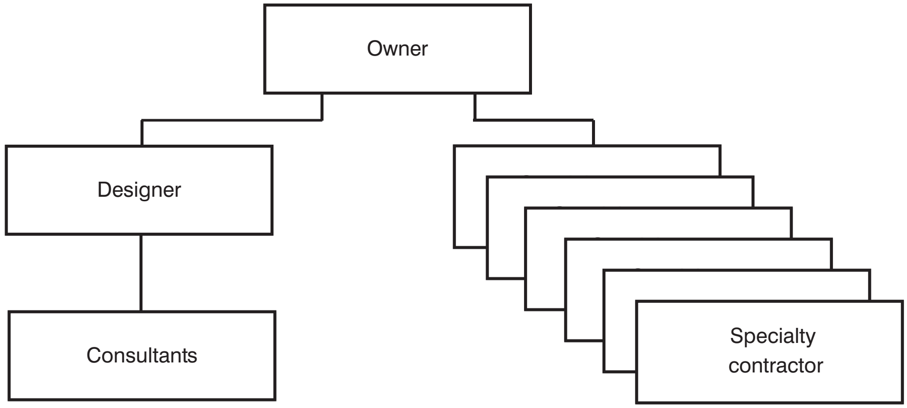


Figure 1.3 Traditional project delivery method with multiple prime contractors

Agency construction management project delivery method

In the agency construction management project delivery method, the owner has three separate contracts (one with the designer, one with the general contractor, and one with the construction manager) as illustrated in Figure 1.4. The construction manager acts as the owner's agent (also known as the owner's representative) and coordinates design and construction issues with the designer and the general contractor. The construction manager usually is the first contract awarded, and he or she is involved in hiring both the designer and the general contractor. In this delivery method, the general contractor usually is not hired until the design is completed. The general contractor's project manager has responsibilities in this delivery method similar to those listed for the traditional project delivery method. The primary difference is that the general contractor's project manager interfaces with the construction manager in this delivery method instead of with the owner, as is the case in the traditional method.

Another form of the agency construction manager project delivery method is shown in Figure 1.5. In this project delivery method, there is no single general contractor. Instead, the project owner awards separate contracts to multiple specialty contractors and then tasks the construction

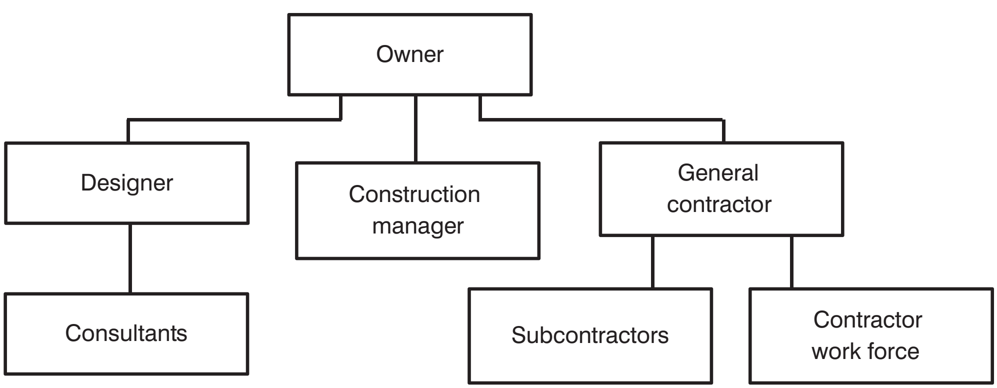


Figure 1.4 Agency construction management project delivery method with general contractor

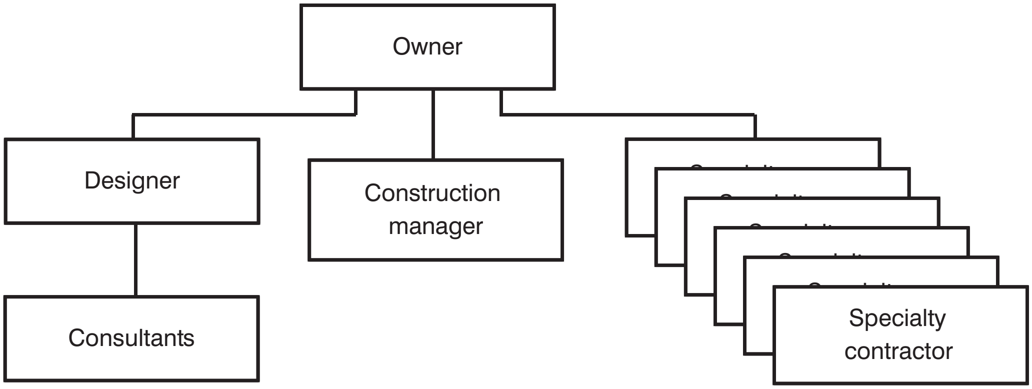


Figure 1.5 Agency construction manager project delivery method with multiple prime contractors

manager to coordinate their activities. The construction manager has no contractual relationship with any of the specialty contractors and performs none of the construction tasks nor procures any materials for the project.

Construction manager-at-risk project delivery method

In the construction manager-at-risk project delivery method, the owner has two contracts (one with the designer and one with the construction manager) as illustrated in Figure 1.6. In this delivery method, the designer usually is hired first. The construction manager typically is hired early in the design development to perform a variety of preconstruction services, such as cost estimating, constructability analysis, and value engineering studies. Once the design is completed, the construction manager becomes the general contractor and constructs the project. Some project owners require the construction manager to subcontract all of the work to specialty contractors while other owners allow the construction manager to self-perform selected scopes of work. In some cases, project construction may be initiated before the entire design is completed. This is known as fast-track or phased construction. The contractor's project manager interfaces with

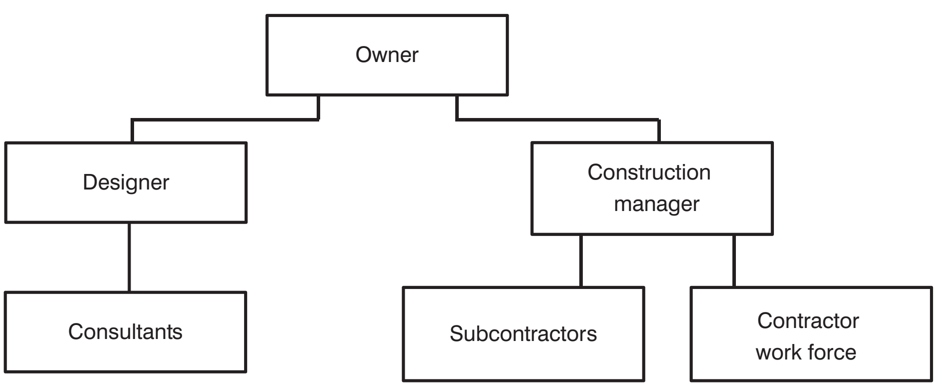


Figure 1.6 Construction manager-at-risk project delivery method

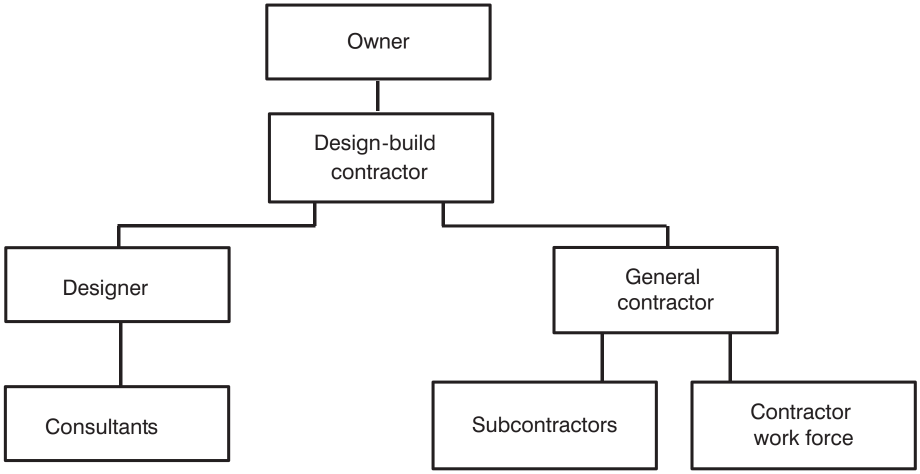


Figure 1.7 Design-build project delivery method

the designer and manages the execution of preconstruction tasks. Once construction starts, the project manager's responsibilities are similar to those in the traditional project delivery method. This is the project delivery method that was used in the project that serves as the case study used throughout this book.

Design-build project delivery method

In the design-build project delivery method, the owner has a single contract with the design-build contractor for both the design and construction of the project as illustrated in Figure 1.7. The design-build contractor may have a design capability within its own organization, may chose to enter into a joint venture with a design firm, or may contract with a design firm to develop the design. On some projects, a design firm may sign the contract and hire the construction firm. Construction may be initiated early in the design process using fast-track procedures or may wait until the design is completed. In this delivery method, the contractor's project manager is responsible for interfacing with the owner and managing both the design and the construction of the project. A variation to this method is the design-build-operate-maintain (DBOM) project delivery method in which the contractor operates the facility after construction for a specified period for an annual fee. This delivery method often is used for utilities projects such as water treatment or sewage treatment plants.

Bridging project delivery method

The bridging project delivery method is a hybrid of the traditional and the design-build delivery methods. The owner contracts with a design firm for the preparation of partial design documents. These documents typically define functional layout and appearance requirements. A design-build contractor is then selected by the owner to complete the design and construct the project.

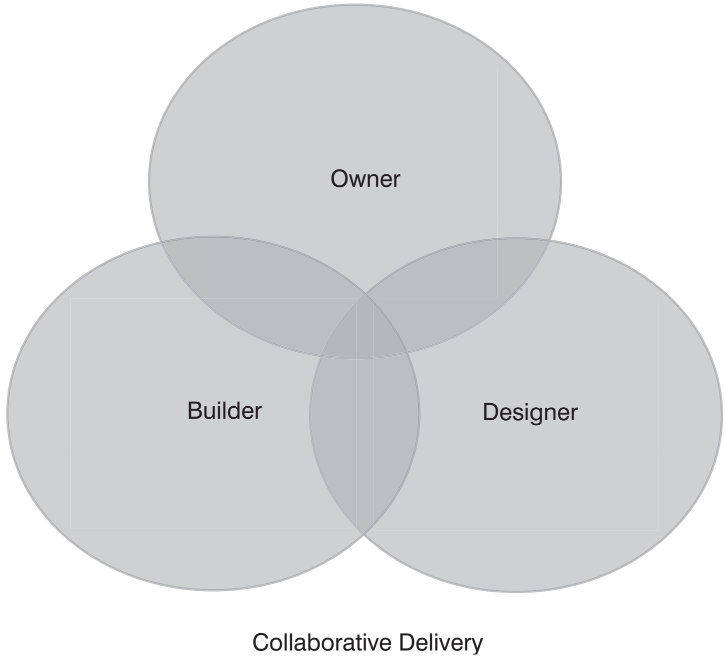


Figure 1.8 Integrated project delivery method

Integrated project delivery method

The design and construction contracts awarded in the other project delivery methods are transactional contracts, written for the purpose of acquiring design and construction services. The contract awarded in the integrated project delivery (IPD) method is a relational contract that creates a collaborative relationship among the owner, designer, and builder as illustrated in Figure 1.8. An example of this type of contract is ConsensusDocs 300, Standard Multi-Party Integrated Project Delivery Agreement.

Under the contract provisions, the three parties commit to collaborating in the design, construction, and commissioning of the project and agree to share in the risks and rewards associated with the project. Typically, there is a target project cost and a risk pool, similar to a contingency, established in the contract to address project risks and cover unanticipated expenses. When the project is completed, any funds remaining in the risk pool are equally distributed among the three parties. In this project delivery method, the project is managed by a management group composed of senior representatives of the owner, designer, and builder who are empowered to serve as the decision-making body for delivery of the project, and there is total fiscal transparency among the three representatives.

Public–private partnership project delivery method

Contracts awarded in the public–private partnership (PPP) project delivery method are known as build-operate-transfer (BOT) contracts. Under these contracts, a private sponsor, usually a consortium or joint venture, executes a contract with a public agency to finance, design, construct, and operate a project for a specified period of time. At the end of the operating or concession period, ownership of the project is transferred from the private sponsor to the government agency. In this delivery method, a government agency identifies project requirements, establishes the concession period for project operation, solicits proposals, and awards the contract. The project designer and constructor may be joint venture participants or may be subcontractors to the private sponsor. Funding for the project may come from equity participation in the sponsoring consortium, loans, or the sale of bonds. During the concession period, the project sponsor collects revenues from operation of the project to recover its investment and earn a profit. This delivery method is often used for large infrastructure projects such as highways that charge tolls for use and power plants that sell generated electricity.

Sustainable construction

The design, construction, and operation of projects have environmental, economic, and social impacts. Sustainable construction means evaluating these potential impacts and selecting strategies that emphasize the positive impacts while minimizing the negative impacts. The overall sustainability of a project is greatly influenced by the design, but the builder can influence the environmental and social impact of the construction operations. Some contractor sustainable actions include:

- reuse of materials and minimization of construction waste;
- minimization of noise, light, and air pollution during construction;
- protection and restoration of the natural environment;
- elimination of storm water runoff and soil erosion; and
- selection of construction materials with high recycle content.

Buildings that are designed and constructed to achieve sustainability goals are often referred to as “green” buildings. There are several systems that have been developed to provide a framework for assessing the achievement of sustainability goals.

The United States Green Building Council (USGBC) (www.usgbc.org) developed its Leadership in Energy and Environmental Design (LEED) green building rating system to provide a common standard for the measurement of what constitutes a high-performance green building. The LEED rating system has been revised several times, but it provides for four levels of certification and measures compliance with eight categories of standards. The four levels of certification are:

- certified,
- silver,
- gold, and
- platinum.

The eight categories of standards are

- location and transportation,
- sustainable sites,
- water efficiency,
- energy and atmosphere,

- materials and resources,
- indoor environmental quality,
- innovation, and
- regional priority.

The level of certification achieved by a project depends on the number of credits awarded by a third-party certification process. This process is described in more detail in Chapter 5.

Another assessment process is known as Green Globes, which is distributed and run by the Green Building Institute (GBI) (www.thegbi.org). The Green Globes rating system includes a web-based self-assessment tool, a rating system for certification of a building, and a guide for enhancing the sustainability of a project. Its ratings are based on project management; site; energy; water; resources, building materials, and solid waste; emissions and effluents; and indoor environment. Based on verification by a third-party, certification can be granted as one to four globes, with four globes being the highest. Certification levels are based on the percentage of applicable points achieved by the project.

Building information models

A building information model is an integrated database containing parametric information and design documents for the entire building or other project. The data are used to create three-dimensional projections of the building as illustrated in Figure 1.9 or may be used to depict the locations of underground utility lines or structures. Building information modeling (BIM) involves the process of designing a building collaboratively using a coherent system of computer models. The architectural, structural, mechanical, electrical, and plumbing models can be brought together to discover any clashes or elements of the separate models that occupy the same space. BIM can be used throughout the design and construction processes to illustrate the designers' intent, to simulate construction sequences, and to manage construction activities. It can be used to develop quantity take-offs of building components to support development of cost estimates, to develop site logistics plans, to create construction schedules, and to identify opportunities for offsite prefabrication of building components. The use of BIM for preconstruction planning will be discussed in more detail in Chapter 5.

Lean construction

Lean construction is a continuous process for analyzing the delivery of construction projects to eliminate waste while meeting or exceeding project owner expectations. The application of lean principles results in better utilization of resources, especially labor and materials. While lean construction does not replace the project master schedule, it does utilize better short-interval planning and control that improve the timely completion of project tasks. The strategy for lean supply is to provide materials when needed to reduce variation, eliminate waste, improve workflow, and increase coordination among the trades. The project manager's responsibility is to create a realistic construction flow that shows the contractor's and the subcontractors' dependency on material suppliers. Material deliveries are then scheduled so that the materials arrive on site just as they are needed for installation on the project. Another aspect of lean construction is the expanded use of off-site construction or

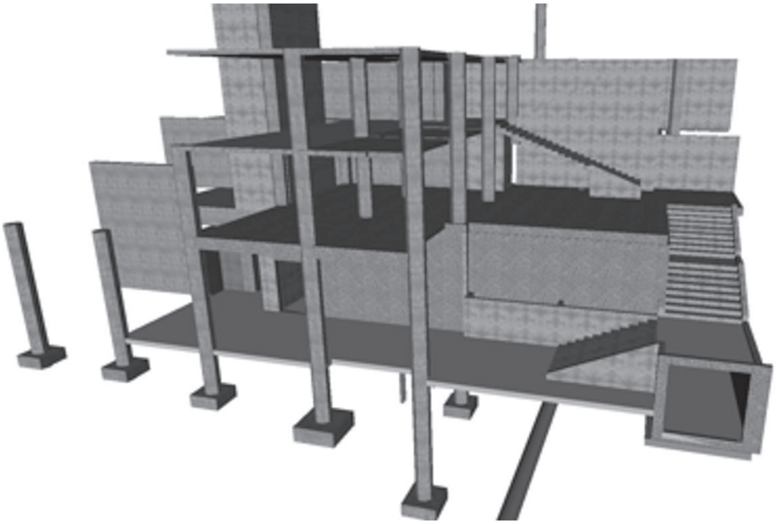


Figure 1.9 Building information model

prefabrication of building components. Reduced fabrication on the project site enables workers to concentrate on component installation rather than construction, saving time, reducing material waste, enhancing project safety, and enhancing quality. Examples of lean construction techniques are discussed in more detail in Chapter 5. Accomplishment of lean construction objectives requires a cultural change in the behavior of the project team including the subcontractors.

Project management organizations

The size and structure of the project management organization depend on the size of the project, its complexity, and its location with respect to other projects or the contractor's home office. The cost of the project management organization is considered project overhead and must be kept economical to ensure the cost of the contractor's construction operation is competitive with that of other contractors. The goal in developing a project management organization is to create the minimum organization needed to manage the project effectively. If the project is unusually complex, it may require more technical people than would be required for a simpler project. If the project is located near other projects or the contractor's home office, technical personnel can be shared among projects, or backup support can be provided from the home office. If the project is located far from other contractor activities, it must be self-sufficient.

General contractors typically organize their project management teams in one of three organizational structures. In one type of structure, estimating and scheduling are performed in the contractor's home office as illustrated in Figure 1.10. In an alternative organizational structure, estimating and scheduling are the project manager's responsibilities, as illustrated in Figure 1.11. Both the project manager and the superintendent may report to the contractor's chief of construction operations as illustrated in Figure 1.11. In the third alternative organizational structure, the superintendent may report to the project manager, as illustrated in Figure 1.12. The choice of project management organizational structure depends on the contractor's approach to

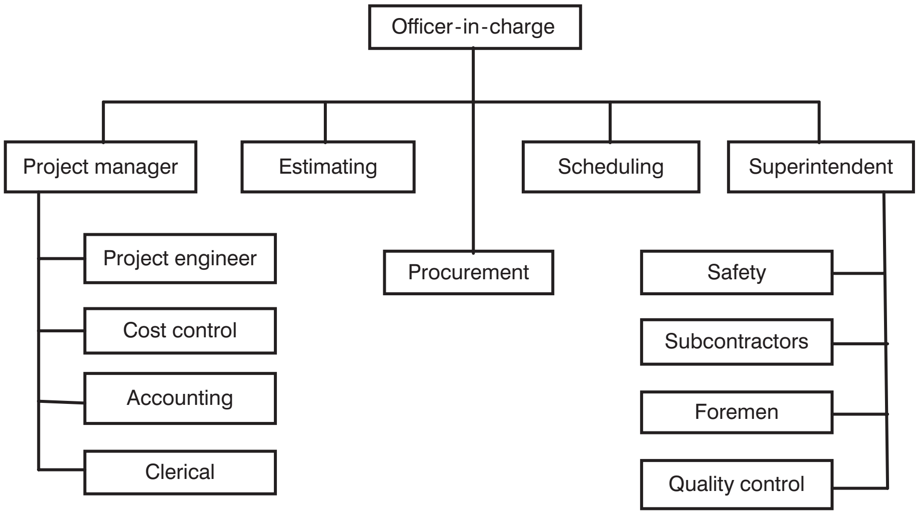


Figure 1.10 Contractor's project management organization with estimating and scheduling at home office

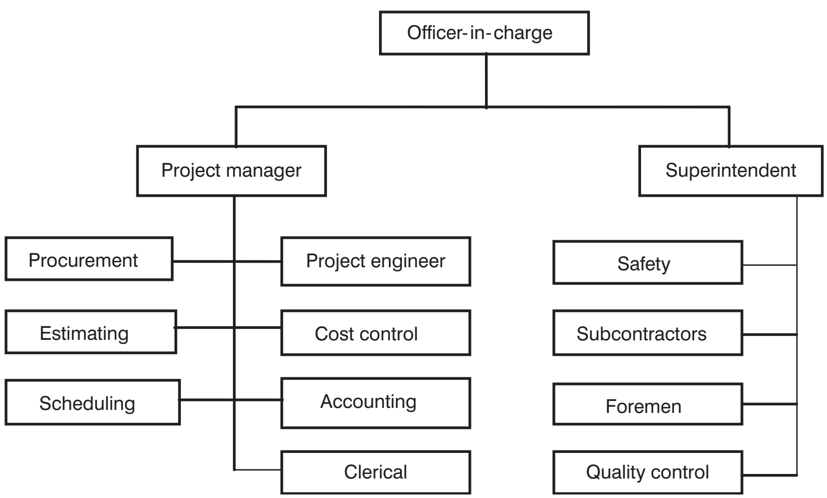


Figure 1.11 Contractor's project management organization with estimating and scheduling under project manager

managing projects. The officer-in-charge (OIC) is the project manager's supervisor. He or she may have various titles as described later in this chapter.

Project team development

Once the project management organization is selected for a project, the project manager identifies the individuals to be assigned to each position. Most people will come from within the contractor's

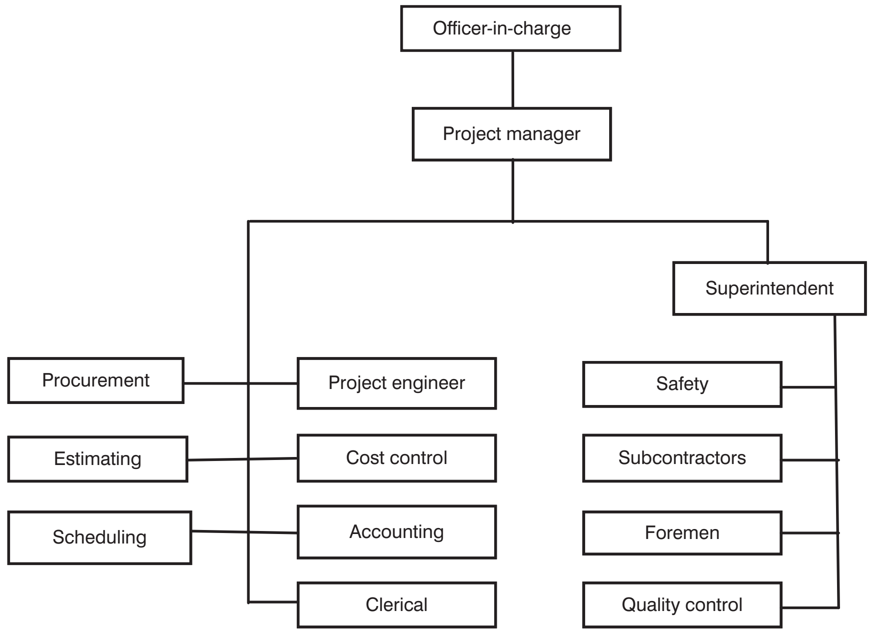


Figure 1.12 Contractor's project management organization with superintendent reporting to project manager

organization, but some may be hired externally. Selection of project team members from inside the construction firm may be made by the project manager or may be made by senior company managers. If new people are hired, the project manager must prepare a job description for each position and a list of skills needed to perform the job, recruit and select new employees, and train them on the contractor's methods of doing business. These human resource management responsibilities are explained in more detail in Chapter 18. Once all of the team members have been selected, the project manager must forge them into a cohesive team. This requires team building, which may be a significant challenge for the project manager. Team building is discussed in Chapter 5.

