NINTH EDITION

Ferry and Brandon's Cost Planning of Buildings

with website

Richard Kirkham

WILEY Blackwell

Ferry and Brandon's

Cost Planning of Buildings

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Cost Planning of Buildings

Ninth edition

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with contributions from

Anas Bataw, Brian Greenhalgh and Anthony Waterman

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Douglas J. Ferry, PhD, FRICS, was formerly Dean of Architecture and Building, New South Wales Institute of Technology, and then as a Research Manager with Construction Industry Research and Information Association (CIRIA). He authored the very first edition of this text in 1964 while based at the College of Technology, Belfast, where he lectured in quantities and building construction. In that same year, he also published *Rationalisation of Measurement* with the Royal Institution of Chartered Surveyors.

Peter S. Brandon, MSc, DSc, FRICS, is Pro-Vice Chancellor (Research and Graduate School) at the University of Salford. Prior to this, he was Professor of Quantity and Building Surveying. He was the inaugurator of several high-profile initiatives including Construct IT, the national network for Information Technology in Construction which received the Queen's Anniversary Prize in 2000; SURF, the Centre for Sustainable Urban and Regional Future; CCI, the Centre for Construction Innovation and the BEQUEST international network.

Richard J. Kirkham, BA (Hons), PhD (Liverpool), is a lecturer in Engineering Project Management at The University of Manchester. His research interests are in whole life cycle costing, quantitative risk analysis, stochastic modelling techniques and performance measurement for public sector facilities. Prior to this, he worked as a senior lecturer in Construction Management and Quantity Surveying at Liverpool John Moores University and as a Research Officer in School of Industrial and Manufacturing Systems at Cranfield University. He has published widely in the field of whole life cycle cost modelling and is the co-author of *Whole Life Cycle Costing: Risk and Risk Responses*. He is a series advisor to the RICS Research/Wiley Construction Series and formerly Scientific Secretary of CIB-TG62 Complexity and the Built Environment. Richard is a Fellow of the Royal Statistical Society, an Incorporated Member of the Chartered Institution of Building (Vice Chair Liverpool Centre 2006/2007 and Chair 2007/2008) and was elected a member of the Association of Cost Engineers in 2004.

Contributors to the Ninth Edition

Anas Bataw, BSc (Hons), MRICS, is a PhD student in the School of Mechanical, Aerospace and Civil Engineering. His research focuses on the role of Building Information Modelling (BIM) in modern construction projects, particularly from a small and medium enterprises (SME) perspective. As a Chartered Quantity Surveyor (CQS), he worked on a range of buildings and infrastructure projects before joining the university to undertake his research. Anas is a member of the Higher Education Academy BIM working committee and leads BIM4Manchester, a group designed to support construction professionals working within BIM.

Brian Greenhalgh, BSc, MBA, FRICS, FCIOB, is a Contracts Manager at Petroleum Development Oman (PDO) – Oman. Prior to this, he has held several appointments in the Gulf Region leading contracts management on complex infrastructure scheme. Prior to his return to professional practice, Brian was Head of External Affairs in the School of the Built Environment at Liverpool John Moores University where he specialised in the procurement and management of construction projects. As a Chartered Quantity Surveyor, he has served on Royal Institution of Chartered Surveyors (RICS) committees both locally and nationally and has lectured widely on aspects of construction management and contract administration.

Anthony Waterman, BA (Hons), MSc (University College London), is a Director of ADW Developments, a specialist Built Environment consultancy focusing on whole life costing. Prior to this, he was Research Manager at SENSE Cost Consultancy (division of MACE) and a Principal Consultant at the Building Research Establishment, his first appointment after completing his Masters degree in Construction Economics at University College London (UCL). During his career at the BRE, he worked on various aspects of whole life cycle costing and performance modelling including the development of public sector comparator (PSC) models for Private Finance Initiative (PFI) schemes and the National Audit Office (NAO) reports on *PFI for schools*.