Project team member responsibilities

Individual team member responsibilities may vary from company to company and from project to project, but in general they are as described below. The superintendent is the only position that is specified in most construction contracts.

Officer-in-charge

The OIC is the principal official within the construction company who is responsible for construction operations. He or she generally signs the construction contract and is the individual to whom the owner turns in the event of any problems with the project manager. This individual often carries the title of vice president for operations, operations manager, district manager, or may be the owner or chief executive officer (CEO).

Senior project manager

In some construction companies, senior project managers are appointed to oversee multiple projects. When they are used, senior project managers are between the OIC and the project managers.

Project manager

The project manager has overall responsibility for completing the project in conformance with all contract requirements within budget and on time. He or she organizes and manages the contractor's project team. Specific responsibilities include:

- coordinating and participating in the development of the project budget and schedule;
- developing a strategy for executing the project in terms of what work to subcontract;
- communicating frequently with the owner and the designer;
- soliciting, issuing contract packages, evaluating, and awarding subcontracts and material purchase orders;
- negotiating and finalizing contract change orders with the owner and subcontractors;
- implementing project cost and schedule control procedures;
- scheduling and managing project team meetings;
- supervising project office staff;
- submitting monthly progress payment requests to the owner; and
- managing project close-out activities.

General superintendent

In some construction companies, a general superintendent may be appointed for a single large complex project, with area superintendents selected for major areas within the project. In other companies, the general superintendent is in charge of all superintendents employed by the company.

Superintendent

The superintendent is responsible for the direct daily supervision of construction activities on the project, whether the work is performed by the contractor's employees or those employed by subcontractors. Specific responsibilities include:

- planning, scheduling, and coordinating the daily activities of all craft labor working on the site;
- determining the construction building methods and work strategies for work performed by the contractor's own work force;
- preparing a 3-week look-ahead schedule and coordinating equipment requirements and material deliveries;
- preparing daily reports of project activities;
- submitting daily time cards for self-performed work;
- ensuring all work performed conforms to contract requirements; and
- ensuring all construction activities are conducted safely.

Project engineer or field engineer

The project or field engineer is responsible for resolving any technical issues relating to completion of the project. On small projects, the project engineer's responsibilities may be performed by the project manager. Specific responsibilities include:

- maintaining submittal and request for information logs;
- reviewing submittals and transmitting them to the owner or designer;
- preparing and submitting requests for information;
- preparing contract documents and correspondence and maintaining the contract file; and
- reviewing subcontractor invoices and requests for payment.

In some companies, this position might be called *assistant project manager*.

Quality control inspector

On some projects, the owner may require or the contractor may choose to assign a quality control inspector. This individual continually inspects the work under construction to ensure compliance with contract quality requirements.

Safety inspector

On some projects, the contractor may choose to assign a full-time safety inspector to ensure that all required safety equipment is worn and all accident prevention measures are taken by all individuals working on site, whether they are employed by the contractor or anyone else.

General foreman and assistant superintendent

On some projects, the contractor may choose to have general foremen who are responsible for all the work being performed in selected areas of the project. In a similar manner, some contractors may assign assistant superintendents to assist the superintendent in the performance of his or her responsibilities.

Foremen

The foremen are responsible for the direct supervision of the craft labor on the project. The construction firm will assign foremen for work that is performed by the company's own construction crews. Foremen for all subcontracted work will be assigned by each subcontractor. Specific responsibilities include:

- coordinating the layout and execution of individual trade work on the project site;
- verifying that all required tools, equipment, and materials are available on site;
- ensuring all craft work conforms to contract requirements; and
- preparing daily time sheets for all supervised personnel.

Project management ethics

A construction company is judged by the integrity that it demonstrates in conducting its business and in treating its employees. A key component of the company's reputation is the ethics of the company leaders and employees. Ethics are the moral standards used by people in making personal and business decisions. They involve determining what is right in a given situation and then having the courage to do what is right. Each decision has consequences, often to ourselves as well as to others. Generally, there are three primary ethical directives: loyalty, honestly, and responsibility. Loyalty means doing what is in the best interest of the construction company and the project owner. Honesty is more than truth telling; it involves the correct representation of ourselves, our actions, and our words. Responsibility involves anticipating the consequences of our actions and taking responsible measures to prevent harmful occurrences. While laws and regulations define courses of action with which we must legally comply, ethics are standards of conduct that help us make the right decisions.

A construction company's ability to acquire and maintain customers will be greatly influenced by the potential customer's perception of the ethics of the construction firm and its project managers. The project manager establishes the ethical culture for the entire project team and leads by example. Additional discussion on project leadership is contained in Chapter 19. Subcontractors, material suppliers, and project owners may choose not to do business with project managers who have reputations for unethical behavior. The following paragraphs address the most common ethical challenges to be faced in obtaining a construction contract and performing the work needed to complete the project.

Bid shopping

Bid shopping occurs when general contractors disclose to prospective subcontractors the price quotation received from competing subcontractors. The intent is to encourage subcontractors to lower their quotations. Such practice is considered unethical. The subcontractors are being asked to submit their best prices for a specific scope of work, and they provide their quotations to the general contractor with the expectation that they will be kept confidential and not shared with competitors. Another form of bid shopping that is unethical occurs when a general contractor uses the quotation from one subcontractor in their bid but selects another subcontractor to perform the work.

Timely payment of subcontractors and suppliers

Subcontracts and purchase orders (supply contracts) often contain a provision that the general contractor will make payment once they receive the monthly payment from the project owner. It is unethical for the general contractor to withhold payment to the subcontractors and suppliers for an extended period of time after receipt of the payment from the owner. While withholding the payments may assist the general contractor in managing its cash flow, it has a significant adverse effect on the financial condition of the subcontractors and suppliers. Construction companies with reputations for late payment of subcontractors and suppliers often have difficulty obtaining competitive quotations from subcontractors and suppliers.

Withholding information

Situations may arise on a project that may impact subcontractors. This may include changes in the construction schedule or differing site conditions. The project manager needs to ensure that all parties potentially impacted by the information are given timely notice.

The best strategy with respect to ethical behavior on a project is to adhere to the so-called Golden Rule, which is to treat others as we would wish to be treated.

Summary

The contractor's project manager is the leader of the contractor's project management team. He or she is responsible for managing all the activities required to complete the job on time, within budget, and in conformance with quality requirements specified in the contract. The major phases of a construction project are: project planning, project start-up, project control, project close-out, and post-project analysis.

There are seven major project delivery methods used in the United States. The primary differences among them are the relationships between the project participants. In the traditional delivery method, the owner has separate contracts with the designer and the general contractor. There is no contractual relationship between the designer and the general contractor. In the agency construction management delivery method, the owner has separate contracts with the construction manager, designer, and the general contractor. The construction manager acts as the owner's representative on the project but has no contractual relationship with either the designer or the general contractor. In the construction management-at-risk delivery method, the owner has two separate contracts, one with the designer and one with the general contractor who also acts as the construction manager. In the design-build delivery method, the owner has a single contract with the design-build contractor who is responsible for both designing and constructing the project. The bridging delivery method is a hybrid method in which the owner first contracts with a designer for a partial design and then contracts with a design-build firm to complete the design and construct the project. In the IPD method, the owner, designer, and builder form a collaborative relationship to execute the project. In the PPP project delivery method, a private sponsor finances, designs, constructs, and operates the project.

Sustainable construction involves the design and construction of projects that minimize adverse environmental and social impacts of construction. Building information models are integrated databases that can be used to illustrate the designer's intent, to simulate construction sequences, and to manage construction activities. Lean construction involves the selection of processes for delivering construction projects to eliminate waste.

Contractors establish project management organizations to manage construction activities. The project team typically consists of a project manager, superintendent, project engineer, foremen for self-performed work, and administrative support personnel depending upon project size and complexity. Project management ethics are moral standards used by project team members in making personal and business decisions. The project manager establishes the ethical culture for the project team and leads by example.

Review questions

1. What are five critical project attributes that the project manager must integrate?
2. What are the major phases of a construction project, and what occurs during each phase?
3. What is the difference between the traditional and the construction management delivery methods?
4. What is the difference between the construction manager-at-risk and the design-build delivery methods?
5. What is the difference between the design-build delivery method and the IPD method?
6. How do the responsibilities of the project manager differ from those of the project superintendent?
7. What are the major duties of the project or field engineer?
8. What is bid shopping, and why is it considered to be unethical behavior?

Exercises

1. Develop an organization chart for a project management organization to manage the construction of a $20 million office complex that is to be completed within 1 year.
2. Describe the advantages and disadvantages of the project management organization shown in Figure 1.12 as compared with the organization shown in Figure 1.11.
3. Redraw Figure 1.4 depicting the lines of communication among the project participants.

CHAPTER 3

03: QS Pocket Book

Chapter: The quantity surveyor and the construction industry

1

The quantity surveyor and the construction industry

THE UK CONSTRUCTION INDUSTRY

The UK construction industry is a unique, complex and often fragmented industry. Nevertheless, in 2015 the total turnover of the industry was close to £103 billion or the equivalent to 6.5% of the UK gross domestic product, as shown in Table 1.1, making it an important contributor the wealth of the nation.

The industry employs approximately 250,000 contractors, 2.1 million people, a high percentage of which are self-employed with a ratio of male to female of 9:1, with 99% of workers on construction sites being male. The construction industry is defined in accordance with Division 45 of the 2007 Standard Classification to include the following:

- general construction and demolition work: establishments engaged in building and civil engineering work not specialised to be classified elsewhere;
- construction and repair of buildings: establishments engaged in construction, improvement and repair of both residential and non-residential buildings, including specialists engaged in sections of construction and repair work, such as bricklaying and the erection of steel and concrete structures;
- civil engineering: construction of roads, railways, airport runways, bridges, tunnels, pipelines, etc.;
- installation of fixtures and fittings: establishments engaged in the installation of fixtures and fittings, including gas fittings, plumbing, electrical fixtures and fittings, etc.;
- building completion work: establishments engaged in work such as painting and decorating, plastering, and on-site joinery.

Table 1.1 Construction sector's contribution to the economy – gross value added

	£ billions (current prices)	£ billions (2011 prices)	Real % change	% of economy
1997	43	79	–	5.5
1998	47	80	1.5	5.7
1999	48	81	1.3	5.6
2000	56	82	0.9	6.1
2001	59	83	1.8	6.2
2002	66	88	5.7	6.6
2003	72	92	4.8	6.8
2004	76	97	5.3	6.8
2005	81	95	−2.4	6.8
2006	86	96	0.8	6.8
2007	91	98	2.2	6.9
2008	90	95	−2.6	6.6
2009	81	83	−13.2	6.0
2010	84	90	8.5	6.0
2011	92	92	2.2	6.3
2012	89	85	−7.5	6.0
2013	92	86	1.4	6.0
2014	103	94	9.5	6.5

(Sources: ONS series KKI3, KKP5, KL9D)

Market drivers

Demand for construction and civil engineering work can be divided in broad terms into the public and private sectors. Public sector work is work for any public authority such as:

- government departments
- public utilities
- universities
- the National Health Service
- local authorities.

Private sector work is for a private owner or organisation or for a private client and includes:

- work carried out by firms on their own initiative;
- work where the private sector carries out the majority of the risk/gain.

Increasingly, the distance between public and private sectors is disappearing with the introduction of strategies such as public–private partnerships which are included in Chapter 4.

Demand for construction is influenced by the following factors:

- The industry is vulnerable to economic influences as witnessed by the downturn in the UK housing sector in 2008. Figure 1.1 illustrates that the last 50 years have seen a number of periods of 'boom and bust' associated with the economic performance of the UK as a whole. The construction industry has regularly been used by government in the recent past as a method of regulating the general economy, for example by varying interest rates in order to adjust demand for housing.
- Almost half of all construction works are commissioned by the public sector and therefore cutbacks in public sector spending on projects such as schools, hospitals and roads can have the effect of cooling down an overheating economy.
- Demand comes from a variety of sources, from mega projects, such as the £15 billion Crossrail (Elizabeth line) project to a single-story kitchen extension.
- A buoyant construction market depends on the availability of reasonable cost credit.
- Further ways in which the government can manipulate demand are with the use of tax breaks for certain categories of development, e.g. enterprise zones were established in various parts of the country in 1982. These zones offer certain types of development: lucrative tax breaks, rapid planning approvals and exemption from business rates. Enterprise zones were reintroduced in England in the 2011 budget, when 21 locations were named. In addition to the above incentives, high-speed broadband was added to the enterprise zone package. Subsequently, in November 2015 an additional 18 new enterprise zones where announced and eight existing enterprise zones were extended. In Scotland four enterprise areas were announced in April 2012 with a five-year timescale.
- Nearly half the output of the construction industry is repairs and maintenance, often neglected in times of economic downturns.

The supply side of construction is characterised by the following factors:

- Its unique structure: statistics produced by the Office of National Statistics indicate that in 2015 there were approximate 250,000 firms working in construction; however, only 60 of these had more than 1,200 employees,

Figure 1.1 Construction output – percentage change 1965–2016
(Source: Department for Business, Innovation and Skills)

with the greatest majority (approximately 200,000) being small jobbing builders employing three people or less. This structure makes it difficult to introduce new initiatives and working practices to increase productivity and/or efficiency. It is generally only the larger organisations that have the time and resources to try to introduce change. The above pattern is repeated in civil engineering with only eight firms out of a total of 16,000 employing greater than 1,200 people.

- 1.5% of construction firms account for approximately 60% of the workload. The UK structure is not unique and is replicated, for example, in Australia and North America.
- During the past 30 years or so there has been less reliance on traditional construction trade skills such as bricklaying and plastering. Instead there has been a move towards an assembly process, for example, with the extensive use of timber kits for low- and medium-rise structures – as like the motor industry, construction becomes more a case of assembly rather than construction.
- The early 1960s witnessed a movement towards the use of industrialised buildings, buildings that were constructed from mass-produced, factory-made components that were assembled on site. The object was to reduce the amount of skilled expensive labour in the construction process, thereby reducing costs and increasing profits and by 1966 accounted for 25% of all social housing starts. However, industrialised building tends to be inflexible and the Roman Point disaster of 1968, when a high-rise

block of system-built flats partially collapsed, without warning, turned public opinion away from this type of approach. Despite the above the last 20 years have seen increased use of modern methods of construction (MMC), including off-site prefabrication; perhaps one of the most notable projects to use MMC being the so-called ‘Cheesegrater’ in the City of London.

- The time lag between the response to supply to increased demand will nearly always result in a distortion of the market. For example, increased house building in response to increased demand, triggered by lower interest rates and full employment.
- With a standing housing stock of 25 million units, in addition to office buildings, shops, etc., the repair and maintenance is also an important part of the construction industry.

Industry reports

The Latham (1994) and Egan (1998) reports tried to analyse the workings of the construction industry and suggest ways in which it could become more efficient and deliver better value for money. The principal messages from the reports were that the construction industry needed to concentrate and invest in:

- modernisation
- innovation
- mass production.

The top industry reports since 1998 are:

- ‘Achieving Excellence’, Office of Government Commerce (OGC) (1999).
- ‘Modernising Construction’, National Audit Office (NAO) (2001).
- ‘Accelerating Change’, Strategic Forum for Construction (2002).
- ‘Improving Public Services through Better Construction’, NAO (2005).
- ‘Be Valuable’, Constructing Excellence (2005).
- ‘The Callcutt Review of housebuilding delivery’ (2007).
- ‘Construction Commitments’, Strategic Forum for Construction (2008).
- ‘Strategy for Sustainable Construction’, Government/Strategic Forum (2008).
- ‘Construction matters’, Business and Enterprise Select Committee (2008).
- ‘Equal Partners’, Business Vantage and Construction Clients’ Group (2008).
- ‘Never Waste A Good Crisis’ (the Wolstenholme Report) Constructing Excellence, (2009).

- 'Government Construction Strategy', Cabinet Office (2011).
- 'Construction 2025', Construction Industrial Advisory Council (2013).

In 2009 the Wolstenholme Report benchmarked progress against the key drivers and appeared to show progress, albeit many on demonstration projects instead of industry-wide projects, and concluded that at its best UK construction was excellent, but there was also evidence of processes that were not so good. The most recent of the reports are as follows.

Government Construction Strategy 2011

The government's 'The Plan for Growth', published alongside its 2011 budget, highlighted the critical importance of an efficient construction industry to the UK economy. The report focused on public works with some 40% of construction/civil engineering work being in this sector. This strategy calls for a profound change in the relationship between public authorities and the construction industry to ensure the government consistently gets a good deal and the country gets the social and economic infrastructure it needs for the long term. The report called for a reduction in costs of 20% by 2015!

A detailed programme of measures called for:

- replacement of adversarial cultures with collaborative ones;
- cost reduction and innovation within the supply chain to maintain market position rather than innovation that is focused on the bidding process, with a view to establishing a bargaining position for the future.

The proposed model for public sector construction procurement in the UK is one in which:

- clients issue a brief that concentrates on required performance and outcome, designers and constructors work together to develop an integrated solution that best meets the required outcome;
- contractors engage key members of their supply chain in the design process where their contribution creates value;
- value for money and competitive tension are maintained by effective price benchmarking and cost targeting;
- by knowing what projects should cost, rather than through lump sum tenders based on inadequate documentation, supply chains are, where the programme is suited, engaged on a serial order basis of sufficient scale and

duration to incentivise research and innovation around a standardised (or mass-customised) product;
- industry is provided with sufficient visibility of the forward programme to make informed choices (at its own risk) about where to invest in products, services, technology and skills;
- there is an alignment of interest between those who design and construct a facility and those who subsequently occupy and manage it.

Approaches to help achieve this reduction were outlined:

- The use of building information modelling (BIM). The government required fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by April 2016. A staged plan to be published with mandated milestones showing measurable progress at the end of each year.
- The introduction of soft landings, which aims to ease the transition from completion to commissioning with the alignment of design/construction with operation and asset management.
- Post-handover defects are a regular feature of construction projects, leading to the cost of remediation (and frequently the higher cost of resolving disputes). Even when there are no latent defects, it is still rare to find that a built asset performs exactly in accordance with its design criteria (and particularly in terms of energy efficiency, for example).
- Integration of the design and construction of an asset with the operation phase should lead to improved asset performance. This has been demonstrated in projects which have integrated design and construction with whole-life operation. The same alignment can be created by requiring those who design and construct buildings to prove their operational performance for a period of say three to five years. Proposals for this will be developed with the Government Property Unit to ensure alignment with subsequent arrangements for facilities management.

BIM and soft landings will be discussed more fully at the end of this chapter.

Construction 2025

In July 2013 another government report, 'Construction 2025', hit the bookstands, this time targeted at both the public and private sectors and which outlined a vision for the construction industry by 2025. Even more targets were set as follows:

- 33% reduction in the initial cost of construction and whole-life costs;
- 50% reduction in overall time from inception to delivery;
- 50% lower greenhouse emissions;
- 50% improvements in exports.

THE BUILDING TEAM

In addition to construction firms, architects, surveyors and allied professions are involved in the concept, design, finance and management of the construction process. Sir Harold Emmerson remarked in the Emmerson Report in 1964 that: 'In no other important industry is the responsibility for the design so far removed from the responsibilities of production.' What is more, unlike other major industries, such as car manufacturing or aerospace, construction activity is carried out:

- in the open air, exposed to the elements;
- at various locations with each project, to some degree being bespoke, unlike a standard model of car or computer.

These factors have contributed to some of the problems that the industry has experienced and during the past 50 years or so where the construction industry has been confined to a mere assembly process, with little input from the contractor. These characteristics have led to claims that the industry is inefficient and wasteful and that clients have historically received a bad deal and poor value for money, with projects being delivered late and over budget.

The construction supply chain

The construction supply chain is the network of organisations involved in the different processes and activities that produce the materials, components and services that come together to design, procure and deliver a building.

Figure 1.2 illustrates part of a typical construction supply chain; although in reality many more subcontractors could be involved. The problems for process control and improvement that the traditional supply chain approach produces are related to:

- the various organisations which come together for a specific project disband at its completion to form new supply chains;
- communicating data, knowledge and design solutions across the organisations that make up the supply chain;

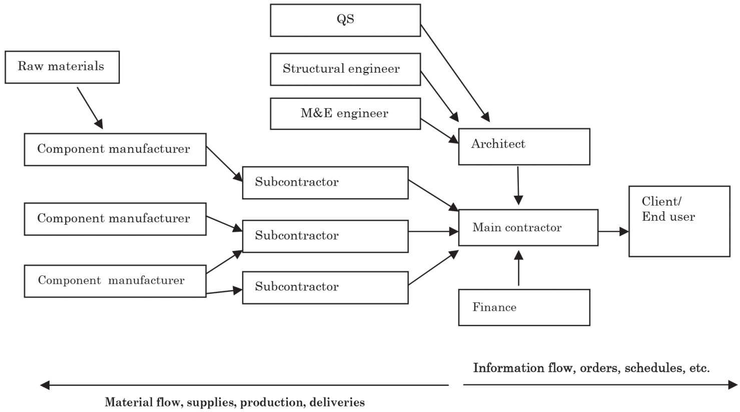


Figure 1.2 Construction supply chain

- stimulating and accumulating improvement in processes that cross the organisational borders;
- achieving goals and objectives across the supply chain;
- stimulating and accumulating improvement inside an organisation that only exists for the duration of a project.

The role of professional institutions

There are a number of professional institutions for building professionals, namely, but not in any particular order:

- The Royal Institution of Chartered Surveyors – RICS.
- The Royal Institute of British Architects – RIBA.
- The Institution of Civil Engineers – ICE.
- The Institution of Structural Engineers – IStructE.
- Chartered Institute of Building – CIOB.
- The Institution of Clerks of Works and Construction Inspectorate of Great Britain.
- The Chartered Institution of Building Services Engineers – CIBSE.

Each of the above organisations has developed over time to regulate and further the aims of its members. Corporate membership is generally either at member or fellow grade and members must pay substantial annual fees in order to use designatory letters after their names. The main reasons for the establishment of the professional bodies are to:

- safeguard the public, for example, by ensuring that all members working in private practice have adequate professional indemnity insurance;
- enforce codes of conduct;
- lobby governments;
- train and educate.

Quantity surveyor

Prior to the Napoleonic Wars, Britain, in common with its continental neighbours, had a construction industry based on separate trades. This system still exists in France as 'lots séparés' and variations of it can be found throughout Europe, including in Germany. The system works like this: instead of the multi-traded main contractor that operates in the UK, each trade is tendered for and subsequently engaged separately under the co-ordination of a project manager.

The Napoleonic Wars, however, brought change and nowhere more so than in Britain – the only large European state that Napoleon failed to cross or occupy. The government of the day was obliged to construct barracks to house the huge garrisons of soldiers that were then being transported across the English Channel. As the need for the army barracks was so urgent and the time to prepare drawings, specifications, etc. was so short, the contracts were let on a 'settlement by fair valuation based on measurement after completion of the works'. This meant that constructors were given the opportunity and encouragement to innovate and to problem solve – something that was progressively withdrawn from them in the years to come. The same need for haste, coupled with the sheer magnitude of the individual projects, led to many contracts being let to a single builder or group of tradesmen 'contracting in gross', and the general contractor was born. When peace was made the Office of Works and Public Buildings, which had been increasingly concerned with the high cost of measurement and fair value procurement, in particular in the construction of Buckingham Palace and Windsor Castle, decided enough was enough. In 1828 separate trades contracting was discontinued for public works in England in favour of contracting in gross. The following years saw contracting in gross (general contracting) rise to dominate, and with this development the role of the builder as an innovator, problem-solver and design team member was stifled to the point where contractors operating in the UK system were reduced to simple executors of the works and instructions (although in Scotland the separate trades system survived until the early 1970s).

Then in 1834 architects decided that they wished to divorce themselves from surveyors and establish the Royal Institute of British Architects (RIBA), exclusively for architects. The grounds for this great schism were that architects wished to distance themselves from surveyors and their perceived 'obnoxious commercial interest in construction'. The events of 1834 were also responsible for the birth of another UK phenomenon, the quantity surveyor.

For the next 150 or so years the UK construction industry continued to develop along the lines outlined above, and consequently by the third quarter of the twentieth century the industry was characterised by:

- powerful professions carrying out work on comparatively generous fee scales;
- contractors devoid of the capability to analyse and refine design solutions;
- forms of contract that made the industry one of the most litigious in Europe;
- procurement systems based on competition and selection by lowest price and not value for money.

Some within the industry had serious concerns about procurement routes and documentation, the forms of contract in use leading to excess costs, suboptimal building quality and time delays, and the adversarial and conflict-ridden relationships between the various parties. A series of government-sponsored reports (Simon, 1944; Emmerson, 1962; Banwell, 1964) attempted to stimulate debate about construction industry practice, but with little effect.

It was not just the UK construction industry that was obsessed with navel-gazing during the last quarter of the twentieth century; quantity surveyors had also been busy penning numerous reports into the future prospects for their profession, all produced either directly by, or on behalf of, The Royal Institution of Chartered Surveyors – the most notable of which were:

- 'The Future Role of the Quantity Surveyor' (1971) was the product of a questionnaire sent to all firms in private practice together with a limited number of public sector organisations. The report paints a picture of a world where the quantity surveyor was primarily a producer of bills of quantities; indeed, the report comes to the conclusion that the distinct competence of the quantity surveyor of the 1970s was measurement – a view, it should be added, still shared by many today. In addition, competitive single-stage tendering was the norm, as was the practice of receiving most work via the patronage of an architect. It was a profession where design and construct projects were rare, and quantity surveyors were discouraged from forming multidisciplinary practices and encouraged to adhere to the scale of fees charges. The report observes that clients were becoming more informed, but there was little advice about how quantity surveyors were to meet this challenge.

- 'The Future Role of the Chartered Quantity Surveyor' (1983).
- 'Quantity Surveying 2000: The Future Role of the Chartered Quantity Surveyor' (1991).
- 'The Challenge for Change: QS Think Tank' (1998). A mere 25 years after the original report, the 1998 report was drafted in a business climate driven by information technology, where quantities generation is a low-cost activity and the client base is demanding that surveyors demonstrate added value. In particular, medium-sized quantity surveying firms (i.e. between 10 and 250 employees) were singled out by this latest report to be under particular pressure owing to:
  - competing with large practices' multiple disciplines and greater specialist knowledge base;
  - attracting and retaining a high-quality work force;
  - achieving a return on the necessary investment in IT;
  - competing with the small firms with low overheads.

Interestingly, 'The Challenge for Change' report also predicts that the distinction between contracting and professional service organisations will blur – a quantum leap from the 1960s, when chartered surveyors were forced to resign from their institution if they worked for contracting organisations! The trend for mergers and acquisitions continues, although it has to be said not without its problems, with the largest quantity surveying firms developing into providers of broad business solutions.

RICS Futures

In 2015 the RICS published its latest vision for the industry and the profession: 'RICS Futures – Our changing world: let's be ready'. The report, which reflects global views, starts by outlining social and economic trends and the changing business landscape, before concentrating on the changing role of the profession. The debate according to the RICS is where the future industry will demand specialists or generalists. There is strong emphasis on ethical practice as well as recognition that the profession must embrace new and emerging technologies such as BIM.

As discussed previously, mergers and acquisitions result in significant change to traditional quantity surveying firms' structures and ownership models. For many professionals including quantity surveyors this means adapting to more cross-functional teams and new business cultures. As organisations become larger and provide services to a multitude of industries, the trend towards interdisciplinary working and the demand for generalist skills appears to be growing. This it is thought could result in greater awareness of the work processes of fellow professionals such as architects and engineers in meeting team goals and client outcomes. Having said this, it is recognised that many firms still require, and will continue to demand, specialist technical skill sets such as traditional quantity surveying competencies. For firms that offer such services, staff with strong technical knowledge are essential. Larger, more generalist organisations that do not maintain such knowledge in-house will rely on the expertise of specialist organisations, a trend that was highlighted in 'The Challenge for Change: QS Think Tank'.

The profession

A quantity surveyor may choose to work in any number of different fields; however, principally these can be divided into:

- private practice, now often referred to as project management;
- commercial management or contracting surveying.

Private practice

The conventional model for quantity surveying firms in private practice is to trade as a sole practitioner or as a partnership. A surveyor who is a partner in a partnership is jointly and severally liable for all debts and liabilities of the partnership and liable to the full extent of their personal wealth for the debts of the business. However, in 2001 the Limited Liability Partnership Act made limited liability partnerships (LLPs) available to any 'two or more persons associated for carrying on a lawful business with a view to profit'. This followed on from the RICS's decision in 1986 to remove the restrictions on limited liability. The arguments for the introduction of LLPs were:

- The general partnership, which had existed since the Partnership Act of 1890, was no longer an appropriate vehicle for modern firms and for their businesses.

- Unlike a partnership, an LLP is a separate legal entity. Although some LLPs call their members 'partners', they are not partners in a partnership; their legal title is 'members of an LLP'.
- The primary purpose of an LLP is to provide additional protection for the members through limited liability; a member will not be personally liable for acts and defaults of a fellow member, however, he or she may still be personally liable for his or her own negligence.
- The recession of 2008–2012 triggered a round of quantity surveying practice mergers and acquisitions with long-established quantity surveying practices being taken over by large international multidisciplinary organisations.

Commercial management

Commercial management is generally meant to be managing the contractual and commercial aspects of projects for the supply side of the industry. Many commercial managers are members of the CIOB and the RICS.

The Royal Institution of Chartered Surveyors (RICS)

The RICS was founded in 1868 and today there are approximately 130,000 members operating in over 140 countries of which approximately 35,000 are quantity surveyors.

The key roles of RICS are to:

- regulate and promote the profession;
- maintain the highest educational and professional standards;
- protect clients and consumers through a strict code of ethics;
- provide impartial advice, analysis and guidance.

Training and education

Until the 1960s the principal route to becoming a quantity surveyor was to follow a course on either a full or part-time basis (some of these courses were really tests of attrition, involving attending evening classes for three hours a night, four nights a week, for several years) and then sit the examinations of either the RICS or the Institute of Quantity Surveyors (IQS). These examinations had a fearsome reputation with approximately only 35% of all candidates being successful each year. However, during the 1960s the first CNAA degree and diploma courses in surveying started to be offered at universities and other institutions of higher education that granted exemption from the majority of the professional institutes' examinations. In 1982 the RICS and the IQS merged and the IQS ceased to exist. With the transition from examinations set by the RICS to degrees and diplomas, the RICS role changed to one of an accrediting body. In 2001 the RICS radically revised its accreditation process and introduced a 'partnership' scheme for selected universities etc. The aims of the partnership arrangements are to:

- maintain standards;
- attract the best entrants to the profession;
- to promote research;
- develop courses in response to the needs of the profession and industry;
- improve education/professional links.

One of the principal routes to becoming a member of the Royal Institution of Chartered Surveyors is as follows:

- The individual obtains a first degree awarded by an RICS partnership university. In the UK there a number of higher education establishments that offer three-year, or four-year in the case of Scotland, degree courses.
- On completion of the first degree the graduate then typically gains employment in a private practice or contractor's organisation with a structured training framework and after a minimum of two years of work experience applies to take the Assessment of Professional Competence (APC).
- The purpose of the APC is to ensure that those applying for RICS membership are competent to practise. It is structured to provide a number of pathways to cover 19 different areas of practice. The APC for quantity surveyors covers a number of mandatory, core and optional competencies such as:
    - commercial management of construction or design economics;
    - contract practice;
    - construction technology and environmental services;
    - procurement and tendering;
    - project financial control;
    - quantification and costing of construction studies.
- If successful, the candidate may apply for membership of the RICS (MRICS). Approximately half of all entrants to the surveying profession come via this route. Corporate membership is at two levels: members and fellows. In 2002 the RICS raised the standards for its fellowship award to reflect the career achievements. Now normally only MRICS members with a minimum of five years' service who are major achievers will be considered.

In addition to the first degree route, in recent years a number of other routes have become very popular. These are:

- Cognate and non-cognate degree courses available in full-time, part-time and distance learning modes. These courses are typically two to three years in duration and have been developed to attract candidates who already have a first degree in a related (cognate) or unrelated (non-cognate) subject area. These courses are intensive but have proved to be very popular with almost 50% of all entrants to surveying now coming from this route.
- Master's degrees (MSc). There are a number of second degree courses both full-time/part-time and distance learning that are recognised by the RICS for entry to the institution and enrolment to take the APC.
- In addition to the above routes for entry to the profession the RICS encourages entry from non-traditional routes and many higher education establishments retain a number of places for candidates who do not have any of the above traditional qualifications.
- High National Diplomas and Certificates in a cognate area with passes at a high level are also recognised as an entry qualification to a RICS first degree course at advanced level.

AssocRICS

For many years the RICS has been promoting a 'two-tier' profession, the lower technical tier being provided by technicians or TechRICS. This clearly did not capture the imagination of the industry and take-up was always at low levels and consequently TechRICS was replaced in 2010 by AssocRICS, an experience- and competency-based route leading to associate membership of the RICS. AssocRICS is an opportunity for those with relevant experience and vocational qualifications to gain recognition of their skills.

AssocRICS can be a route to full corporate membership of the RICS.

Continuing professional development (CPD) and Lifelong Learning (LLL)

Since 1984 CPD has been mandatory for all corporate members and is a process by which practising surveyors can keep pace with the latest professional standards and practices while monitoring current levels of knowledge.

CPD can be grouped into four main categories:

1. professional work-based activities
2. personal activities outside work

3. courses, seminars and conferences
4. self-directed and informal learning.

Lifelong learning is defined by the RICS as:

> a learning activity undertaken through life with the aim of improving knowledge, skills and competence within a personal and/or employer-related perspective. It is seen as a key element of CPD and an important tool in maintaining a person's employability in a rapidly changing business environment.

Since 2014 the system for recording CPD was formalised by the RICS with members required to prove 20 hours minimum of CPD per year, of which 10 hours must be formal structured learning, and to log their activities online.

The RICS Black Book

The 'Black Book' takes the form of a series of separate guidance notes in both hard copy and electronic format. The guidance notes describe the standard of work that is expected of a reasonable, competent quantity surveyor in the subject to which the guidance relates. It describes 'what good looks like'. Each guidance note has been written to cover the scope of the relevant competencies of the RICS Assessment of Professional Competence. Topics published to date cover:

- Construction insurance
- Cash flow forecasting
- Defining completion
- Procurement strategies
- Contract selection.

In addition to the quantity surveyor, other professionals are involved in the design and the delivery of a construction project, and collectively they are called the design team.

Project manager

The role of the project manager is one that has emerged during the past 40 years or so. Latterly, the term 'project manager' has been used to refer to a quantity surveyor working for the client's side in private practice, and the term quantity surveyor is used to refer to a quantity surveyor working for a contracting organisation. This is by no means universal, especially outside the UK where the term 'quantity surveyor' is more universally used to describe the quantity surveyor irrespective of where or for whom they work. In the UK therefore it is possible for a private practice to supply both quantity surveying and project management services for the same project and client. Project managers may be drawn from all building professionals with the appropriate training and expertise.

The project manager therefore represents the client's interests from the initial inception to the completion and commissioning of a project. For the client, the main advantage of using a project manager is the establishment of a single point of contact in the case of queries. The client simply contacts the project manager instead of having to decide which of the design team has the answer. Training and qualifications for project managers are generally at postgraduate level, typically MSc.

Architect

Traditionally in the UK, the architect has been regarded as the leader of the design team and the first person to be appointed by the client at the start of a new project. So much so, that traditional single-stage tendering is sometimes still referred to as 'architect-led tendering'.

Until recently it was usual for the majority of a quantity surveyor's work to come via the architect, although this has changed to some extent with quantity surveyors and other members of the design team winning work in their own right. Perhaps the most difficult part of the architect's role is to interpret a client's user requirements and transform them into a building. Architects can also act as contract administrators, although increasingly this role is being taken over by others. Unlike the rest of Europe, most architects work within private practice, with few working for contractors or developer. The UK is home to some of the largest firms of commercial architects in the world.

The work of architects influences every aspect of our built environment, from the design of energy-efficient buildings to the integration of new buildings in sensitive contexts. Architects work closely with other members of the construction industry, including engineers, builders, surveyors, local authority planners and building control officers. The Royal Institute of British Architects and The Royal Incorporation of Architects in Scotland are the professional institutes for architects in the UK.

Building surveyor

Building surveying in a comparatively new profession, being a branch of the RICS general practice section until the 1970s when it became a separate division within the RICS. Key to building surveying is an in-depth knowledge of building pathology and building surveyors can frequently be found working on historic and conservation projects. For smaller new build contracts, building surveyors can also take on the design role and the contract administration.

Structural engineer

A structural engineer is involved in the design and supervision of the construction of all kinds of structures, such as houses, theatres, sports stadiums, hospitals, bridges, oil rigs, space satellites and office blocks. The central strength of a building lies in the framework, often hidden, that supports the shape and design concept produced by the architects and is integral to the completed project's function. To the chartered structural engineer, the considerations of strength, shape and function are paramount in their conception of the framework of a structure. Having chosen appropriate materials, such as steel, brick, concrete or timber, they have to design the structure and make all the necessary checks and calculations to ensure that the foundations will be sound, that the floors and roof will not fall down, and that the construction as a whole will remain safe and serviceable for the length of its intended lifetime. The specialist skills of a structural engineer will include calculating loads and stresses, investigating the strength of foundations and analysing the behaviour of beams and columns in steel, concrete or other materials to ensure the structure has the strength required to perform its function safely, economically and with a shape and appearance that is visually satisfying.

Civil engineer

Civil engineers are involved with the design, development and construction of a huge range of projects in the built and natural environment. Their role is central to ensuring the safe, timely and well-resourced completion of infrastructure projects in many areas, including highways construction, waste management, coastal development and geotechnical engineering.

Consulting civil engineers liaise with clients to plan, manage, design and supervise the construction of projects. They work in a number of different settings and, with experience, can run projects as project manager. Within civil engineering, consulting engineers are the designers;

contracting engineers turn their plans into reality. Consulting civil engineers provide a wide range of services to clients. During the early stages of a career, work will involve taking responsibility for minor projects, but the size of the projects may increase as experience is gained. Typical work activities include:

- undertaking technical and feasibility studies and site investigations;
- developing detailed designs;
- assessing the potential risks of specific projects, as well as undertaking risk management in specialist roles;
- supervising tendering procedures and putting together proposals;
- managing, supervising and visiting contractors on site and advising on civil engineering issues;
- managing budgets and other project resources;
- managing change, as the client may change their mind about the design, and identifying, formalising and notifying relevant parties of changes in the project;
- scheduling material and equipment purchases and delivery;
- attending public meetings and displays to discuss projects, especially in a senior role;
- adopting all relevant requirements around issues such as building permits, environmental regulations, sanitary design, good manufacturing practices and safety on all work assignments;
- ensuring that a project runs smoothly and that the structure is completed on time and within budget;
- correcting any project deficiencies that affect production, quality and safety requirements prior to final evaluation and project reviews.

Infrastructure is the thing that supports our daily life: roads and harbours, railways and airports, hospitals, sports stadiums and schools, access to drinking water and shelter from the weather. Infrastructure adds to our quality of life, and because it works, we take it for granted. Only when parts of it fail, or are taken away, do we realise its value. In most countries, a civil engineer has graduated from a post-secondary school with a degree in civil engineering, which requires a strong background in mathematics, economics and the physical sciences; this degree is typically a four-year degree, though many civil engineers continue on to obtain a Master's, engineer, doctoral and postdoctoral degrees. In many countries, civil engineers are subject to licensure, and often, persons not licensed may not call themselves 'civil engineers'.

Building services engineer

Building services engineers are responsible for ensuring the cost-effective and environmentally sound and sustainable design and maintenance of energy using elements in buildings. They have an important role in developing and maintaining buildings, and their components, to make the most effective use of natural resources and protect public safety. This includes all equipment and materials involved with heating, lighting, ventilation, air conditioning, electrical distribution, water supply, sanitation, public health, fire protection, safety systems, lifts, escalators, facade engineering and even acoustics.

While the role increasingly demands a multidisciplinary approach, building services engineers tend to specialise in one of the following areas:

- electrical engineering
- mechanical engineering
- public health.

Activities will vary according to the specialist area of work and whether you are employed by a single organisation or a consultancy, but tasks typically involve:

- advising clients and architects on energy use and conservation in a range of buildings and sites, aiming to minimise the environmental impact and reduce the carbon footprint;
- managing and forecasting spend, using whole-life-cycle costing techniques, ensuring that work is kept to budget;
- developing and negotiating project contracts and agreeing these with clients, if working in consultancy, and putting out tenders;
- attending a range of project groups and technical meetings;
- working with detailed diagrams, plans and drawings;
- using specialist computer-aided design (CAD) software and other resources to design all the systems required for the project;
- designing site-specific equipment as required;
- commissioning, organising and assessing the work of contractors;
- overseeing and supervising the installation of building systems and specifying maintenance and operating procedures;
- monitoring building systems and processes;
- facilities management;
- ensuring that the design and maintenance of building systems meets legislative and health and safety requirements.

The professional institution for building services engineers is the Chartered Institution of Building Services Engineers. There are a variety of grades of membership depending on qualifications and experience.

BIM manager/co-ordinator

An emerging role with a wider set of responsibilities than with information management, these being more closely aligned to design. A BIM manager's primary function is to manage the process of virtually constructing a building and accurately documenting the design contract documents. This encompasses managing a team of production professionals, designers and technicians of multiple disciplines. It is also critical for BIM managers to lead model management and BIM planning, collaboration and co-ordination on projects they are leading. The BIM manager becomes the go-to person on the project for modelling, documentation and verifying design.

The BIM manager's responsibilities include:

- design team compliance with the project BIM standards;
- managing delivery of the appropriate visuals to team members to support their work;
- creating and capturing evidence of BIM values which influence the commercial outcomes on the project, and extracting data from the model to contribute directly to support monthly reporting;
- interrogation of the design input of the model to identify clashes and produce and manage a clash register;
- oversee the extraction of key data from the project model to produce scheduled material quantities/take-offs;
- interface with and support the procurement team;
- interface with the project planning software to create a virtual build of the 3D model;
- connect BIM to the on-site activities through the site management team;
- optimise the site logistics through the model when planning temporary works;
- build a data set during the design and construction to reflect the needs of the client's asset manager.

The RICS has developed a BIM manager certification in response to industry requirements to have a Kitemark that demonstrates the skills and competence of construction professionals in using BIM.

Clerk of works

The clerk of works is the architect's representative on site and usually a tradesman with many years of practical experience.

- 1882 – formed as the Clerk of Works Association.
- 1903 – renamed the Incorporated Clerks of Works Association of Great Britain.
- 1947 – became the Institute of Clerks of Works Great Britain Incorporated.

The job title 'clerk of works' is believed to derive from the thirteenth century when 'clerics' in holy orders were accepted as being more literate than their fellows, and were left to plan and supervise the 'works' associated with the erection of churches and other religious property. By the nineteenth century the role had expanded to cover the majority of building works, and the clerk of works was drawn from experienced tradesmen who had wide knowledge and understanding of the building process.

The clerk of works, historically as well as now, is a very isolated profession on site, most easily associated with the idiom 'poacher turned gamekeeper'. He or she is the person that must ensure quality of both materials and workmanship and, to this end, must be absolutely impartial and independent in their decisions and judgments. They cannot normally, by virtue of the quality role, be employed by the contractor – only the client, and normally by the architect on behalf of the client. Their role is not to judge, but simply to report (through exhaustive and detailed diary notes) all occurrences that are relevant to the role.

Experience in the many facets of the building trade is essential and, in general terms, most practitioners will have 'come from the tools' in the first place. When originally formed the Association was to allow those that were required to operate in isolation on site a central organisation to look after the interests of their chosen profession, be it through association with other professional bodies, educational means or simply through social intercourse among their own peers and contemporaries. Essential to this, as the Association developed, was the development of a central body that could lobby Parliament in relation to their profession, and the quality issues that it stands for.

Although the means of construction, the training of individuals and the way in which individuals are employed have changed dramatically over the past 130 years, the principles for which the Association was originally formed remain sacrosanct.

Site manager/agent

The site manager, often referred to as an agent, is the person in charge of a building contract and, as such, must be aware and in control of all aspects of site operations, including the planning of site progress. It is the manager/agent who has responsibility for both the profitability of operations and adherence to the agreed construction and cost plans.

Site managers/agents are employed by building and construction companies, civil engineering firms and contractors.

Typical work activities include:

- attending regular site meetings with professionals, including quantity surveyors, building services engineers, foremen, subcontractors, and the client who has commissioned the building;
- maintaining strict quality control procedures – this necessitates regular testing of materials, visual inspections of work, and frequent tours of the site;
- conducting regular site safety checks;
- ensuring the project runs to schedule and to budget, and finding solutions to problems that may cause delays, i.e. late arrival of materials.

Recent graduates are unlikely to take on a full site manager/agent role until the necessary site engineering experience is gained. However, the period of apprenticeship or training in the role of site manager appears to be shortening, with firms forced to promote graduates earlier.

Training and education

The Chartered Institute of Building (CIOB) offers a qualifications framework for trainee and practising site managers/agents. Progression is normally to contracts management or project management. A number of site managers/agents are self-employed.

UK PROFESSIONALS AND THE EU

UK construction professionals have always been in demand worldwide. With the establishment of the single European market in 1992 many professionals began expanding their practices into Europe, with varying degrees of success. EU Directive 2005/36/EC on the recognition of professional qualifications allows holders of a regulated professional qualification to pursue their profession in another EU member state. What impact Brexit will have on this situation is yet to be established.

REGULATION AND CONTROL OF THE CONSTRUCTION PROCESS

Where and what you can build in the UK is heavily controlled and before undertaking most building projects, it is first necessary to obtain planning permission and building regulations approval.