Preface to the First Edition

This book is intended as an introduction to Cost Planning for practicing quantity surveyors and as a textbook for students talking the Final Examination (Quantities Part II) of the Royal Institution of Chartered Surveyors, or the Third Examination of the Institute of Quantity Surveyors. I have therefore assumed that the reader is already familiar with the ordinary processes of Quantity Surveying, particularly the preparation of bills of quantities, and this is taken for granted in the text; nevertheless I hope that the book may be read with advantage by members of allied professions.

I have tried to present the subject in a way that will be helpful to the surveyor coming to grips with it for the first time, and have concentrated on explaining the basic principles, basic methods and some of the main pitfalls. I have not tried to reprint the masses of tables, charts and detailed examples which have appeared in the technical press, as once the principles have been understood the reader will find the lack of time rather than lack of material which will limit his further studies. A list of some of this material is included as an appendix to the book.

I have received a good deal of assistance in the compilation of this work from the various organisations that are mentioned therein, but I would particularly like to mention the help given by the officers of Hertfordshire County Council Architects Department and the Building Cost Advisory Service of the Royal Institution of Chartered Surveyors.

Douglas J. Ferry
Belfast June 1964

Preface to the Ninth Edition

'Are you doing BIM?' is a question many quantity surveyors are asked; in fact the same could be said of most of the multi-disciplinary team. I must confess that my knowledge of Building Information Modelling (BIM) is somewhat 'elementary'; so it was with a degree of trepidation that I agreed, 2 years ago now, to undertake the supervision of a PhD student (who quickly became a good friend!) whom quite fancied doing a bit of research into BIM from a Contractors Quantity Surveyor (CQS) perspective. It has been an interesting experience getting to grips with BIM and the potential benefits it can realise in the cost planning process. The first UK government pilot projects are emerging as positive demonstrators of BIM (see Chapter 2 of this book), but speaking to surveyors on the ground, it seems that no one really truly knows what BIM is and how it will change their way of working. Recent studies undertaken by us at Manchester following the Royal Institution of Chartered Surveyors (RICS) BIM conference highlighted that this was particularly acute in the SME sector, which accounts for a significant proportion of the overall construction supply chain. The technologies underpinning BIM are emerging apace, the issue is perhaps a cultural one and the notion of enhanced collaborative working requires an awareness of procurement systems, client relationships and the wider project environment, topics addressed (in some part) within the text.

You will also notice in this ninth edition that we have updated the procurement and contracts content, mainly to reflect the success of NEC3 in the delivery of important infrastructure schemes like London 2012 and Crossrail.

The remainder of the text has been freshened up to reflect other changes such as the new RIBA Plan of Work 2013 and the RICS New Rules of Measurement, which emerged just after publication of the eighth edition of this text.

There are some basic concepts of cost planning that will remain constant (even in the advent of BIM), so familiar readers will be pleased to note that the core principles of Ferry and Brandon remain throughout.

Richard Kirkham
University of Manchester, June 2014

Acknowledgements

It was somewhat a relief when a young man by the name of Anas talked me into supervising his PhD, not only did I have the chance to work with a bright and enthusiastic young student, but one that knew a thing or two about quantity surveying. Anas has been a great help, leading the project to revise and update this book and his knowledge of Building Information Modelling (BIM) will have a material impact on the major changes that will shape the text over the coming decades.

I would also like to extend my thanks to colleagues at Manchester and, in particular, Ms Jenny O'Mara, she has to put up with a good deal from me but I count her among my closest of friends. Dr Paul Blackwell, ditto.

As is always appropriate, I must thank my wife Joanne and our three lovely boys Samuel Matthew, James Richard and George William.

And, finally, to Mr John Hardy (the in-law!) who provided me with the picture of The Shard, used in this new edition.