Planning permission

The main statutes governing planning law are:

- Town and Country Planning Act 1990, as amended.
- Planning (Listed Building and Conservation Areas) Act 1990.
- Planning and Compensation Act 1991.
- Planning and Compulsory Purchase Act 2004.
- Planning Act 2008.
- Localism Act 2011.

The purpose of the planning system is to protect the environment as well as public amenities and facilities. The planning control process is administered by local authorities and exists to 'control the development and use of land and buildings for the best interests of the community'. Planning is administered at two levels:

1. Local development frameworks.
2. Local development schemes.

There are three main types of planning permission, all of which are subject to a fee that can range from hundreds to thousands of pounds, depending on the scale of the proposed project:

1. Outline – this is an application for a development in principle without detail of construction etc. Generally used for large-scale developments to get permission in principle.
2. Reserved matters – a follow-up to an outline application stage.
3. Full planning permission – sometimes referred to as detailed planning permission when a fully detailed application is made. Permission when granted is valid for six years.

If planning permission is refused then there is an appeals process, although appeal can only be made on certain matters, as listed below. Appeals are made to the Secretary of State for Environment, Food and Rural Affairs, the National Assembly for Wales or the Scottish Executive. Allowable reasons for appeal are:

- properties in conservation areas;
- non-compliance with local development plan;
- property is subject to a covenant;
- planning permission already exists;
- infringements of rights of way.

Appeal may not be made on the grounds of:

- loss of view;
- private issues between neighbours;
- loss of privacy;
- etc.

It is thoroughly recommended that prior to a proposed development the regional spatial strategies are read and understood. Buildings erected without planning permission will have a demolition order served on them and the structure will be taken down and destroyed.

Building regulations

Even when planning permission is not required, most building work is subject to the requirements of the building regulations. There are exemptions such as buildings belonging to the Crown, the British Airports Authority and the Civil Aviation Authority. Building regulations ensure that new and alteration works are carried out to an agreed standard that protects the health and safety of people in and around the building. Builders and developers are required by law to obtain building control approval, which is an independent check that the building regulations have been complied with. There are two types of building control providers: the local authority and approved private inspectors.

The documents which set out the regulations are:

- The Building Act 1984.
- The Building (Scotland) Act 2003.
- The Building (Scotland) Regulations 2004.
- The Building Regulations 2010 and The Building (Approved Inspectors etc.) Regulations 2010 for England and Wales, as amended.

The Building Regulations 2010, England and Wales, are a series of 'approved documents'. Each approved document contains the relevant subject areas of the building regulations. This is then followed by practical and technical guidance (that include examples) detailing the regulations. The current set of approved documents are in 13 parts and include details of areas such as structural, fire safety, electrical safety. In Scotland the approved documents are replaced with technical handbooks.

Contravention of the building regulations is punishable with a fine or even a custodial sentence plus, of course, taking down and rebuilding the works that do not comply with the regulations.

There are two approaches to complying with building regulations:

- Full plans application submission, when a set of plans is submitted to the local authority who checks them and advises whether they comply or whether amendments are required. The work will also be inspected as work proceeds.
- Building notice application, when work is inspected as the work proceeds and the applicant is informed when work does not comply with the building regulations. The work is also inspected as work proceeds.

Once approval is given and a building notice is approved, it is valid for three years.

Health and safety – CDM regulations

The construction industry is one of the most dangerous in the UK. In the last 25 years, over 2,800 people have died from injuries they received as a result of construction work. Many more have been injured or made ill.

Efficient site organisation is of vital importance from two aspects:

- safety, and
- efficient working.

Safety: key statistics

- In 2014/15, 35 operatives were killed in construction-related activities.
- There were 16,000 over-seven-day injuries to employees (2014/15).
- 1.7 million working days lost per year due to injury and ill health (2014/15).

(Source: Health and Safety Executive (HSE))

It is clear from the above figures that for a number of reasons the UK construction sector has a poor record in health and safety matters. In an attempt to improve the industries attitude to health and safety the Construction (Design and Management) Regulations were introduced in 1994 in order to comply with EU legislation. CDM 1994 made the duties on clients and designers explicit by identifying the need to reduce risk by better co-ordination, management and co-operation. The introduction of the CDM regulations, without doubt, led to major changes in how the industry managed health and safety although several years after their introduction there were concerns from industry and the Health and Safety Executive (HSE) that the regulations were not delivering the improvements in health and safety that were expected. The principal reasons were said to be:

- slow acceptance, particularly among clients and designers;
- effective planning, management, communications and co-ordination was less than expected;
- competence of organisations and individuals slow to improve;
- a defensive verification approach adopted by many, led to complexity and bureaucracy.

During 2002–2005 extensive consultations were carried out between the HSE and the construction industry and as a result, in April 2007, CDM 2007 was brought into force, the characteristics of which were to:

- simplify the regulations and improve clarity;
- maximise their flexibility;
- focus on planning and management;
- strengthen requirements on co-operation and co-ordination and to encourage better integration;
- simplify competence assessment, reduce bureaucracy and raise standards.

In April 2015 the CDM regulations were again revised and a summary of the roles of the duty holders is shown in Table 1.2. Now virtually everyone involved in a construction project has legal duties under CDM 2015. The definition of a client under the regulations is anyone who has construction work carried out for them. The main duty for clients is to make sure their project is suitably managed, ensuring the health and safety of all who might be affected by the work, including members of the public. CDM 2015 recognises two types of client: commercial and domestic.

Table 1.2 Roles of duty holders

Commercial clients Organisations or individuals for whom a construction project is carried out that is done as part of a business.	Make suitable arrangements for managing a project, including making sure: • other duty holders are appointed as appropriate; • sufficient time and resources are allocated. Make sure: • relevant information is prepared and provided to other duty holders; • the principal designer and principal contractor carry out their duties and welfare facilities are provided.
Domestic clients People who have construction work carried out on their own home (or the home of a family member) that is **not** done as part of a business.	Though in the scope of CDM 2015, their client duties are normally transferred to: • the contractor for single contractor projects; • the principal contractor for projects with more than one contractor. However, the domestic client can choose instead to have a written agreement with the principal designer to carry out the client duties.
Designers Organisations or individuals who, as part of a business, prepare or modify designs for a building, product or system relating to construction work.	When preparing or modifying designs, eliminate, reduce or control foreseeable risks that may arise during: • construction • the maintenance and use of a building once it is built. Provide information to other members of the project team to help them fulfil their duties.
Principal designers Designers appointed by the client in projects involving more than one contractor. They can be an organisation or an individual with sufficient knowledge, experience and ability to carry out the role.	Plan, manage, monitor and co-ordinate health and safety in the pre-construction phase of a project. This includes: • identifying, eliminating or controlling foreseeable risks; • ensuring designers carry out their duties. Prepare and provide relevant information to other duty holders. Liaise with the principal contractor to help in the planning, management, monitoring and co-ordination of the construction phase.
Principal contractors Contractors appointed by the client to co-ordinate the construction phase of a project where it involves more than one contractor.	Plan, manage, monitor and co-ordinate health and safety in the construction phase of a project. This includes: • liaising with the client and principal designer; • preparing the construction phase plan; • organising co-operation between contractors and co-ordinating their work.

(continued)

Table 1.2 *(continued)*

Principle contractors *(cont.)*	Make sure: • suitable site inductions are provided; • reasonable steps are taken to prevent unauthorised access; • workers are consulted and engaged in securing their health and safety; • welfare facilities are provided.
Contractors Those who carry out the actual construction work – contractors can be an individual or a company.	Plan, manage and monitor construction work under their control, so it is carried out without risks to health and safety. For projects involving more than one contractor, co-ordinate their activities with others in the project team – in particular, comply with directions given to them by the principal designer or principal contractor. For single contractor projects, prepare a construction phase plan.
Workers Those working for or under the control of contractors on a construction site.	Workers must: • be consulted about matters which affect their health, safety and welfare.

(Source: adapted from HSE – the Construction (Design and Management) Regulations 2015)

Notifiable construction works under CDM 2015 are those projects with construction work:

- lasting longer than 30 days and which has more than 20 workers working simultaneously at any one point;
- that exceeds 500 person days.

SUSTAINABILITY AND THE QUANTITY SURVEYOR

Perhaps the most important influence on construction and its professions since the turn of the millennium is the prominence given to sustainable issues.

If this book had been written 20 years ago, then sustainability would not have been an issue; 15 years ago, sustainability issues were starting to be discussed, but were considered only to be of interest to 'tree-hugging' cranks. We are now well into the second decade of the twenty-first century where sustainability and the need to be badged a green construction organisation is seen to be vital to maintain market share.

The 'Stern Review' (2006) came to the conclusion that: 'An overwhelming body of scientific evidence now clearly indicates that climate change is a serious and urgent issue. The Earth's climate is rapidly changing, mainly as a result of increases in greenhouse gases caused by human activities.' As illustrated in Figure 1.3, buildings account for nearly 50% of UK carbon emissions and it is for this reason that such importance has been given both by the European Union and the UK governments on the introduction of energy performance certificates (EPCs) and display energy certificates (DECs). It is the stated long-term goal in the UK is to reduce carbon emissions by 60% by 2050.

Legislative background

EU Directive 2002/91/EC, the Energy Performance of Buildings Directive (EPBD), became law on 4 January 2003 and made it mandatory for EPCs and DECs to be available for constructed, marketed or rented buildings including non-dwellings by 4 January 2009, at the latest. The EU Directive was implemented in the UK by means of:

- The Housing Act 2004, Section 134.
- The Home Information Pack (No. 2) Regulations 2007.

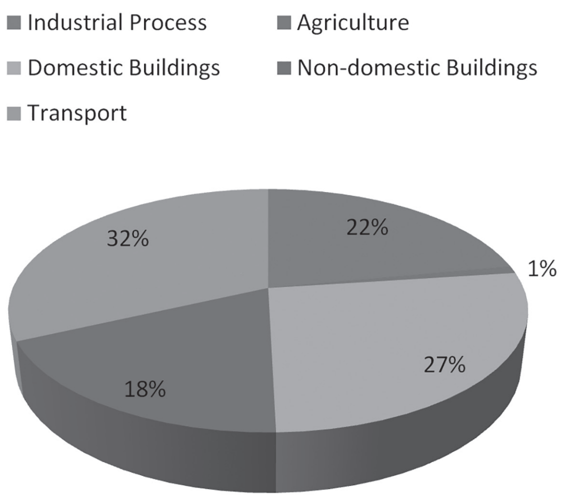


Figure 1.3 UK Carbon emissions (Source: BRE/BRECSU)

- The Energy Performance of Buildings (Certificates and Inspections) (England and Wales) Regulations 2007/991.
- Similar enabling legislation was introduced for the devolved administrations of Scotland (The Housing (Scotland) Act 2006) and Northern Ireland.

In 2010 a recast of the Directive (EPBD2) was agreed, and in 2012 it was implemented by member states. The key provisions in the recast are:

- minimum energy performance requirements to be set for all new and refurbished buildings and compared against requirements calculated in accordance with cost-optimal requirements;
- energy use of technical building systems to be optimised by setting requirements relating to installation, size, etc. Covers heating, hot water, air conditioning and large ventilation systems;
- all new buildings developed after 2020 to be nearly zero-energy buildings, with an earlier target date of 2018 where the building will be owned and occupied by a public authority;
- property advertisements to include details of EPC rating;
- member states to provide details of the fiscal incentives in place (if any) which could be used to improve the energy efficiency of their buildings;
- content of EPCs to be improved by making them more specific to a particular building and including more detailed information on the cost-effectiveness of recommendations, along with the steps to be taken to implement those recommendations;
- DECs to be issued and displayed in buildings larger than 500m^2 (current threshold is 1000m^2) that are occupied by a public authority and frequently visited by the public. This threshold will fall to 250m^2 after five years;
- EPCs to be displayed in commercial premises larger than 500m^2 that are frequently visited by the public and where one has previously been issued;
- a statistically significant percentage of EPCs and air conditioning reports (ACRs) to be checked by independent experts for quality assurance purposes.

Prior to the introduction of EPCs a series of other models were developed to assess the energy performance of buildings across the UK, namely as follows.

BREEAM (Building Research Establishment Environmental Assessment Method)

BREEAM has been developed to assess the environmental performance of both new and existing buildings over the following areas:

- management – overall management policy, commissioning and procedural issues
- energy use
- health and well-being
- pollution
- transport
- land use
- ecology
- materials and waste
- water, consumption and efficiency
- innovation.

BREEAM covers a range of building types, such as offices, industrial units, retail units, schools and even leisure centres. BREEAM measures the environmental performance of buildings by awarding credits for achieving levels of performance. The cost of having a BREEAM assessment can be considerable.

So what is sustainability? There are many definitions, but in reality it would appear to mean different things to different people in different parts of the world, depending on their circumstances. Consequently, there may never be a consensus view on its exact meaning; however, one way of looking at sustainability is (from BS ISO 15686–5:2008): 'The ways in which built assets are procured and erected, used and operated, maintained and repaired, modernised and rehabilitated and reused or demolished and recycled constitutes the complete life cycle of sustainable construction activities.'

Why is construction significant in the sustainability big picture?

- Over 90 million tonnes of construction and demolition waste arises annually in the UK alone.
- The construction industry spends over £200 million on landfill tax each year.
- 13 million tonnes of construction and demolition waste is material that is delivered to sites but never used!
- Over 5 million tonnes of hazardous waste is produced in England and Wales, 21% of which is produced by construction and demolition.

- Construction and demolition waste forms nearly 30% of all Environment Agency recorded fly-tipping incidents.
- In addition around 40% of total energy consumption and greenhouse gas emissions are directly attributable to constructing and operating buildings.

Although high, on the face of it, the true cost of waste is generally around 20 times that of the disposal costs due to the:

- purchase cost of materials;
- cost of storage, transport and disposal of waste;
- loss of income from selling salvaged materials.

The so-called waste hierarchy has been described as follows:

- eliminate – avoid producing waste in the first place;
- reduce – minimise the amount of waste you produce;
- reuse – use items as many times as possible;
- recover (recycling, composting, energy) – recycle what you can only after you have reused it;
- dispose – discard of what is left in a responsible way.

The process of achieving the minimum whole-life cost and environmental impact is complex, as illustrated in Figure 1.4. Each design option will have associated impacts, costs and trade-offs, e.g. what if the budget demands a choice between recycled bricks or passive ventilation?

The solution to a complex problem will be iterative.

Generally, attention to the following issues will increase the design costs, but not the costs of the building itself and will reduce whole-life costs:

- short supply chains to reduce transport costs;
- exercise waste minimisation and recycling construction;
- building orientation;
- durability and quality of building components, generally chosen to last for the appropriate refurbishment or demolition cycle;
- local sourcing of materials;
- design sensitive to local topological, climatic and community demands;
- construction type – prefabrication, wood or concrete structures.

During procurement supply chains should be aware that components should be chosen selectively to minimise:

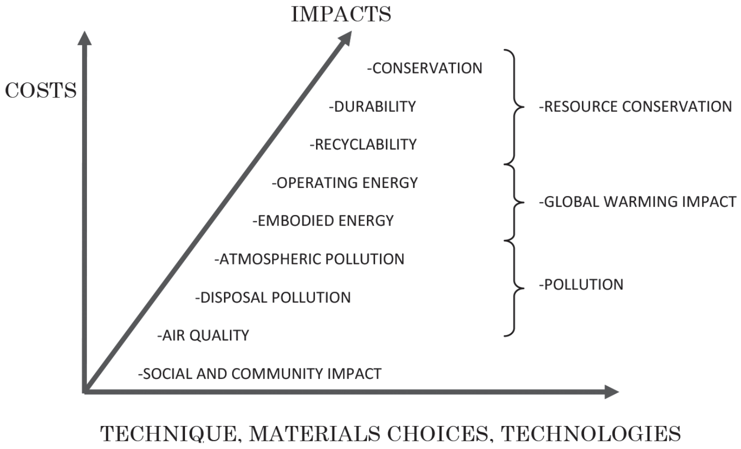


Figure 1.4 Graph showing the minimum whole-life cost and environmental impact

- embodied energy: energy of production and transport;
- atmospheric emissions from boilers etc.;
- disposal to landfill of non-biodegradable waste;
- air quality contaminants, e.g. solvents and wood preservatives continue to emit volatile chemicals long after construction, though in much smaller quantities, and these have been implicated in 'sick building syndrome';
- replacement due to poor durability;
- use of finite resources, or at least promote the use materials like wood from forests which are being replenished.

THEMES FOR ACTION DURING THE PROCUREMENT PROCESS

The following courses of action should be considered by the quantity surveyor and the procurement team when developing a procurement strategy:

- Reuse existing built assets – consider the need for new build. Is a new building really the answer to the client's needs, or is there another strategy that could deliver a more appropriate solution and add value?
- Design for minimum waste – think whole-life costs, involve the supply chain, specify performance requirements and think about recycled materials.

Sustainability in design requires a broad and long-term view of the environmental, economic and social impacts of particular decisions. Design out waste both from the process and the lifespan. As well as the obvious definition, waste can also include:

- the unnecessary consumption of land;
- lower than predicted yield from assets.

Consider 'lean construction' – in its entirety, this is for many a complex and nebulous concept; however, the ethos of lean construction with its focus on the following is worthy of consideration:

- continuous improvement
- waste elimination
- strong user focus
- high-quality management of projects and supply chains
- improved communications.

Minimise energy in construction and in use

Fully investigate the whole-life cost and life-cycle cost implication of the materials and systems that are being procured. Draw up environment profiles of components.

Do not pollute

Understand the environmental impacts of construction and have policies to manage such impacts in a positive manner.

Construction can have a direct and obvious impact on the environment. Sources of pollution can include:

- waste materials
- emissions from vehicles
- noise
- releases into water, ground and atmosphere.

Set targets

Use benchmarking and similar techniques discussed in Chapter 6 to monitor continuous improvement. UK construction industry key performance indicators (KPIs) are issued in June of each year.

Site waste management plans

Clearly, given the above statistics, the construction industry can address sustainability by reducing waste; for example, from 6 April 2008 Site Waste Management Plans were required for all construction projects with a value of over £300,000. The responsibility for the production of the site waste management plan is jointly shared between the client and the contractor and should contain the following details:

- types of waste removed from the site;
- identity of the person who removed the waste and their waste carrier registration number;
- a description of the waste;
- site that the waste was taken to;
- environmental permit or exemption held by the site where the material is taken.

However, following a comprehensive government review from December 2013 site waste management plans are no longer compulsory for construction projects in England. The reason cited was an attempt to reduce red tape.

Without doubt, sustainable considerations will continue to be high on the list of construction industry issues for the foreseeable future.

The RICS *New Rules of Measurement* (NRM) initiative

By the end of 2014 the RICS had launched three volumes of the *New Rules of Measurement:*

- NRM1: *Order of cost estimating and cost planning for capital building works*, 2nd edition (2012).
- NRM2: *Detailed measurement for capital building works* (2012).
- NRM3: *Order of cost estimating and cost planning for building maintenance works* (2014).

The suite of documents, the result of an initiative of the RICS Quantity Surveying and Construction UK Professional Group Board that began in 2003, aimed to more accurately reflect the changes that have taken place in procurement practice during the past 20 years or so, as well as, for the first time, to give guidance on the preparation of cost plans and whole-life costs. The rationale for the introduction of the NRM is that they provide:

- a standard set of measurement rules that are understandable by all those involved in a construction project, including the employer, thereby aiding communication between the project/design team and the employer;
- direction on how to describe and deal with cost allowances not reflected in measurable building work;
- a more universal approach which was required as it was thought that the SMM7 was too UK-centric.

The impact of the launch of the NRM suite will be explained and discussed more fully in the following chapters.

ETHICS AND THE QUANTITY SURVEYOR

Ethics is an important topic and particularly so for surveyors who operate in a sector that is generally perceived to have low ethical standards. Professions can only survive if the public retains confidence in them. Conducting professional activities in an ethical manner is at the heart professionalism and the trust that the general public has in professions such as the chartered quantity surveyor. One of the principal reasons for construction-related institutions like the RICS is to ensure that their members operate to high ethical standards, indeed ethical standards was a top priority on the 'RICS Agenda for Change' in 1998. For quantity surveyors, transparency and ethical behaviour is particularly important as they deal on a day-to-day basis with procurement, contractual arrangements, payments and valuations and client's money.

Interestingly in a survey carried out by the Chartered Institute of Building in 2006, nearly 40% of those questioned regarded the practice of cover pricing either 'not very corrupt' or 'not corrupt at all', regarding it as the way that the industry operates! In addition 41% of respondents admitted offering bribes on one or more occasions. One of the major issues from the CIOB survey is a clear lack of definition of corruption and corrupt practices. The industry is one that depends on personal relationships and yet a particular nebulous area in non-cash gifts that range from pens to free holidays.

Recently the RICS has published a number of guides/documents to help surveyors find their way through the ethical maze. These are:

- 'Professional ethics guidance note' (2000).
- 'Professional ethics guidance note: case studies' (2003).
- 'RICS Core Values' (2006).
- 'RICS Rules of Conduct for Members' (2007).
- 'RICS Rules of Conduct for Firms' (2007).

- 'Fraud in Construction – Follow the money' (2009).
- 'Fraud in Construction – RICS Guidance' (2010).

In addition to the above the RICS has also published a help sheet titled 'Maintaining Professional and Ethical Standards' in which the behaviour of a chartered surveyor in their professional life is characterised as follows:

1. **Act honourably** – never put your own gain above the welfare of your clients or others to whom you have a professional responsibility.
2. **Act with integrity** – be trustworthy in all that you do, never deliberately mislead, whether by withholding or distorting information.
3. **Be open and transparent** in your dealings.
4. **Be accountable** for all your actions and do not blame others if things go wrong.
5. **Know and act within your limitations** and competencies.
6. **Be objective at all times** – never let sentiments or your own interests cloud your judgement.
7. **Always treat others with respect** – never discriminate.
8. **Set a good example** in both public and private behaviour.
9. **Have the courage to make a stand.**
10. **Comply with relevant laws and regulations.**
11. **Avoid conflicts of interest** – declare any potential conflicts of personal or professional interest.
12. **Respect confidentiality** of client's affairs.

(Source: 'RICS Ethics Help Sheet', 2007)

Although the list above appears to be straightforward, things are never quite that simple in practice when matters such as economic survival and competition are added into the mix. The position is even more complicated when operating in countries outside the UK where ideas of ethics may be very different to those expected by the RICS.

BUILDING INFORMATION MODELLING (BIM)

Perhaps the big news since the second edition of this pocket book is the introduction of BIM into the UK construction industry. As discussed previously, the UK (England, Wales and Northern Ireland) government remains unconvinced that it is receiving value for money from construction procurement and therefore as part of the Government Construction Strategy 2011 announced that from April 2016 all central government funded projects must be BIM enabled to Level 2. In the tradition of UK government-led construction industry initiatives, the introduction of BIM was poorly handled to the extent that on deadline day the target had to be revised to public sponsored projects exceeding £10 million. Scotland will follow in 2017 for public sector projects over £4.32 million. Interestingly, the phrase 'central government funded projects' has come under scrutiny as there is uncertainty as to what projects actually fall into the category. For example, High Speed 2 (HS2) is centrally funded but is not obligated to apply the BIM mandate because it is a non-departmental government agency and therefore subject to a different compliance regime. It certainly does not appear to be the catch-all model envisaged at the time BIM was first announced in 2011.

As far as BIM adoption in the EU single market is concerned, the use of electronic communications with regard to procurement procedures is now mandatory (unless an exemption applies); however, all 28 member states have the opportunity to recommend or require the use of BIM on public projects. The EU Public Procurement Directive (EUPPD) states: 'For public works contracts and design contests, Member States may require the use of specific electronic tools, such as of building information electronic modelling tools or similar.' Clearly the use of BIM will not be mandatory, but the EUPPD does go some way in encouraging or pushing member states to recommend or specify the use of BIM; however, the tools and devices must not restrict access to public procurement. If the tools and devices proposed are not generally available, the contracting authorities must offer an alternative means of access. Furthermore, public contracts must comply with the principles of the Treaty of Rome on the Functioning of the European Union: equal treatment, non-discrimination, proportionality and transparency.

Early BIM adoption

As the 'National Building Specification (NBS) BIM Report 2016' illustrates, the construction industry's appetite for BIM appears to be less than enthusiastic. A survey of over a thousand organisations, taken immediately before the introduction of BIM into public sector procurement, indicated that just 54% of those approached were 'aware or had used BIM', with 42% not using BIM and 4% claiming not to be aware of BIM at all!

In addition early feedback from post-implementation surveys carried out in 2016 by CIOB/BIM with over 82 organisations appears to indicate that:

- 60% of respondents reported no increase in margins/fees/profit from BIM.
- 24% of respondents reported that BIM saved time during the construction phase.
- 40% or respondents reported that they have no intention to make BIM a requirement on their projects.

The problem, as always, is how to get a message across in such a fragmented industry – not just the top 50 companies, but the remaining 249,950!

What is BIM?

BIM is different things to different people and has been described as:

- a risk management tool;
- a way to increase the understanding of a project;
- an aid to the design team;
- an aid to the construction team;
- a communication tool.

BIM is the process of bringing together and sharing information in a digital format among all those involved in a construction project, including architects, engineers, surveyors and builders. By making information far more accessible and available to the client and end-user, to support through-life asset management, BIM is claimed to be a path to greater productivity, risk management, improved margins and sustainability. BIM envisages virtual construction of a facility prior to its actual physical construction, in order to reduce uncertainty, improve safety, work out problems, and simulate and analyse potential impacts. Subcontractors from every trade can input critical information into the model before beginning construction, with opportunities to prefabricate or pre-assemble some systems off site. Waste can be minimised on site and components delivered on a just-in-time basis rather than stockpiled on site.

A BIM digital representation of a building is structured as follows:

- building;
- spaces within the building;
- systems within the spaces;
- products that make up the spaces;
- the relationship/constraints between the spaces.

The use of digital fly-through models is commonplace today; however, with BIM it is the structured information behind the models that is so important and enables the project to be built digitally before being built on site. On site it can be used for the purchase of materials and checking compliance of systems and specifications.

Therefore, to put it simply, BIM is a process, facilitated by software, which is accessible by all the players in a construction project and is used to enter and store information on a project. The information need not only apply to the construction phase but also to the operation and maintenance of the completed project. In addition the software can produce virtual models of the complete/proposed project prior to start on site which facilitates:

- avoidance of design clashes;
- generation of quantities;
- the application of alternative solutions including cost estimates;
- sharing of information in real time;
- important information on running and maintenance regimes for the client;
- environmental assessments;
- quicker and easier design revisions;
- consistency of standards;
- more accurate scheduling of information;
- more accurate tendering processes;
- project planning and resource allocation;
- more efficient construction phasing;
- links to facilities management systems.

BIM is not a new idea and has been used in other industries since the 1970s. Facilities such as the NBS National BIM Library are now freely available. The library contains thousands of generic and manufacturer's BIM objects in 3D format, created to comply with global standards that can be dragged and dropped directly into models.

Challenges for BIM

Two major challenges have emerged for early BIM adopters. These are:

1. **Legal issues:** These issues centre around:
   - where the design liability lies – if something goes wrong, whose fault is it?;
   - ownership – who owns the model and the data within it?;

- copyright and intellectual property rights;
- who pays for the model?

2. **Culture change:** At a cultural level, communication, sharing of information and trust has never been the strong point of the UK construction process. To many this factor is the major obstacle to the adoption of BIM by UK plc.

What impact will BIM have on quantity surveying practice?

To some extent the jury is still out regarding this question. One thing is certain – BIM will not herald the death of the quantity surveyor. According to the RICS, BIM will 'enhance rather than damage' the quantity surveying profession. Others within the profession warn that BIM will not kill the quantity surveying profession, but firms that do not embrace the changes will lose relevance. The ability of BIM models to automatically generate cost estimates does not lessen the need for an expert to interpret the vast amounts of data produced, or to distil it into a form that clients can use to make informed decisions. Equally, the quality of the data you get out of a BIM model depends on what data you put into it and quantity surveyors are uniquely qualified to input and analyse output of data.

SOFT LANDINGS

The term 'soft landings' refers to a strategy adopted to ensure the transition from construction to occupation is as seamless as possible and that operational performance is optimised. Crucially, the quantity surveyor should be aware this transition needs to be considered throughout the development of a project, not just at the point of handover. The client should commit to adopting a soft landings strategy in the very early stages in order that an appropriate budget can be allocated and appointment agreements and briefing documents can include relevant requirements. This should include agreement to provide the information required for commissioning, training, facilities management and so on, and increasingly will include requirements for BIM. To ensure that a soft landings strategy is implemented properly from the outset, it may be appropriate to appoint a soft landings champion to oversee the strategy. Facilities managers should also be involved from the early stages. Soft landings documentation extends the duties of the team during handover and the first three years of occupation. Soft landings or Government Soft Landings (GSL), is a comparatively new approach and is focused at the point in a project when the client takes possession of the facility where traditionally the project manager, design team and contractor walk away, with the exception of contractual obligations relating to the rectification period. Soft landings is a joint initiative between BSRIA (Building Services Research and Information Association) and UBT (Usable Buildings Trust) and was devised in the late 1990s. It is an open-source framework available to use and adapt free of charge from BSRIA.

CHAPTER 4

04: Estimating and Tendering for Construction Chapter: Introduction

Chapter 1

Introduction

Evolution of estimating and tendering

The role of the estimator in main and specialist contracting has not changed, but aspects of pricing strategies and methods have. In the early 1980s, estimators began to embrace computers for the power of building complex price models, with the facility to change inputs, with powerful results. In the 1990s, estimators were sceptical about using historical data and cost plans as a basis of a bid. Since the beginning of this millennium, database systems and spreadsheets have competed as the tools of choice for estimators – sometimes both systems are used. Bespoke computer-aided estimating systems for handling the bills of quantities and spreadsheets for cost plans, cash flows and summary reports. We now see fewer estimating assistants in contractors' offices because estimators build the estimates themselves.

Batching projects in the public sector has allowed the adoption of cost plans as the route to tenders. A contractor bidding for a succession of schools, for example, deals with repetitive building designs which lend themselves to cost plans based on historical data. This works for the superstructure, but site conditions can introduce significant variations in cost.

The use of priced risk registers is now the 'norm'. Estimators record their concerns, and those of the whole team, at tender stage. Risk workshops provide a forum for the designers to contribute to the register. Risks and opportunities are managed from the outset of a tender so that the impact on the tender sum (for the client's benefit) can be reduced to a minimum.

Successful tenderers are no longer selected on price alone. All public contracts must now be awarded on the basis of the most economically advantageous tender (MEAT). There are now some elaborate scoring systems adopted to capture, over the life of a building, experience, designs, quality, sustainability and price.

The building industry has been showered with advisory reports and guidance publications, mostly aimed at producing integrated teams working efficiently and communicating electronically. New Rules of Measurement (NRM), introduced in 2013, bring a welcome support for order-of-cost documentation and detailed measurement principles. Also in 2013 came the new RIBA Plan of Work providing a framework for building design and construction. Perhaps the biggest change will be Building Information Modelling (BIM) – a catalyst for complete designs in 3D, well-coordinated and providing data for construction and beyond. BIM is an emerging technology and its success will depend on the steps people take towards implementation. A BIM culture will materialize when enthusiastic staff in each discipline push forward with implementation. History tells us that it will be slow but unavoidable.

Successful estimators are in demand throughout the construction industry in most countries. Their primary skills are listed in Figure 1.1. In addition, they need a working knowledge of: the selection plant, alternative materials and systems, environmental issues, soft landings, government

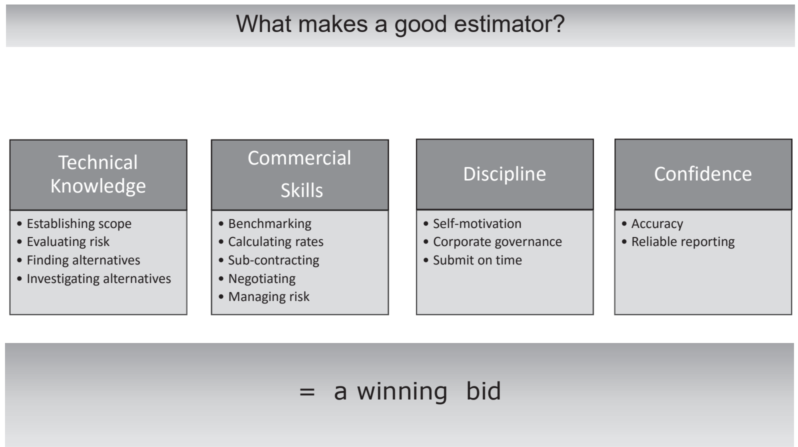


Figure 1.1 What makes a good estimator?

initiatives, contract responsibilities and negotiation skills. It is said that an estimator who can present a robust set of numbers in a settlement meeting – with confidence – will inspire management to take a less cautious stance and often will be more successful in winning bids.

Constituents of a tender price

A tender price is a sum of money required by a bidder to complete a construction project in accordance with the invitation to tender requirements and commercial setting. The estimator calculates the cost estimate, and management convert it into a tender, usually at the settlement meeting, by applying their commercial judgement to cash flow, risks, opportunities and expected return – overheads and profit.

Figure 1.2 shows a simple make-up of a tender. There are no longer nominated sub-contractors and suppliers; and contractors increasingly engage with sub-contractors for the work, thus eliminating nearly all of the direct works.

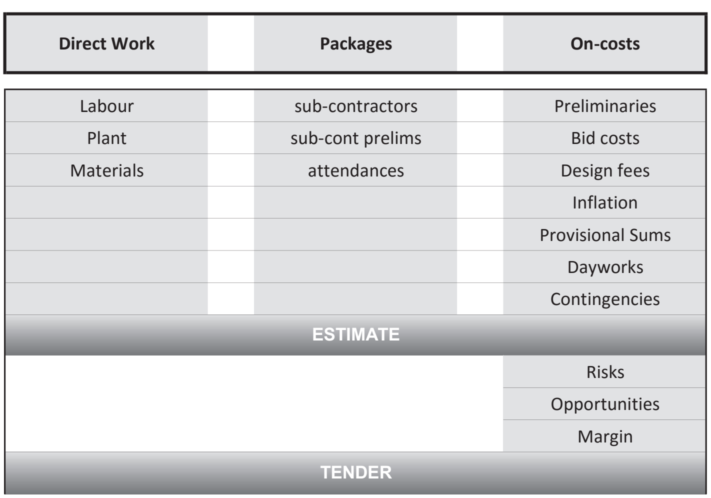


Figure 1.2 Constituents of a tender price.

Estimating cycle

There are three parts to modern estimating, shown in Figure 1.3. Estimating traditionally started with the receipt of tender documents in the form of drawings, bills of quantities and specifications. Some estimating was based on drawings and specifications which required a measurement stage before seeking market prices. With so many contracts now procured using the design-and-build system, contractors are involved much earlier and provide cost-planning services. A measurement exercise will still be needed, now at RIBA Stage 3 and 4.

The traditional approach to estimating is identified in Figure 1.4, and is well documented in both editions of the *CIOB Code of Estimating Practice*, published in 1997 and 2009. There are many references in this book to cost planning conducted in association with estimating, because many forms of procurement result in a design-and-build form of agreement. In other words, estimators are called on to advise on costs from inception to the collection of feedback data on completion – RIBA work stages 1 (preparation of brief) to 6 (handover and close out).

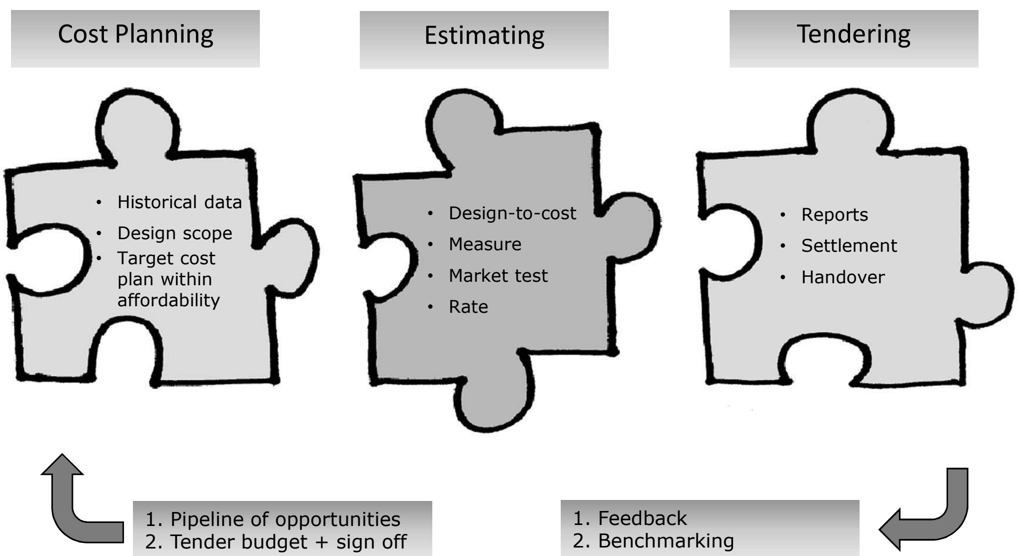


Figure 1.3 The estimating cycle.

Traditional estimating (see *CIOB Code of Estimating Practice*)	**Cost-planning and estimating** (in addition to traditional estimating)
Preselection and decision to tender	Collect benchmark data for similar buildings
Receipt of tender documents	Understand client's affordability – produce high-level cost plan to meet affordability
Tender strategy	Set design-to-cost targets in terms of elemental costs and specifications
Procurement	Work up designs with key sub-contractors. Obtain market rates and cost plans
Planning and temporary works	
Pricing the works	Attend design meetings to advise on design options. Check floor areas do not exceed targets.
Preliminaries	Project team given cost targets to meet
Completion of estimate	Benchmark data must be shown alongside the estimate figures
Tender settlement	Check that the design matches the pricing – some designers add embellishments later
Post-tender activities	Create elemental cost/specification sheet for use on future projects

Figure 1.4 Comparison between traditional and cost-planned tenders.

Top-down and bottom-up estimating

Top-down estimating is all about meeting, and improving on, a client's target price for a project. This is based on two assumptions: the client is prepared to state the target price before the design is developed, and there are reliable historical cost data available to the estimator.

If, for example, a client has a requirement for a hotel at a vacant city centre site, and can provide the following, a contractor can develop the first cost plan (Figure 1.5) in an elemental format:

1 a budget, say £31,000,000 excluding development costs, loose furniture and VAT;
2 a brief with a schedule of accommodation;
3 the quality expected – often expressed as a star rating;
4 an outline programme for design and construction;
5 some site survey and ground investigation reports.

Using the diagram in Figure 1.6, and starting with the affordability target, in this case £31,000,000, the estimator can first deduct a margin of 5 per cent on turnover. The figure before margin will be £31,000,000 × 0.95 = £29,450,000. By working through each of the on-cost categories, the estimator can establish the works cost, shown below in Figure 1.5.

Armed with this table of costs, allowances can be set for each element of the design. It can be seen that the engineering services portion is £5,947,500, which can be shared with an MEP (mechanical, electrical and plumbing) sub-contractor – assuming they are on the contractor's team. The final piece of work, at this early stage, is to agree some design statements with the design team. For example: where plant is to be located either within or on top of the building.

Cloud Construction Services
Stannet Cole Hotel

	Business Hotel 'Top-down' cost plan			
1	GIA	9,150	m2	
2	Bedrooms	200	Nr	
3	Storeys	11	nr	
3	**Affordability target**	**31,000,000**	%	
4	Target excluding margin	29,450,000	5%	on turnover
5	Target	29,450,000		< goal seek to get match
6	Risks and opportunities	1,000,887	4%	on prelims + works costs
7	Inflation	1,251,108	5%	on prelims + works costs
8	Design fees and surveys	1,958,256	9%	on works cost
9	Bid costs	217,584	1%	on works cost
10	Preliminaries	3,263,761	15%	on works cost
11				
12	**Works cost**	**21,758,404**	£/m2	
13	Facilitating works + abnormals	1,189,500	130	using knowledge of site
14	Substructure	732,000	80	design-to-cost target
15	Superstructure	7,320,000	800	design-to-cost target
16	Internal finishes	1,830,000	200	design-to-cost target
17	Fittings, furnishings and equipment	2,470,500	270	design-to-cost target
18	Services	5,947,500	650	design-to-cost target
19	External works	915,000	100	design-to-cost target
20	Design reserve	1,353,904		balancing item

Figure 1.5 Top-down cost plan using a client's affordability target.

In practice, the top-down cost plan will be produced in an NRM1 format by inserting the client's target at the bottom of the sheet.

Bottom-up estimating is characterized by working from a design solution, creating a bill of quantities and obtaining quotations for work packages. A planning manager will produce a programme, and preliminaries will be calculated late in the tender period. The estimate is completed immediately prior to the settlement meeting, which of course creates huge challenges if the design has to be changed due to cost overruns.

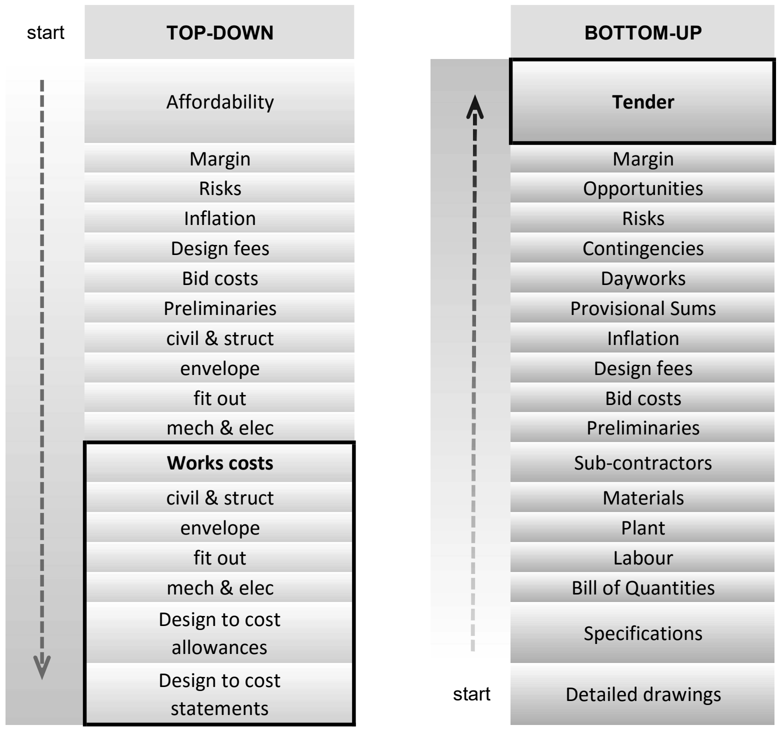


Figure 1.6 'Top-down' and 'Bottom-up' estimating.

Formats for cost plans

There are two principal formats for cost plans using spreadsheet software: bills of quantities in a single tab (linear bills) and bills of quantities on separate tabs representing the elements of a building.

Alternative 1: linear bills in cost plan workbook

Figures 1.7 to 1.9 illustrate a linear bill cost plan where all the work items are listed in a single worksheet. Other worksheets are reports derived from the first sheet. Here, an elemental summary has been produced (Figure 1.8) for submission to the client to satisfy the requirement for a contract sum analysis. Costs for each element are automatically taken from the linear bill, to the summary, using the 'sumif' formula.

The next sheet, Figure 1.9, has been created to list the work packages and their associated costs. This project comprises three buildings: Block 1, Block 2 and Community building. Package totals have been allocated to each building. This is achieved using the 'sumifs' formula in the Excel workbook.

A cost plan workbook will typically contain the following sheets:

- cover sheet
- tender settlement summary
- tender preparation notes
- floor areas broken down by buildings and floors
- linear bill of quantities

HYPARK CONSTRUCTION
Oldmills Skills Campus — COST PLAN - STAGE 3 **Linear Bill of Quantities**

Building	NRM	Sub	Element	Description	quant	unit	rate	Total
Block 1	**1.1**		**Substructure**	**Substructures** Building GIA =	**9,025**	**m2**	-	
Block 1	1.1	16	Substructure	Site clearance and excavation to reduced le	4,000	m2	5.00	20,000
Block 1	0.6	16	Abnormals	EO cost for providing 750mm total thicknes	4,496	m2	14.25	64,068
Block 1	0.6	16	Abnormals	Excavate to remove surface of piling mat 15	450	m3	25.00	11,250
Block 1	0.6	32	Abnormals	Piling as Earthbank Constr quote	1	Item	134,291.00	134,291
Block 1	0.6	16	Abnormals	Allow for disposal pile arisings	638	m3	25.00	15,950
Block 1	0.6	16	Abnormals	Allow for machine attendance	3	weeks	1,000.00	3,000
Block 1	0.6	16	Abnormals	Pile probing & cut down top of piles	300	Nr	55.00	16,500
Block 1	1.1	16	Substructure	RC Pile cap PC1; 2600 x 800 x 900mm	30	Nr	630.00	18,900
Block 1	1.1	16	Substructure	RC Pile cap PC2; 4400 x 800 x 900mm	1	Nr	1,010.00	1,010
Block 1	1.1	16	Substructure	RC Pile cap PC3; triangular; 2600 x 2350 x 9	16	Nr	1,030.00	16,480
Block 1	1.1	16	Substructure	RC Pile cap PC5; 2700 x 2700 x 900mm	8	Nr	1,680.00	13,440
Block 1	1.1	16	Substructure	RC Pile cap PC6; 4018 x 2700 x 900mm	10	Nr	2,445.00	24,450
Block 1	1.1	16	Substructure	RC Pile cap PC7; 4500 x 2700 x 900mm	1	Nr	2,780.00	2,780
Block 1	1.1	16	Substructure	Allow for VE reduced.pile cap sizes	1	Item	- 2,500.00	- 2,500
Block 1	1.1	16	Substructure	RC Ground beam; 800 x 650mm	282	m	100.75	28,412
Block 1	1.1	16	Substructure	RC Ground beam; 800 x 650mm	727	m	100.75	73,245
Block 1	1.1	16	Substructure	Allow for VE reduced ground beams	1	Item	- 3,500.00	- 3,500
Block 1	1.1	16	Substructure	Ground floor slab; 250mm thick	3,246	m2	102.50	332,715

Cover | **Lin Bill** | Elements | Packages | Cashflow | Areas

Figure 1.7 Linear bill of quantities in cost plan workbook.

HYPARK CONSTRUCTION
Oldmills Skills Campus — COST PLAN - STAGE 3 **Elements**

Project	**Oldmills Skills Campus - All buildings**	12,542	m2	
Cost Centre	Element	Cost/m2 of GIA	Total Cost	%
			£ 26,841,636	
	FACILITATING WORKS AND BUILDING WORKS			
0	Facilitating works [insert summation of all	115	1,442,601	5%
0.6	Abnormals - relating to chosen site	115	1,442,601	5%
1	Substructure	85	1,070,047	4%
1.1	Substructure	85	1,070,047	4%
2	Superstructure	569	7,135,324	27%
2.1	Frame	141	1,765,018	7%
2.2	Upper floors	48	600,663	2%
2.3	Roof	57	709,065	3%
2.4	Stairs and ramps	17	208,584	1%
2.5	External walls	100	1,250,636	5%
2.6	Windows and external doors	69	863,948	3%
2.7	Internal walls and partitions	106	1,331,920	5%
2.8	Internal doors	32	405,491	2%
3	Internal finishes	80	1,000,158	4%
3.1	Wall finishes	13	168,795	1%
3.2	Floor finishes	43	542,864	2%
3.3	Ceiling finishes	23	288,499	1%
	… etc			

Cover | Lin Bill | **Elements** | Packages | Cashflow | Areas

Figure 1.8 Elemental summary in cost plan workbook (data in column I using formula 'sumif…').

HYPARK CONSTRUCTION
Oldmills Skills Campus — COST PLAN - STAGE 3 **Packages**

Ref	Package	Location	G	H	I	J
Project	**Oldmills Skills Campus**		9,025	3,297	220	12,542
		Package totals	£ 13,565,000	£ 6,288,115	£ 352,866	£ 20,205,981
Ref	**Package**	**Location**	Block 1	Block 2	Community	TOTAL
1	Aluminium Windows & Doors		533,209	248,457	20,809	802,475
2	Brickwork/blockwork/render		121,624	61,335	10,259	193,218
3	Bris soleil		23,800	7,350	-	31,150
4	BWIC M&E Installation		136,686	69,194	3,462	209,342
5	Cladding & Roofing		584,522	194,572	34,000	813,094
6	Concrete Frame		307,903	108,771	6,600	423,274
7	Demolition		168,673	70,332	-	239,005
8	Demoliton, repairs and alterations		-	-	-	-
9	External Rendering		140,938	73,905	2,800	217,643
10	Fencing/Barriers		83,780	156,310	-	240,090
11	Fire Protection		57,313	32,125	2,900	92,338
12	Floor & Wall Tiling		7,365	2,720	899	10,984
13	Furniture and fittings		1,104,308	354,696	8,800	1,467,804
14	Grilles and Shutters		3,000	15,792	897	19,689
15	Groundworks drainage and service trenches		294,735	313,110	-	607,845
16	Groundworks sub-structures		927,311	399,618	18,150	1,345,078
17	Groundworks site works		607,588	187,326	-	794,915
18	Highway Works		60,480	-	-	60,480
19	ICT infrastructure structured cabling		569,104	171,627	13,500	754,231
	… etc					

Cover | Lin Bill | Elements | **Packages** | Cashflow | Areas

Figure 1.9 Package summary in cost plan workbook (data in columns G to I using formula 'sumifs…').

- preliminaries
- elemental summary
- package summary
- value-drawdown chart
- elemental cost summary for submission to client
- benchmarking data
- priced risk and opportunities schedule
- life-cycle information for a life-cycle manager to understand the likely capital replacement costs.

The linear bill of quantities and preliminaries sheets provide the data for all the other reports.

Alternative 2: cost plan workbook with separate tabs for each element

A cost plan, where bills of quantities are spread across separate tabs, has been a popular format since spreadsheets became a widespread tool for producing a cost plan. Figure 1.10 is an example of a cost plan with the internal doors worksheet open. This layout has the benefit of simplicity, but some serious drawbacks, as follows:

1 Each page total has to be linked to the elemental summary.
2 With multiple buildings in a project, there will be a separate workbook file for each building.

3 It is very difficult to produce a package summary where each building is shown in a 'side-by-side' format (shown in Figure 1.9).
4 In a similar way, it would be difficult to produce other reports such as tender summaries and cash flow forecasts for the three buildings shown in Figures 1.7 to 1.9.

HYPARK CONSTRUCTION

Oldmills Skills Campus COST PLAN - STAGE 3 **BLOCK 1**

	Internal doors	Quant	Unit	Rate	£
1	Carpentry as WYY quote - supply and fix				
2	Single classroom doors; incl frame + ironmongery	173	Nr	1,150	198,950
3	Double doors; incl frame + ironmongery	35	Nr	1,650	57,750
4	Riser double doors	17	Nr	1,600	27,200
5	Extra over single door for glazed side panel	64	m2	700	44,800
6	Fire shutter to kitchen servery 7150 x 1200	1	Nr	3,100	3,100
7	Painting to internal woodwork as Doker quote	1	sum	23,500	23,500
8	Allowance for Blackwell locks	1	sum	11,500	11,500
9	Sub-contract preliminaries	12	%	366,800	44,016
	TOTAL FOR INTERNAL DOORS			£	410,816

Ext walls | Windows | Int walls | **Int doors** | Wall fin | Floor fin | Ceiling fin | FF+E

Figure 1.10 Internal doors sheet in a workbook with elemental cost plan tabs.

The Public Contracts Regulations 2015

New public contracts regulations came into force in 2015 – aligned with EU public sector procurement directives, they clarify and simplify EU public procurement law.

Competitive procedure with negotiation will be a preferred procurement route where prior negotiations are necessary due to specific circumstances related to the nature, complexity or risk profile of the contract. The competitive procedure with negotiation is intended for use when the open or restricted procedures are unlikely to lead to a satisfactory outcome.

Award criteria (Regulations 67 and 68) says that all public contracts must now be awarded on the basis of the MEAT. This means that the evaluation of bids must be on the basis of the best quality/price ratio. However, authorities are permitted to determine MEAT on the basis of price or cost alone.

Whole-life costs can also be used for the purpose of awarding a contract. An authority wishing to base their award on whole-life costs must clearly set out the criteria for award in their invitations to tender. In a recent competition to design, build and operate a major hospital, the client set a target floor area which was deemed to be the most economical long-term design solution. Any excess area offered by the tenderers was penalized by a rate of £x/m^2 per annum for the duration of the concession. The reason for this criterion was that each square metre of building needs heating, cleaning and maintenance for a 30-year period.

Experience of the staff: an authority can include organization, qualifications and experience of staff allocated to a project in the award criteria.

Abnormally low tenders need to be investigated by contracting authorities. The regulations set a number of elements of a tender that can be assessed by consulting the tenderer. The authority may reject the abnormally low bid where the evidence supplied does not satisfactorily account for the low level of price proposed.

Communications and information exchange are to be by electronic means of communication, although there are a few exceptions listed in the regulations.

Unrestricted and full direct access to procurement documents (Regulation 53) is a requirement of authorities. They are to offer unrestricted and full direct access to procurement documents from the date of publication of the OJEU notice (or the date on which an invitation to confirm interest is sent). Procurement documents are to be available electronically from the date of the OJEU advertisement. For many contracting authorities, this means starting the preparation of tender documents at an earlier stage than is currently the case.

Electronic auctions (Regulation 35) are permitted whereby new prices are submitted electronically (in a live bidding process) with the intention that prices are revised downwards (as opposed to upwards in a traditional auction). Bidders may also submit prices for elements of the auction. A set of rules is set out for the conduct of an e-auction.

A standstill period of ten days is required from notification of an award to the signing of a contract with the successful bidder. This first became compulsory in the UK in 2005, in order to allow unsuccessful bidders to challenge the decision before the contract is signed.

CHAPTER 5

05: Building Measurement Chapter: Introduction

1 Introduction

1.01 Getting started
1.02 Context and purpose
1.03 General principles
1.04 The classification system
1.05 Traditional tendering

1.01 Getting started

Before starting we need to establish the purpose and intention of measurement. If you were asked to measure a building, or the room you are in right now, most people would find a measuring tape, a clipboard and something to write with. You might sketch out the plan shape of the building or room and write the individual lengths and widths down as you go along.

ACTIVITY: If you can, try sketching the plan shape of the room you are in right now. Get a tape measure and record the principal lengths and widths and annotate your sketch of the floor layout (plan) by recording the plan dimensions. It doesn't matter if you haven't got a tape measure to hand – you can simply 'pace the room'. This will obviously depend on how big your stride is so, for the purposes of getting you started we will just assume that one of your strides is equivalent to one metre.

TIP: most rooms are a regular shape (rectangular), so you will only need to measure one width and one length. Older buildings (and some poorly constructed new ones) may be 'out of square', so the above technique may not be appropriate. One way of checking whether a room is square is to measure both of its diagonals (from one corner of the room to the other). If the two diagonal dimensions are the same then it is a safe bet that the room is square and each of the corners is at 90 degrees.

Being able to read and draw to scale is an important part of what quantity surveyors call measurement.

Once you know the length, area or volume of the various components that go together to make up a finished building, you are in a position to allocate costs based on the units that you have measured. For example, if you were measuring a skirting board and you knew how much it cost per metre, finding the total cost once you know the internal room dimensions (perimeter length) is straightforward (Figure 1.1).

Recording dimensions from finished buildings is one way of finding out how much the building will cost. Once you are able to 'read' scale drawings and 'record dimensions' it becomes possible to cost buildings even before they are built. In essence, this is the service that a quantity surveyor offers to a client.

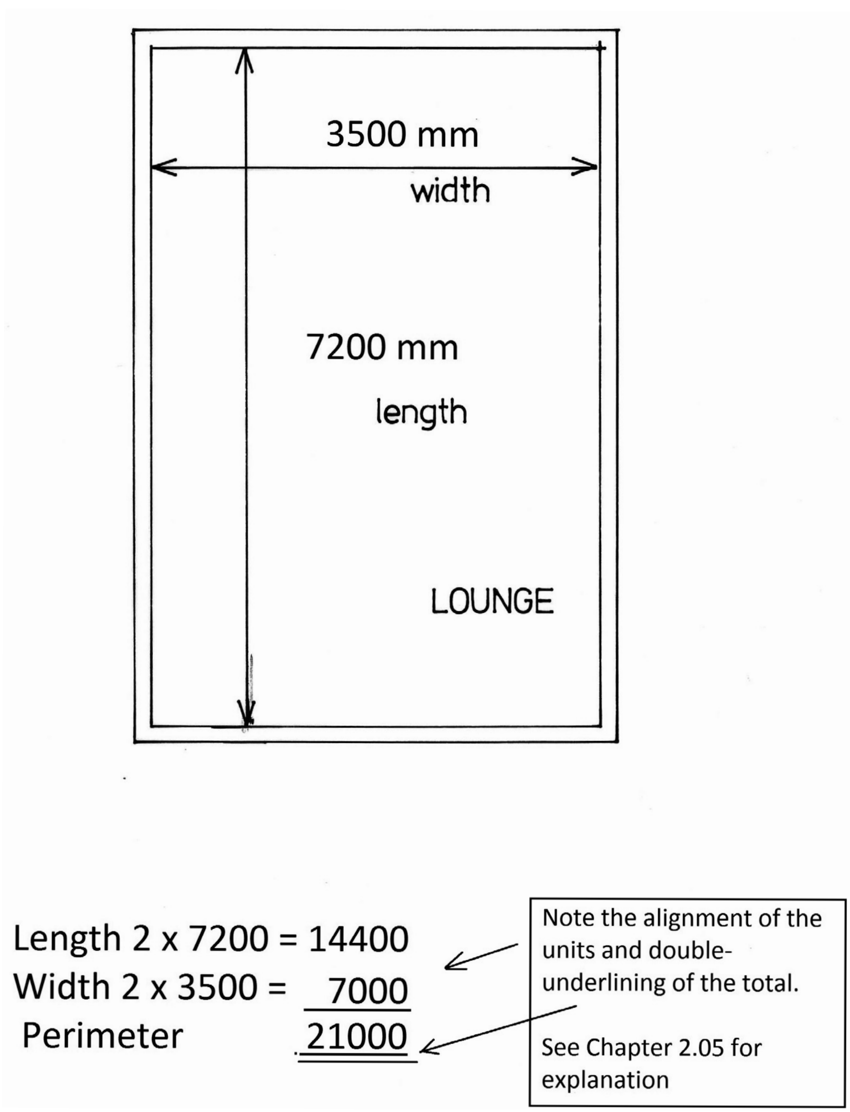


Figure 1.1 Dimensioned plan of room.

One of the first things that anyone thinking about commissioning a new building wants to know is 'how much?' By measuring the individual components and then allocating a cost to these, the likely finished build cost can be established. Simply adding together all of these individual components will give the total building cost.

OK, so this sounds simple enough but there are some other things to consider, especially when we are dealing with an idea that was 'in someone's head' and is now in the form of a drawing rather than a finished building.

With a finished building we can see its quality (or not) both in terms of the materials used and the workmanship. If we are measuring from a drawing this isn't going to be so obvious. This is of course significant when we are applying costs to our measured items. Consider the skirting we measured earlier around the perimeter of a room. A softwood skirting (pine) is likely to cost less than a hardwood (oak) equivalent; so we need to have some indication of the quality of the materials and the standard of workmanship required before we can state with certainty what things will cost.

So a set of measurements from a scale drawing isn't enough on its own. In order to cost a building we need to know two things: how much is there (the quantity) and what quality of finish/standard is required/expected (the specification).

1.02 Context and purpose

To the uninitiated, the phrase 'building measurement' brings to mind the fixed notion of a tape, a building and some numbers. One thing it probably does not immediately imply is cost and forecasting. Yet the purpose of measurement in this context is inextricably linked with providing an assessment of the cost of a building long before work has commenced on site. Initially, and most importantly, someone requires the provision of a new building. Normally they are likely to approach an architect so that their ideas and intentions can be set down on paper. It is very likely, even at this early stage, that they will need to know how much the building design proposals are going to cost (Figure 1.2a, b).

Armed with a set of drawings, a scale rule and a calculator, measurements can be taken from these drawings and a document produced. This document identifies in some detail the component parts of the proposed works, together with their quantity, and will allow construction costs to be allocated to the appropriate parts of the building. Having costed each component, a forecast for the scheme can be established (Figure 1.3).

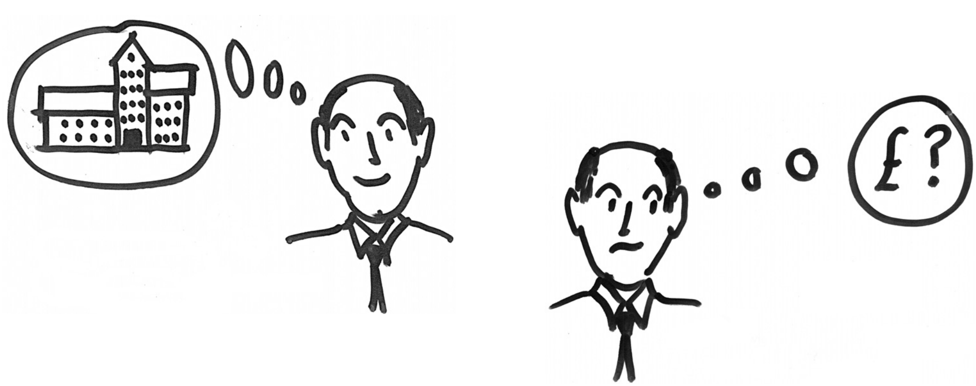


Figure 1.2 A building is proposed – how much will it cost?

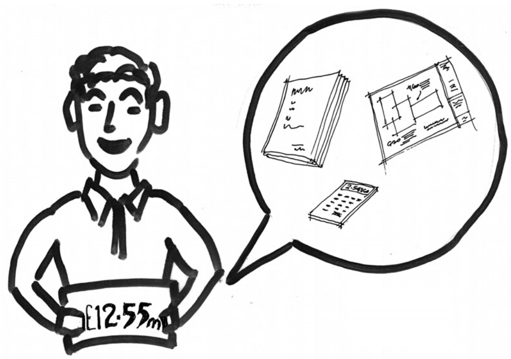


Figure 1.3 A forecast of the proposed scheme is prepared.

To enable this forecast of cost to be made with any confidence, a number of basic principles must be in place. It is very important that none of the building operations are overlooked and that the items which have to be costed are presented in a recognisable form. The consequence of an error in measurement or ambiguity in a description could result in the client being ill-advised with regard to the eventual cost of building operations.

1.03 General principles

Having identified the purpose of measuring building work it is necessary to establish the general principles that will ultimately result in a document which is mutually understood and conveys the scale and extent of the construction. A consistent approach is necessary both in terms of presenting this finished document and setting down dimensions so that others are able to understand our approach (Figure 1.4).

It is not hard to imagine the confusion that would result if everyone adopted their own set of rules when measuring building work. It was exactly this situation that prompted the publication in 1922 of the first nationally recognised (UK) set of rules for the measurement of building work. An indication of the chaotic state of affairs that prevailed prior to this

Figure 1.4 Clearly understood set of documents.

publication can be gleaned from reading the preface of this very first edition. Phrases such as 'diversity of practice' and 'idiosyncrasies of individual surveyors' suggest a picture of confusion and doubt for the hapless early twentieth-century contractor. Almost a century later, the same set of principles still apply. Now in an eighth edition, the current document *NRM2: Detailed Measurement for Building Works* provides the basic principles for the measurement of building work.

A report commissioned by the RICS Quantity Surveying and Construction Professional Group (Measurement-based procurement of buildings; 2003) claimed that the (then) current version of the Standard Method of Measurement (SMM7) was out of date and represented a time when bills of quantities and tender documents were required to be measured in greater detail than was warranted by procurement practice. At the same time it reported that the rise in the use of design and build procurement had encouraged the use of contractors' bills of quantities where few documents were prepared in a standard recognised form.

Importantly the report confirmed that some form of measurement remained necessary in the procurement of buildings, and that any new method of measurement would need to be flexible enough to accommodate the different ways that measurement was used. So any replacement document would need to be accessible and functional for a variety of different clients, contractors, subcontractors and suppliers in the procurement process. In short, it was time for an overhaul and an update.

Rather than 'reinventing the wheel' each time it was necessary to update construction costs, the new approach would need to allow the measured information and associated cost data to be passed on to the next stage. Different approaches to measurement and quantification at different stages in the design would of course remain necessary. However, wherever possible, any measurement/costs established for early-stage cost advice could be refined to inform approximate estimates, cost plans, bills of quantities and eventually the maintenance and repair costs of an operational building. This was the philosophy that underpinned the drafting of a suite of three interoperable documents – NRM1, NRM2 and NRM3 (Figure 1.5).

NRM1: Order of cost estimating and cost planning for capital building works.
NRM2: Detailed measurement for building works.
NRM3: Order of cost estimating and cost planning for building maintenance works.

Measurement can therefore be identified as the starting point from which construction costs are established. There is a standard format for the presentation of measured work and a set

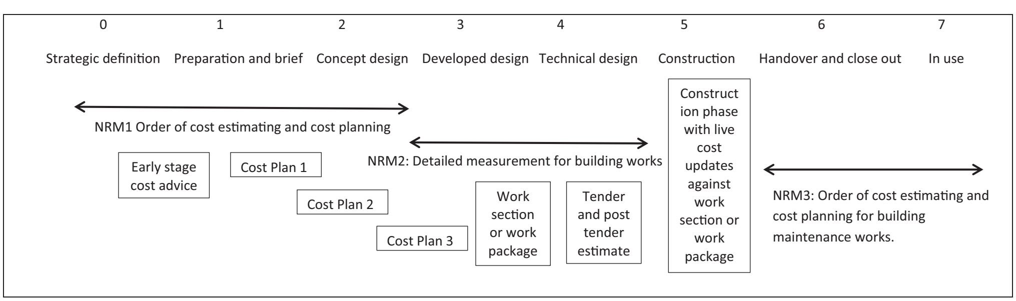


Figure 1.5 Timeline showing the NRM suite of documents with stage of estimating/costing mapped against RIBA Plan of Work (2013).

of rules that are mutually known and accepted. These rules are embodied in a document called *The New Rules of Measurement 2* (NRM2). *The New Rules of Measurement 2* is generally recognised by the acronym NRM2 and further defined by the phrase 'detailed measurement for building work'.

In turn, measurement provides the basis for the preparation of a Bill of Quantities (BQ). This document sets out the quality and quantity of all the component parts necessary for the construction of the works. It is prepared in a predetermined order which, in normal circumstances, would follow the same sequence as the work sections presented in NRM2.

Assuming a contract based on traditional tendering, each contractor would receive an identical set of tender documents including a BQ, architect's and structural engineer's drawings and a specification. Until recently these documents were prepared and provided to tenderers as hard copy, but more recently they became available electronically. See sections 4.01 and 4.02 for further details of Building Information Modelling (BIM) and e-tendering.

The costing columns of the BQs are completed, extended and totalled independently by each tendering contractor in order to establish a tender price for the completion of the construction work. Individual tenders are submitted and compared to the other tenders received. The client, acting on advice, normally accepts the most suitable tender and enters into a formal agreement with the selected contractor. The BQs, along with the drawings, specification and schedules, will eventually become part of the contract documentation to which both parties are formally contracted. While this costing activity achieves the principal function of the BQ (and thereby the measurement process), it also provides a valuable insight into the financial management of the project during, and to some extent after, the construction process. There are more sophisticated variants of the tender procedure described above but whichever technique is used, all construction costs will, at some stage, have been prepared from quantities established by the process of measurement.

The remainder of this text offers an interpretation by description and example of the techniques that are commonly practised in the preparation of detailed measurement in order to produce a BQ prepared in accordance with NRM2. Custom and practice will vary between individual surveyors, and the examples and procedures given here should not be considered as irrevocable. In spite of the rigours of NRM2, it is not unusual for individual practice to vary. With this in mind, the reader is advised that the techniques described and illustrated here should be regarded as recommendation rather than prescription.

1.04 The classification system

In the very first place, someone has to agree a system of classification for the construction process. It has to be sufficiently robust to embrace the variety of trades employed in the construction process, detailed enough to allow for technical distinctions and commonly understood by all those who use it. NRM2 was established to achieve these goals and has been adopted as the framework with which the detailed measurement of building work should be drafted. The classification system is loosely based on the pattern of trades employed during building operations. The order in which these are presented generally reflects the sequence of events as they are likely to occur on site. While the details might not always be obvious, the general coverage of each of the TABULATED WORK SECTIONS is clearly recognisable from the Work Section title. At this point it would be helpful to have a copy of NRM2 to hand so that the readers can begin to familiarise themselves with the structure and sequence adopted when preparing detailed measurement for building work. A free pdf download of NRM2 is available from the Royal Institution of Chartered Surveyors (RICS) – available to members and student members. In order for detailed measurement to take place it is a condition of NRM2 that sufficient design and production data are available (Figure 1.6)

For the purposes of measurement, NRM2 identifies a 'trade-specific' set of rules under each of the above Work Sections. The rules of measurement for the various trades or work

No.	Work Section:
2	Off-site manufactured materials, components and buildings:
3	Demolitions;
4	Alterations, repairs and conservation;
5	Excavating and filling;
6	Ground remediation and soil stabilisation;
7	Piling;
8	Underpinning;
9	Diaphragm walls and embedded retaining walls;
10	Crib walls, gabions and reinforced earth;
11	In-situ concrete works;
12	Precast/composite concrete;
13	Precast concrete;
14	Masonry;
15	Structural metalwork;
16	Carpentry;
17	Sheet roof coverings;
18	Tile and slate roof and wall coverings;
19	Waterproofing;
20	Proprietary linings and partitions;
21	Cladding and covering;
22	General joinery;
23	Windows, screens and lights;
24	Doors, shutters and hatches;
25	Stairs, walkways and balustrades;
26	Metalwork;
27	Glazing;
28	Floor, wall, ceiling and roof finishings;
29	Decoration;
30	Suspended ceilings;
31	Insulation, fire stopping and fire protection;
32	Furniture, fittings and equipment;
33	Drainage above ground;
34	Drainage below ground;
35	Site works;
36	Fencing;
37	Soft landscaping;
38	Mechanical services;
39	Electrical services;
40	Transportation; and
41	Builder's work in connection with mechanical, electrical and transportation installations.

Figure 1.6 NRM2 work sections (RICS Publications).

packages are presented in a table using a numerical prefix to distinguish each work section. The coding/classification system adopted by the NRM suite of documents (NRM1, NRM2 and NRM3) is intended to be interchangeable, allowing measurement and costings to be mutually interoperable across all documents. Details relating to the application of this coding system are explained in NRM2 2.15.3.

Specific measurement rules relating to particular trades can be found in NRM2 under each Work Section (see Figure 1.6). This is supplemented by general measurement rules that precede this and apply to the measurement of all construction operations. These rules comprise a uniform basis for measuring, describing and billing building works. To this end they identify the standard of accuracy necessary for recording quantities (NRM2 3.3 Measurement Rules for building work), together with definitions and interpretations for written descriptions. The application of these rules to specific trades forms the basis of Chapters 5 to 15 of this text. Reference is also made to the way in which the tabulated rules should be implemented. The following is an extract from NRM2 work section 5 Excavation and filling, and is included here to illustrate this (Figure 1.7).

Figure 1.7 shows an example of the tabular arrangement for NRM2 Work Section 5 Excavation and Filling. The first set of columns lists descriptive features that are commonly encountered in building operations, labelled 'items of work to be measured' (in this instance, excavation). The second narrow column is reserved for the appropriate unit of measurement (in this instance, cubic metres). The third provides sub-groups into which each main group can be further subdivided (known as level one) and the fourth distinguishes still further subdivision (known as level two). The fifth column (level three) identifies particular features unique to certain situations (in this case only one option is offered). Where appropriate, more than one feature may be selected from this column. The final column provides comments, definitions and interpretations. Descriptions are generated by selecting an appropriate descriptive feature from each column working from left to right (see selected text in Figure 1.7).

Item or work to be measured	Unit	Level one	Level two	Level three	Notes, comments and glossary
5 Site preparation—*cont.*	nr	4 Remove specific items.	1 Dimensioned description sufficient to identify size and location of each item.		1 Any existing items on site not specifically designated to remain including all types of rubbish such as abandoned cars, fridges and the like. 2 This excludes all but the simplest of building structures whose demolition is covered in Work Section 3: Demolitions. 3 Removal of any associated foundations, fixings, supports, fastenings and the like is deemed included.
6 Excavation, commencing level stated if not original ground level	m^3	1 Bulk excavation.	1 Not exceeding 2m deep 2 Over 2m not exceeding 4m deep. 3 And thereafter in stages of 2m.	1 Details of obstructions in ground to be stated.	1 Bulk excavation includes excavating to reduce levels or to form basements, pools, ponds or the like. For clarity each type of excavation may be measured and described separately. 2 Obstructions will be piles, manholes and the like that must remain undisturbed.
	m^3	2 Foundation excavation.			1 Foundation excavation includes excavating for strip and pad foundations, pile caps and all other types of foundations. 2 For clarity each type of excavation may be measured and described separately.

Figure 1.7 Building descriptions by selecting pre-defined phraseology from NRM2 Work Sections (example shows Excavation and Filling) (RICS Publications).

The measurer should observe and maintain the wording available within each set of horizontal lines when 'building' each description.

1.05 Traditional tendering

There are many reasons for requiring building work to be measured but the principal purpose is to identify cost. In order to give a client some indication of the likely cost for the proposal, early-stage construction cost estimates can be prepared. These are based on the client's anticipated use of floor space. While useful in providing a range of construction cost (lowest to highest), these are not regarded as reliable since they are frequently prepared on incomplete detail and limited specification. At best they provide the client with an indication of the likely cost. As the design progresses, an improved level of detail becomes available and early-stage cost advice can be refined and improved to reflect this.

Once the design is complete the measurement process can commence and a BQ can be produced. The BQ forms the basis of the tender process and will be priced by a number of competing contractors. Each will price the quantities independently to arrive at a total cost for the work (Figure 1.8).

The pricing process, once completed and totalled, provides the basis for a returned tender. For the successful contractor (usually the lowest returned tender) the priced BQ is incorporated with other documents into a formal contract. Both contractor and client are then legally bound to perform their respective parts of this contract: the contractor to build and the client to pay the agreed sum upon satisfactory completion of the works.

	St Joseph's Upper School – Phase 1				£	p
	5 EXCAVATION & FILLING					
	The work comprises the excavation and associated substructures for a detached residential property all in accordance with Structural Engineer's drawing reference ATR200289. The ground is assumed to consist of 150mm of topsoil overlaying clay and sandstone depths all as detailed in the Structural Engineer's borehole log schedule dated 04/11/2020. The site is substantially level with existing GL established at 100.000. Groundwater level was established at 4.60m (95.400) below existing GL on 04/11/2020. No over or underground services cross the site					
	Preliminary site work;					
	Boreholes to determine ground conditions					
A	100mm diameter, 18.00 metres maximum depth	6	nr	720.00	4,320	00
B	100mm diameter, 24.00 metres maximum depth	4	nr	800.00	3,200	00
	Removing trees					
C	girth 500 -1500mm	8	nr	280.00	2,240	00
D	girth 1500 -3000mm	4	nr	558.00	2,232	00
	Removing tree stumps					
E	girth 500 -1500mm, backfilled with excavated materials	8	nr	120.00	960	00
F	girth 1500 -3000mm, backfilled with excavated materials	4	nr	180.00	720	00
	Site Clearance					
G	Clear site of all vegetation and other growth, dispose of off site	1154	m^2	2.82	3,254	28
	Page 3/45			To Collection	16,926	28

description and quantity columns completed by quantity surveyor

costing columns completed by contractor

Figure 1.8 BQ page showing completed pricing and page collection total.

CHAPTER 6

06: Total Construction Management Chapter: Understanding lean construction

Understanding lean construction

1

Lean quality in construction

Two major management movements have swept over the construction sector in the past 25 years: first of all, the Quality movement initiated by public sector clients mandating compliance with ISO 9000 in the early 1990s and more recently the Lean Construction movement. Currently leading clients for construction services are beginning to require their suppliers and their supply chains to demonstrate a lean approach to their businesses. Some, like Highways England and Crossrail, are even supporting the transformation with a maturity model, performance measures, metrics and resources/training. Both of these significant transformational philosophies, quality and lean, have taken root in other industry sectors well before early adopters in construction have recognized their value. Today we have mature examples of successful lean quality implementation in the construction sector, though we do have to look around the world to find our examples. This book presents the lead adopters in the form of a series of case studies of lean quality management. The book also postulates that lean and quality are two slightly different lenses through which we view management excellence and argues that these perspectives are merging. For example, the 2015 version of the International Standard on Quality Management System Requirements ISO 9001 introduced continuous improvement into the quality framework in a formal sense for the first time.

A case study

We start this book by exploring the unique characteristics of construction and developing an understanding of the specific challenges faced by design and construction organizations in implementing lean quality. Let us begin with an interesting vignette. In 1913, the Commonwealth Bank of Australia, one of Australia's leading banks at the time, commissioned a new building at the corner of Martin Place and Pitt Street in Sydney. The building was six stories high, had a massive sandstone façade, its footprint was approximately 100 metres square with a light well in the centre for ventilation and natural light.

The drawings for this building, which would cost some $200 million in today's terms, consisted of a single A1 sheet with three images on it, a dimensioned plan, an elevation and a dimensioned cross section, all neatly coloured (Figure 1.1).

The entire contract documentation for the project consisted of:

- these three drawings on one sheet;
- a handwritten statement on the back of this single sheet stating: I hereby undertake to build the building described overleaf for $700;
- 53 pages of scope of work/specification; and
- 4 pages of contract conditions.

FIGURE 1.1
Photograph of the Commonwealth Bank of Australia building at its opening in 1916

Today such limited documentation is unimaginable (of course, the services in our buildings are much more complex), we would have many hundreds of drawings and thousands of pages of contract documentation. What has changed?

When this building was commissioned and built, the architect would have had the quantity surveyor and design engineers in-house as a part of his team. Similarly, the contractor would have had the major trades in-house, with construction teams led by master tradesmen. This story tells us a number of things:

- There was one way of building and master tradesmen had the skill and knowledge to build major buildings from simple depictions, and quality was ensured by the high standard and integrity of the master tradesmen.
- The brief contract (4 pages of contract conditions) demonstrates that there was a high level of trust between the client and contractor for this project. A simple contract such as this for a project of this size is unimaginable today.
- The organizations designing and building were integrated and had control over their resources. They could plan the workflow in detail as they had control of all of the resources required to undertake the work.

Distinguishing features of construction projects

The construction industry does have a number of unique features which create challenges for the sector:

- projects are uniquely designed or modified to fit a specific site, the needs of a specific client or client group;
- constructed products are large and fixed in location; hence, in contrast to manufacturing, here it is the work teams that move past the product progressively adding value rather than the product moving through a number of work stations;
- generally, the work teams are from different subcontracting organizations rather than from a single organization, creating challenges for coordination and integration of the product design and the production and assembly process;
- the time frame for larger projects is measured in years, and, increasingly, the design phase and construction are, to some extent, concurrent;
- because of the long time frame of projects, the people involved will invariably change over time;
- on larger projects, in particular, the relationship between the parties is mediated by varying commercial terms and organizational arrangements; this diversity creates further significant variables which alter organizational structures, risk allocation, and the responsibilities of the parties from project to project;
- the client is often involved both in the design and construction phases, defining needs and choosing between alternative solutions, hence, influencing function, cost, and risk while the project design is under development and during construction;
- importantly, when the client has an ongoing interaction with the designers and constructers, the quality of the services will influence relationships and can distort customer perceptions of product quality: either positively or negatively;
- the corollary to this is that clients' approach to their role and function can significantly shift the culture and cost of the project: once again, in either a positive or negative direction; and finally,
- quality is considered almost entirely in product terms, yet the creation of a quality design and construction process, an effective collaboration between numerous suppliers from the early design stage to completion of construction is the greatest challenge – this is not owned by any one party; rather, it is achieved through the negotiations and collaboration of the many players; and it is the industry's processes which determine key outcomes.

Recent decades have seen the rapid globalization in all sections of the construction sector. It started with the emergence of global materials businesses in areas such as cement production, concrete production, brick, plasterboard, construction chemicals and timber processing. At the same time, the specialist requirements of major energy and infrastructure projects led to the development of global EPC (engineering, procurement and construction) businesses such as Bechtel and Fluor Daniel. Also during this period, global specialist design, fabricate and install businesses emerged to supply, install and service elevators, air conditioning, fire systems, electrical and control systems. Most recently, global architectural and engineering consulting businesses have been created.

In today's global construction sector, even mid-sized businesses can procure quite sophisticated products and services globally. Local design teams collaborate with others around the world creating the opportunity for 24/7 services. Often, back-office services such as accounting and call centres are relocated to more economical destinations within the country or internationally. Naturally, geographic diversification brings with it special challenges in terms of the seamless, defect-free delivery of complex products and services.

Today's industry

Among owners today there is a widespread belief that the lowest cost tendered on a project represents best value. On large complex projects nothing can be further from the truth. In fact, by adopting this method of procurement, owners have traded-off flexibility and the ability to collaborate and innovate across the supply chain for the illusion of cost certainty. We say illusion because large complex projects are almost inevitably time critical; they are unique; and they run over several years. Therefore, the final scope is rarely the same as the one priced at the outset.

Nowadays, clients are reluctant to invest in solution generation upfront; they are generally in a rush to start, and they tend to push decisions and risk down the supply chain. Under these circumstances, all risks are priced conservatively to cover the suppliers' risk in the absence of information; and client changes during the project are priced as variations and usually command a price premium.

Today's industry is extremely fragmented and specialized; numerous alternative technologies exist for each part of a building; and, for reasons of managing industrial relations risk and increased technical specialization, most of today's large projects are built by a team of 100 or more (and on extremely large and complex projects, more than 1,000) different design, fabrication and construction specialist organizations.

This extraordinary fragmentation has brought with it significant challenges to coordination, integration and innovation. Each subcontract organization works on many projects concurrently; and there are competing demands for resources between different projects, making it difficult for subcontractors to make reliable commitments to each project. Subcontractors attempt to manage the widely fluctuating demand on their resources by adopting a pyramid subcontracting strategy. However, this further challenges the overall project team's ability to effectively coordinate work and control critical outcomes such as safety, quality and productivity.

Coupled with the extreme fragmentation of their supply chains, many contractors in the sector favour short-term, cost driven relationships with their suppliers. Most head contractors are more interested in the speed of the job than smoothing out the resource requirements of their subcontractors because speed is the factor that has the greatest impact on costs and profits.

While in the past few decades major contractors have narrowed their supply chains, it is fair to say that their relationships with their suppliers are quite shallow. Almost all contractors collaborate with their suppliers only when working together on projects. Examples of deep, long-term commitment to collaboration with the supply chain are rare.

Within this fragmented delivery model, with low levels of trust between owners, suppliers and within the supply chain, open collaboration is further limited by the commercial terms of the contracts which tend to push as much of the risk and responsibility as possible down the supply chain. The outcome is that each party fiercely protects its margin and ensures that information is not shared openly. The tension between the self-interest of the parties and the common good of the project has never been higher.

During the tender stage, each subcontractor develops their own price in isolation. The head contractor chooses the lowest subcontract prices and submits a tender based on the aggregation of those prices plus a margin and an allowance for contingency. In this process, there is limited opportunity for collaborative innovation between the parties as they are all working in isolation. Once contracts are signed, collaboration between subcontractors working on the same project is limited as each fights to protect his/her own margin.

It is this broad scenario that has led the construction sector to stagnant productivity growth in the last half century while other sectors of the economy have improved their productivity by up to 200 per cent. Figure 1.2, from the US Department of Commerce, Bureau of Labor Statistics, plots the trend of construction sector productivity against the non-farm productivity index between 1964 and 2004.

Productivity improvement in all industries is driven by innovation in technology and through business process change. In today's construction industry, with limited collaboration between the parties in the supply chain, innovation is by and large limited to technical developments in individual product and service areas, and through advances in logistics and global procurement.

Given the size and complexity of major projects, it is essential to tap into the creative opportunities afforded by deep and effective collaboration across the very wide supply chain. To develop the creative solutions needed to drive improvements in quality, safety, productivity and client satisfaction, close collaboration between front-end designers and downstream fabricators and erectors is essential. Such relationships are difficult to achieve when trust is low, risk is simply pushed down the supply chain and there is little willingness to invest in solution generation early in the process.

Common construction challenges

The complexities that are described in the previous section have led to performance challenges which are remarkably similar the world over.

- **Safety**
  Construction is one of the most hazardous industries – its accident record is third behind mining and forestry. New legislation has now made head contractors, designers and project managers more responsible and potentially liable for injuries incurred by workers on a site, regardless of who had employed them.

- **Quality**
  Research has shown that the cost of rectifying quality errors during and after the contract is of the same order as the profitability of organizations in the sector. Product quality problems are reflected in leaking buildings and premature deterioration of external finishes.[1]

- **Reliability**
  On most project sites only about half of the tasks planned one week out are actually completed according to plan. This means that while overall progress is being made in terms of a measure such as Value Earned, almost half of the work completed on the job each week is not what had been planned. Hence, individual contractors within the supply chain struggle to maintain efficient workflow and resource utilization, driving them to lose confidence in the planning process and to focus inwards on their own profitability.

- **Decision-making**
  Design often takes longer than anticipated and early budgets are rarely accurate. This reflects the fact that the gap between design and construction is too wide and the design decision-making process is out of touch with the real costs and opportunities of construction. It cannot effectively consider alternate construction methods and

FIGURE 1.2
US Construction vs non-farm productivity 1964–2004

Paul Teicholz, Professor (Emeritus), Department of CEE, Stanford University

materials. Under normal processes, clients are often not afforded the opportunity to make effective choices.

- **Value for money**
  Most clients for constructed products the world over clutch to the belief that the lowest price in a tender represents the best value. While this may hold true for simple fast projects, nothing can be further from the truth for complex and uncertain projects. Too often clients call for tenders on a project providing scant documentation and expecting suppliers to invest in the problem solution at their own cost and, often, to accept unrealistic risk. This has created a very real dilemma for the construction sector. Public sector clients face probity issues, as should any client organization; however, under-investing in the generation of the request (design and planning), and insisting that the lowest price represents best value have led to more poor outcomes than good ones. Under such circumstances clients pay an upfront premium for the risk taken and, generally with time, almost always pay a premium for the inevitable variations to the scope of works.

Against this backdrop of complexity and poor performance, contractors and consultants both claim that their profit margins are very low.

The emergence of very large global organizations has led to rapid restructuring in some sectors of the industry. As these organizations have grown in size, the major challenge for them is to remain flexible, adaptive and creative – these are the skills required for the outstanding collaboration needed to optimize the design, fabrication and assembly of large complex projects.

Whatever the type of organization – whether it is an engineering or architectural design practice, a developer, a contractor, a building product manufacturer or a project manager – competition is intense: for end customers, for employees, for projects and for funds. This book is about the strategies that world leaders in the construction sector have deployed to remain at the leading edge of competitiveness.

Lean production

The ideas of lean production were first introduced to the American automobile industry in 1980 by Fujio Cho, later to become the president of the Toyota Motor Corporation. At that time, these ideas were called the *Toyota Production System* (TPS) or *Just-in-Time* (JIT) manufacturing.

The term 'lean production' was coined by Womack and Jones and their research team a decade later when they were comparing production in the Japanese automobile industry to that of their Western competitors. They introduced the term in their ground-breaking book, *The Machine that Changed the World*. In every measure, they saw that ***more was being done with less***: production costs were lower, inventory costs were lower and product development was faster with fewer resources. While in Western automobile factories, a third of all cars produced were sitting in a re-work pool at the end of the production line, waiting for quality errors to be rectified, at the end of Toyota's production line, there was not a single car in the re-work pool. Most importantly, customer perceptions were that the Japanese cars were more reliable.

The traditional definition of lean production is 'creating value for the customer with no waste'; waste being anything that does not add value to the customer. The concept of 'no waste' highlights the need for efficiency. A basic precept of a lean organization is the continuous drive to eliminate non-value-adding processes from all of its activities. Equally inherent in lean is the focus on quality, in the broadest sense. Giving the customer what he/she wants explicitly draws attention to customer needs and satisfaction and, as with the quality movement, this focus is on all customers: the initial customer (owner, developer), all intermediate customers (all the parties in the supply chain) and the end user. It is the dual focus on quality and efficiency that underpins competitiveness; hence, the focus of this book being lean quality (LQ).

JIT is often misunderstood within construction as simply delivering materials and products to site just as they are required. However, the terms JIT Manufacturing or JIT/TPS were used to describe the entire system of management that is considered to form a part of lean production. After the publication of *The Machine that Changed the World*, the term JIT/TPS has been gradually replaced by the term lean production.

However, as with many management terms, lean production is often used loosely. To redefine the term, Jim Womack sent a message to the Lean Enterprise Institute email list entitled 'Deconstructing the Tower of Babel'. He described how in 1987, working with a group of colleagues, they listed the performance attributes of a Toyota-style production system compared with traditional mass production. The Toyota-style production system:

- needed less human effort to design, make and service products;
- required less investment for a given amount of production capacity;
- created products with fewer delivered defects and fewer in-process turn-backs;
- utilized fewer suppliers with higher skills;
- went from concept to launch, order to delivery and problem to repair in less time with less human effort;
- could cost-effectively produce products in lower volume with wider variety to sustain pricing in the market while growing share;
- needed less inventory at every step from order to delivery and in the service system; and
- caused fewer employee injuries, etc.

The group very quickly ascertained that this system needed less of everything to create a given amount of value, so they called it 'lean', hence the term was born. In the intervening period, the term has become loosely applied to a great variety of improvement activity and so to set the record straight, Jim Womack wrote 'here's what lean means to me':

> - it always begins with the customer;
> - the customer wants value: the right goods or service at the right time, place and price with perfect quality;
> - value in any activity – goods, services or some combination – is always the end result of a process (design, manufacture and service for external customers, and business processes for internal customers);
> - every process consists of a series of steps that need be taken properly in the proper sequence at the proper time;
> - to maximize customer value, these steps must be taken with zero waste;
> - to achieve zero waste, every step in a value-creating process must be valuable, capable, available, adequate and flexible, and the steps must flow smoothly and quickly from one to the next at the pull of the downstream customer;
> - a truly lean process is a perfect process; perfectly satisfying the customer's desire for value with zero waste; and
> - none of us has ever seen a perfect process nor will most of us ever see one; but lean thinkers still believe in perfection, the never-ending journey towards the truly lean process.
>
> Note that identifying the steps in the process, getting them to flow, letting the customer pull, etc. are not the objectives of lean practitioners; these are simply necessary steps to reach the goal of perfect value with zero waste.[2]

Essentially what Womack defined was simply *a focus on the customer, on creating value and on eliminating waste* – the ideal of any production process. The wastes he referred to were those defined by Engineer Ohno of Toyota:

- overproduction;
- waiting;
- excess conveyance;
- extra processing;
- excessive inventory;
- unnecessary motion; and
- defects requiring rework or scrap.

The elimination of these will:

- reduce the proportion of non-value-adding activities;
- reduce lead time;
- reduce variation;
- simplify processes;
- increase flexibility; and
- increase transparency.

The lean production agenda has an increasing amount in common with TQM, the main difference being that the lean focus tends to be on production/delivery processes whereas the TQM focus is on organizations as a whole.

Writing a definition of lean quality for all types of organization is extremely difficult, because the range of products, services and organization structures lead to different impressions of the nature and scope of lean quality. Basically lean quality is a programme directed towards ensuring that the right work is produced at the right quality at the right time throughout the entire supply chain without waste. Anyone who perceives it purely as a material control system, a short-term planning system or a way to reduce overheads and costs is bound to fail.

Lean quality can also be described as a disciplined series of operating concepts which allow the smooth and efficient flow of materials and services as they are required with the minimum amount of resources (facilities, equipment, materials, capital and people). Furthermore, it also creates a basis for the systematic identification of operational problems and proposes a set of tools and strategies for correcting them.

In some organizations JIT was introduced as 'continuous flow production'. This describes the objective of achieving the efficient conversion of purchased material and services to delivery very well (from suppliers to the customer). If this extends into the supplier and customer chains, all operating with lean quality, a perfectly continuous flow of materials, information and services will be achieved. In the VNGC case study there is a section on Takt time planning; this is essentially the application of this concept to the construction planning process.

Lean quality concepts can be used in all parts of all businesses, in administration to manage payments and invoicing, in design to manage the decision-making process as well as the design process, to manage off-site fabrication, logistics and the construction assembly process on site.

There is a well-established range of lean quality and operations management techniques; these include tools and strategies to monitor and analyse processes and outcomes. They include:

- flowcharting to better understand processes;
- process study and analysis to identify potential for improvement;
- preventive maintenance to avoid unplanned disruptions;
- equipment and materials layout to optimize material flow;
- standardized design to reduce process risk;
- statistical process control, applicable to the analysis of all data; and
- value analysis and value engineering to ensure that the focus is on achieving client needs in the most efficient manner.

The following ideas which are directly associated with the operation of JIT are also an important part of the implementation of lean quality:

1. batch or lot size reduction to produce smoother flow of materials and services;
2. flexible workforce to maintain smooth flow and to cope with unanticipated requirements;
3. visible cards that signal material requirements (Kanban);
4. mistake-proofing to ensure errors cannot happen;
5. pull-scheduling: one completed task pulling the other behind it;
6. set-up time reduction such as minimum crane time for assembly operations on site; rapid assembly and stripping of formwork; easy alteration to forms at changes in core configurations; and
7. standardized containers/trolleys for the transport and handling of materials.

In addition to these, joint development programmes with suppliers and customers, establishing long-term relationships, are beneficial. The closer the collaboration between customer and supplier and within the supply chain, the greater the capacity for innovation and the more capable the team is to manage risks in safety, quality and production. These benefits can only be achieved through close collaboration between capable, complementary partners.

There is clear evidence that companies in all industry sectors, all around the world, who, together with their supply chains, have successfully leveraged the benefits of lean quality have made spectacular improvements in their performance. This can be seen in:

- increased flexibility;
- more reliable quality resulting in less rework and disruption;
- more reliable process flow leading to less inventory on site, less damage and less double handling;
- better product and process integration; and
- standardization and simplification of products and processes.

Understanding lean quality in construction

Translated into the construction process, lean quality offers similar benefits to those achieved in manufacturing and service industries. In construction, some of the key areas to target are:

- reliable commitments: all parties (owners, designers, suppliers and contractors) must deliver on their promises for timely decisions and for task completion;
- work handover: all parties must satisfy the needs of the following trade (or designer) in terms of task completeness and quality, to allow everyone's work to proceed smoothly and safely; and
- workflow: all parties need to be well coordinated and progress through the project work (design or construction) at an even completion rate.

The processes of lean construction focus on the planning and management of the production system as a whole. Lean thinking seeks to shift the focus of individual parties in the supply chain from their own efficiency to the efficiency of the entire end-to-end process. For this shift to occur, commercial terms which encourage the seamless collaboration within the supply chain are required.

In construction it is not uncommon for the general contractor to bring a 'cheap' subcontractor on to a project on the basis that they will manage the risks. Generally, this costs everyone on the job, as the disruption to the flow of work caused by a less capable team member has flow-on effects for everyone. Naturally, as far as possible, everyone prices in the increased risk into their tenders as contingency so this is a zero sum game.

Going on to the field with the best team every time creates confidence and trust among the team members, increases the team's capacity for innovation and efficiency and allows all team members to reduce contingency.

The concept of waste in construction

Toyota introduced the concept of Just in Time (JIT): the idea that production should respond to consumer demand rather than mass production edict, thus improving overall efficiency by minimizing work in progress and inventory. However, a system with minimal inventory and work in progress cannot tolerate defective work, and this led to a focus on waste elimination.

The classical seven wastes in lean production were listed earlier in this chapter; however because construction is one-of-a-kind, project-based production and, therefore, significantly different to mass production, the conceptualization of waste has attracted significant attention. Bolviken *et al.* (2013) propose the following detailed taxonomy of waste. They conclude that some of these categories may be less useful in practice than others; however, we include it here to illustrate the broader philosophical thinking about the nature of waste.

Waste in the transformation of materials

1 Material waste: all materials not used in the final product, including materials that are damaged and need to be replaced, material waste through handling and re-handling, and material ordered surplus to requirements;
2 Sub-optimal use of materials: this can be a result of over-design or overly conservative construction, a relative waste, which will be optimized as technology improves design and construction safety margins;
3 Sub-optimal use of machinery, energy or labour.

Waste in the flow of work

4 Unnecessary movements by people: looking for, reaching for, stacking parts or tools, moving too far to get to facilities, location of site office;
5 Unnecessary work: doing things unnecessarily; for example, in design, preparing 2D documents as well as a 3D model when the latter is sufficient;
6 Inefficient work: doing necessary work in an inefficient manner; for example, working at height unnecessarily, when by redesigning the work it could be done on the ground, ergonomic aspects of work;
7 Waiting: lost time because preceding work is incomplete or because information, approvals, materials or equipment are not available.

Waste in the flow of product

8 Space not being worked in: this waste is specific to construction and can be seen as an equivalent of idle equipment, it is the unrealized opportunity for work;
9 Excess inventory (materials not being worked on): raw material, work in progress (WIP) or finished goods are all at risk of damage, they all accrue storage costs as well as mask production and delivery problems;
10 Unnecessary transport: moving materials or products unnecessarily on site, sending physical documents rather than transmitting them electronically or returning to the site office with information rather than transmitting it from the field.

Loss of value in the main product

11 Lack of quality: production of defective trade work on site or delivery of defective components to site creates rework; the organization of rework; scrap; and inspection, errors in documentation and design;
12 Lack of intended use or overproduction.

Value loss as a by-product of construction

13 Harmful emissions; and
14 Injuries and work-related sickness.

An additional waste, *Making-do, h*as been suggested by Koskela (2004). This refers to starting a task before all preconditions are ready. At times, the team on the ground does not have control over all the preconditions for work to proceed but have to choose between *making do* or delaying the project. When a design discipline gets ahead of overall design resolution resulting in rework, or on fast-tracked projects if foundation construction commences before the design is fully resolved, some foundations may be incorrect.

Greg Howell has suggested that the contingency that estimators include in the pricing of new projects is a waste peculiar to construction. The sector has poor data on productivity and comparative efficiency, and it does not capture the cost of even the simplest forms of waste which is rework arising from defective work. Cost estimates include contingency based on previous business as usual, costs which include rework and inefficiency.

The lean quality triangle for construction

While the language of each movement (lean and quality) is somewhat different, and hence, the emphasis seems different, the conceptual frameworks of quality and lean at the core level of philosophy and principles have a common goal of meeting or seeking to exceed client needs and expectations as efficiently as possible.

Projects vary along a spectrum between simple and certain at one end, and complex and uncertain on the other. As complexity and uncertainty increase, it becomes more important to build flexibility into the commercial arrangements and organizational structures and to align the commercial interests of the client and the delivery team. Teams constructing complex and uncertain projects will inevitably have to deal with variability in scope and changes in risk profile during the delivery of their project.

As complexity increases, it is also important to effectively link downstream fabricators and erectors with the design team to ensure that solutions generated during design can be efficiently constructed. This type of flexibility is best provided through the use of relational contracts under which risk and reward are shared across the key members of the delivery team.

Lean construction involves all the parties in the design, fabrication and construction processes working together to best understand the needs of the customers (end and internal customers alike) and to jointly strive to eliminate non-value activities (waste) from their operations. This can only be achieved through the end-to-end collaboration of all parties, from the initial client to the end user, and everyone in between.

In traditional construction, the dominant approach to managing the delivery of constructed projects has been through project management, as against production management; however, it is increasingly recognized that the two approaches are fundamentally different, though complementary.

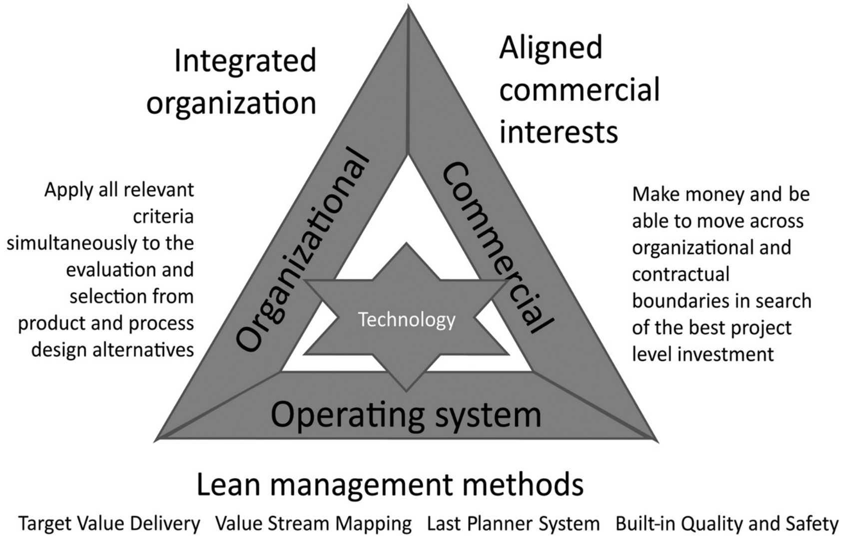
Koskela and Howell argue in their 2010 paper that there are three basic weaknesses in traditional construction project management:

- Planning as supported by sophisticated software products is not closely linked to the execution of the work but is based on an abstract representation of the project.
- There is no systematic approach to managing the execution of the work in the real world.
- Control is limited to taking corrective action after the event rather than as a process of continuous learning and improvement.

The unique aspects of the delivery of constructed products fundamentally alter the production process when compared to other industry sectors. The lean construction community worldwide has over the past two decades developed a three-part framework; which includes commercial terms, organization and a lean operating system to address the challenges described above. This is described in the Lean Construction Institute triangle shown in Figure 1.3.

Often people incorrectly equate lean production with the tools and management processes; while these are invaluable, lean production embraces all three sides of the triangle. The tools without appropriate commercial terms and an integrated organization are limited in what they can accomplish.

FIGURE 1.3
The Lean Construction Institute triangle



Integrated organization

Over the years, construction industry clients have made many attempts to improve project outcomes, Design Build, Design Build Operate, Alliances and most recently Early Constrictor Involvement (ECI) and PPPs have sought to better align the interests of the clients and the supply chain and to encourage end-to-end collaboration in the search for better design solutions. While each of these strategies has had benefits, they also have had their limitations.

Northern Californian healthcare provider Sutter Health, in the US, and BA, in the UK, were among the first major building sector owners to adopt a combination of lean construction thinking and methods, and Integrated Project Delivery agreements to drive better performance on its projects. Several major owners, including Intel, Disney and the University of California in San Francisco have followed in their footsteps.

Sutter with support from its consultants developed the five *Big Ideas* to encompass the changes they sought from their project teams, shown in Figure 1.4.

These ideas define the principal objectives required to drive the kind of open, collaborative problem-solving and learning environment that is necessary to deliver large, complex projects effectively and efficiently. They are the guiding principles for how large, multidisciplinary teams engaged in all necessary activities from feasibility design through to fabrication, assembly and operations can work together to identify and manage risk, develop optimum multi-party solutions to complex problems and continuously improve performance through a creative and productive relationship.

True collaboration

This calls for end-to-end collaboration between front-end designers and tail-end fabricators and erectors, and everyone in between. Real collaboration maximizes positive iteration in the design process and reduces wasted effort and rework.

Increase relatedness between all the parties

For the best outcomes, participants must work closely together, be open to each other, jointly learn from mistakes and continue to improve and innovate in an open, collaborative manner.

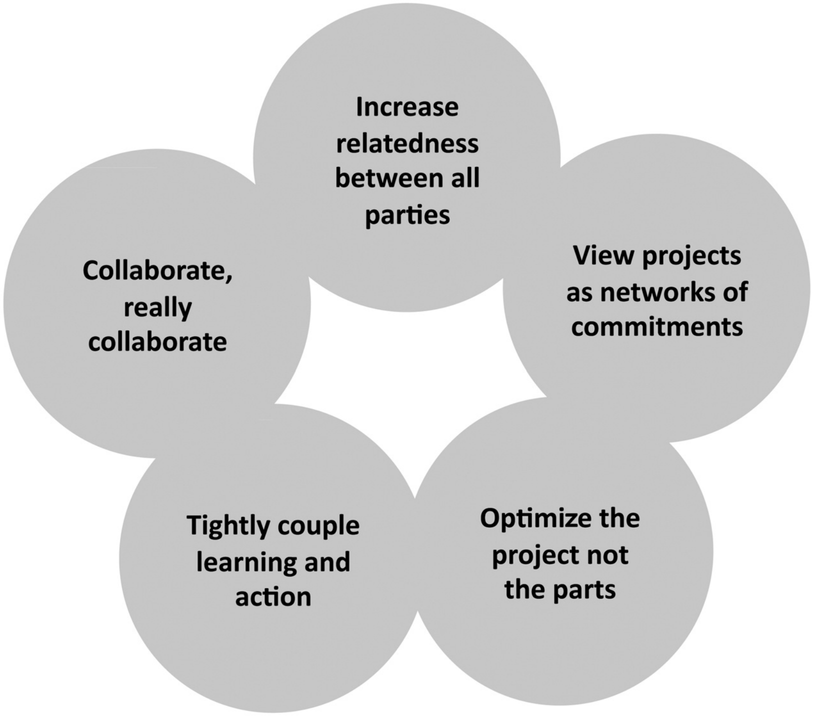


FIGURE 1.4
Sutter Health's five *Big Ideas*

Projects are a network of commitments

Projects are built as a result of sound promises made between the actors on a project. The reliability of these commitments correlates with the reliability of workflow. Collective striving to improve the reliability of commitments brings personal accountability to the flow of work. This is in stark contrast to the traditional view that work is completed through contract and control.

Optimize the project – not the parts

Projects become more uncertain when the parties focus on self-interest at the expense of the project outcomes. However, the commercial terms have to support the shared focus on what is best for the project.

Tightly couple action with learning

The traditional construction industry tolerates error repetition to a remarkable degree. Errors in safety, quality and productivity are repeated on projects daily. Error repetition can only be eliminated through a focused learning environment.

Aligned commercial interests

To encourage behaviours consistent with the owner's interests and priorities, a commercial agreement is required that binds the interests of the parties together in alignment with the owner's interests, and rewards the achievement of clearly identified, exceptional outcomes that benefit the owner and the key stakeholders. This class of agreements is known as Integrated Project Delivery (IPD) or Integrated Form of Agreements (IFOA).

While infrastructure alliance projects in Australia sought to do this between 1997 and 2012, they did not go far enough to identify benefits that were commercially bankable for the client. Too often the Key Performance Indicators (KPI) and Key Result Areas (KRA) frameworks that mediated rewards were not sufficiently commercially focused, and though they may have been demanding of project teams initially, they became too easy to achieve with time. With the exception of programme alliances, once the KPI and KRA frameworks were set, they were not ratcheted up to drive and demonstrate continuous improvement throughout a project.

Commercially expedient thinking that does not engage with the risks and opportunities of a project and simply pushes risk and responsibility down the supply chain generally costs the client more than any alternative strategy. This is in spite of the fact that the client may tender and accept the lowest price in an open and transparent tender process. Large constructed projects are complex and the client inevitably benefits from engagement with the supply chain in a full exploration of the risks and opportunities of the project.

IPDs, at their simplest, seek to bind the designers and constructors to the objectives of the owner by creating alignment of the interests of all parties in the project with the interests of the owner. The selection of project participants is based on technical and cultural fit rather than price; and, it is accepted that the core members of the supply chain should be appointed early in the life of a project, creating the possibility for fabricators and constructors to participate in design decision-making.

Some clients prefer to tie the whole supply chain into the agreement, seeking to work with a co-operative of equals who collaborate to achieve the owner's objectives without the opportunity for any party to bias processes or decisions towards its self-interest. In these arrangements, clients are involved in weekly discussions about risk and opportunity; and the leadership team of the supply chain (including the owner) meet weekly to resolve problems and leverage opportunities for innovation. A key aspect of such arrangements is that money can move across organization boundaries within the project team in search of the best project level investments, and efficiency gains made by any single party are shared by the team.

Under these agreements, there is a commitment to learning and continuous improvement. All of the partners commit to being effective members of the project executive, putting forward able and empowered leaders to contribute to the team decision-making processes. Such agreements use terms such as the following to express the intent of the owner:

> By forming an Integrated Team, the parties intend to gain the benefit of an open and creative learning environment, where team members are encouraged to share ideas freely in an atmosphere of mutual respect and tolerance. Team Members shall work together and individually to achieve transparent and co-operative exchange of information in all matters relating to the Project, and to share ideas for improving Project Delivery as contemplated in the Project Evaluation Criteria. Team members shall actively promote harmony, collaboration and co-operation among all entities performing on the Project.
>
> The parties recognize that each of their opportunities to succeed on the Project is directly tied to the performance of other Project participants. The parties shall therefore work together in the spirit of co-operation, collaboration and mutual respect for the benefit of the Project, and within the limits of their professional expertise and abilities. Throughout the Project, the parties shall use their best efforts to perform the work in an expeditious and economical manner consistent with the interests of the Project.
>
> (Lichtig, 2005)

Lean quality management system

The third side of the Lean Construction Institute triangle refers to the management systems and tools used to drive excellent outcomes and continuous improvement. These apply to all phases and areas of the work from design to commissioning and, if relevant, operations as well. An underlying principle is the use of data to drive processes and improvement.

During the design phase, the key elements of lean management implementation are to:

- understand clearly the owner's need and priorities;
- use Target Value Design (TVD) to drive the design towards achievement of the owner's budget;
- create genuine collaboration between all the relevant team members to shape design resolution, linking fabricators, constructors and users with the initial designers to develop an optimum, holistic design solution (often supported by the use of 3D modelling);
- develop a Built-In Safety and Quality plan to ensure that safety and quality are considered from the outset and readily achievable; and
- manage the flow of decision and design work during the design phase using the Last Planner® System (LPS) and Reliable Promising, based on the Linguistic Action model.

It has been found, around the world, that typically up to 50 per cent of tasks assigned to a week's plan on the preceding Friday were not completed as planned. Using lean thinking and the LPS® the percentage of tasks completed can be increased to 85 per cent.

Other tools and approaches including Built-In Quality and Safety (BIQS) and Value Stream Mapping (VSM) are commonly used to mistake proof and improve assembly in construction processes. Traditional tools, such as visual management, 5S, standard work, BIM and virtual prototyping and value engineering, from lean production and elsewhere are also used to eliminate waste and improve value, primarily, for the end customer, but also with a view to the needs of intermediate customers. In fact, lean is not a set of tools; rather, it is a mindset to use all appropriate tools and techniques combined with the use of metrics to continuously improve key outcomes.

NOTES

1 Perea, S., Davis, S., Karin, K. and Marosszeky, M. *Enhancing Project Completion* (Research Project reports 1 & 2), ACCI, UNSW, 2003.

2 Email from Jim Womack to the Lean Enterprise Institute list titled 'Deconstructing the Tower of Babel', 7 October 2004.

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Chapter highlights

Lean quality in construction

- Two major management movements have swept over the construction sector in the past 25 years: the Quality movement in the early 1990s and more recently the Lean Construction movement.
- Leading clients for construction services are beginning to require their suppliers and their supply chains to demonstrate a lean quality approach to their businesses.
- Lean and quality are two slightly different lenses through which we view management excellence and these perspectives are merging.

Distinguishing features of construction

- Constructed projects are uniquely designed, fitted to a site, and projects are fixed in location, requiring the resources necessary for construction – materials, products, people and equipment – to be brought to the site.
- Work teams from a myriad of different organizations construct the project in situ, and while they physically work around each other, the workers on site are employed by many different companies, each with different values and performance and business drivers.
- Large projects are undertaken over many years and the members of the design and construction team change significantly over this period; this requires special attention to the handover of work between individuals and teams to ensure that the work continues as smoothly as possible.
- When clients are involved in the design and construction process over an extended period, the quality of the service they receive from their providers influences their perceptions regarding the quality of products.
- Clients have the ability to influence the culture on a project as well as the cost; this influence can be either positive or negative.
- In the last decade the ability of even medium-sized firms to procure both services and products globally has fundamentally changed the capability of organizations; it has also posed a new set of risks and hence changed the demands on their management skills.

Today's industry

- There is a confusion among owners between cost and value; many owners drive towards the lowest cost, without understanding where the value is, nor do they understand their impact on cost.
- Owners are reluctant to invest in defining their needs upfront, they seek to get the supply chain to invest in generating the solution to their needs, paying as little as possible for it.
- Between World War II and the end of the twentieth century contractors moved from a detailed involvement with construction to a position where they simply bought services from subcontractors for a fixed price and passed on the risk.

- Today's industry is extremely fragmented and specialized and in general terms, trust is low. Productivity has been in decline for at least 50 years.
- In the last 15 years leading constructors have narrowed their supply chains and some are starting to deepen their relationships with their suppliers, though they are still wedded to the idea of simply buying services.
- Leading lean contractors have moved back to engaging more closely with the processes of construction, developing strategies to better manage risk jointly with their suppliers and are working more closely with them.

Common construction challenges

- Construction processes are error prone; construction is one of the most dangerous industries, the cost of rework due to quality errors during construction costs as much as the profit margin generated by most businesses in the sector.
- The flow of work on construction sites is chronically unreliable, with as much as half of work, planned one week out, not being completed as planned. This outcome undermines the confidence of all construction workers and managers in the planning process.
- While clients seek value from money above all else, they are rarely in a position to make informed decisions that influence value. There is insufficient information about the cost impact of alternative decisions for them to be practically involved.
- The last three decades have seen the rapid emergence of global organizations in every part of the construction supply chain from design through fabrication and construction. During the same period the size and complexity of projects has increased rapidly in every sector of the market.

Lean production

- The central ideal of lean production is to give the customer what he/she wants (value) with no waste. This provides a focus on understanding what customers want and on understanding what is waste and where it is to be found.
- Lean production and TQM have a lot in common; they are different and complementary lenses through which organizational excellence can be viewed. Lean production has tended to have a greater focus at the process level while TQM has had more of an overall organization focus. Today both frameworks are rapidly converging.
- Both lean and TQM are process focused, both are customer focused and both are focused on continuously improving processes and outcomes. The lean production community worldwide has developed a set of tools for focusing the attention of workers and their management on the improvement of processes. Though it is important to recognize that lean is not just tools-based, it is a holistic philosophy similar to TQM.

Understanding lean quality in construction

- In construction areas of focus for lean improvement are the generation of reliable commitments, satisfying the needs of the immediate customer in all stages of work handover and the creation of smooth and reliable workflow so resources can be applied efficiently throughout the supply chain.
- The processes of lean construction focus on improving the reliability and quality of planning, so that work can be executed as planned. There is also a rediscovery of the need to plan the overall workflow so that all parties can rely on a smooth level of demand for their resources.

The concept of waste in construction

- The lean manufacturing community has developed a taxonomy of waste; it has been found that there are several additional wastes that are unique to construction.
- Waste can occur in several different stages of the construction process: in the transformation of materials; in the flow of work; in the flow of product; and we can see a loss of value in the main product; and there can be value loss to external stakeholders as a by-product of construction.

The lean quality triangle for construction

- Projects vary along a spectrum between simple and certain on one end, and complex and uncertain at the other. As complexity and uncertainty increase, it is important to build flexibility both into the organization and commercial arrangements to allow for the inevitability of change.
- It is important to connect early stage designers with downstream fabricators and erectors in order to arrive at optimum construction solutions.
- Computer-based planning tools have created an illusion of certainty in relation to the planning of work, while in fact it is only the leaders of work teams who are in a position to plan work in detail.
- For lean construction to be successful, an integrated organization needs to be created, the commercial interests of the parties need to align around the efficiency of the project as a whole, and lean tools and management methods should be deployed using the latest available technologies.