Nomenclature and Acronyms

$\sum$	the sum of (sigma notation)
P	the principal (in investment terms)
i	the rate of interest
n	time (ordinarily number of years)
r	discount rate or real discount rate (in social time preference rate (STPR) calculations)
ρ	catastrophe risk and pure time preference (in STPR calculations)
μ	elasticity of the marginal utility of consumption (in STPR calculations)
g	output growth
t	time
$\approx$	is approximately equal to
π	pi (3.142 to 3 d.p.)
σ	standard deviation
ACostE	Association of Cost Engineers
ASCII	American Standard Code for Information Interchange
BAA	British Airports Authority
BCIS	Building Cost Information Service
BIM	Building Information Modelling
BMI	Building Maintenance Information Service
BQ	Bills of Quantities
BSI	British Standards Institute
CATO	Computer Aided Taking Off System
CIOB	Chartered Institute of Building
CITE	Construction Industry Trading Electronically
CM	Construction Manager or Construction Management (in procurement)
COBIE	Construction Operations Building Information Exchange
CQS	Contractors Quantity Surveyor
D&B	Design and Build
DCF	discounted cash flow
DPM	damp proof membrane
EST	Energy Saving Trust
GFA	gross floor area
HMRC	Her Majesty's Revenue and Customs
ICE	Institution of Civil Engineers
ISO	International Standards Organisation
IT	Information technology
JCT	Joint Contracts Tribunal for the Standard Forms of Building Contracts
KM	knowledge management
MC	Management Contracting
MoD	Ministry of Defence
M&E	Mechanical and Electrical (services)

NAO	National Audit Office
NEC3	New Engineering Contract (third edition)
NPS	National Procurement Strategy
NPV	net present value
NR	Network Rail
NRM	RICS New Rules of Measurement
Nr.	Number (of)
OGC	Office for Government Commerce (now part of The Cabinet Office)
PFI	private finance initiative
PoW	plan of work
PPP	public–private partnership
PQS	Private Practice Quantity Surveyor
PV	present value
QS	Quantity Surveyor
RC	reinforced concrete
RIBA	Royal Institute of British Architects
RICS	Royal Institution of Chartered Surveyors
SMM7	Standard Method of Measurement of Building Works, seventh edition
TPI	tender price index
VAT	value-added tax (20% in the United Kingdom at the date of publication)
WLCC	whole life cycle costing

About the companion website

The book's companion website at:

www.wiley.com/go/kirkham/costplanningbuilding

provides support material for lecturers and students.

Introduction

Chapter 1

An Overview of Cost Planning

1.1 Introduction

Buildings are an essential part of the infrastructure of modern society. They provide shelter, we work in them; they provide the very means by which civilisations function and it is because of this that we tend to take our built environment for granted. Buildings and civil infrastructure are the enablers of health care, education, commerce and justice, the essential elements of that civilisation. I often remark on the importance of buildings and civil infrastructure to my students in lectures by asking them a simple question:

If you were to ever visit London, Berlin, Paris or Rome, what would you do?

Invariably, the responses always involve visiting buildings: the Houses of Parliament in London, the Brandenburg Gate in Berlin, the Arc de Triomphe in Paris and the Coliseum in Rome, all the usual suspects. Being a railway enthusiast, I am a big fan of I. K. Brunel, the once pioneering chief engineer of the Great Western Railway. I like to use his legacy as an example of the point I am trying to make here. Approaching his iconic station building at Bristol Temple Meads, one is reminded so much of how buildings were seen as the most appropriate symbol of wealth, prosperity, ambition and achievement. For people like Brunel, buildings and civil infrastructure were a statement about the country. Brunel was a visionary but he also had a track record for blowing the budget on his projects! Maybe he used arguments with his projects' sponsors to convince them of the long-term value of their investments, who knows, but notwithstanding the **value**[1] aspects of buildings, the construction industry generally is inextricably linked with money. Simply put – buildings cost money, and usually lots of it!

This may seem a rather simplistic contention, but history reveals that understanding the costs of construction is a skill that has developed over time. In the seventh and eighth editions of this text, Douglas Ferry and Peter Brandon refer back to biblical times in order to trace the origins of cost planning, and the reading from St Luke (Ch. 14) gives a fascinating insight:

> **Would any of you think of building a tower without first sitting down and calculating the cost, to see whether he could afford to finish it? Otherwise, if he has laid its foundations and then is not able to complete it, all the onlookers will laugh at him. "There is the man' they will say, 'who started to build and could not finish".**

While there are clearly metaphorical connotations within this reading, the point is pretty clear. To build well, you must first plan! Interestingly, the final part of the reading is a harrowing reminder to many clients and builders in today's society who have not taken heed of good budgetary management.

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

1.2 The 'art' of cost planning

The relationship between costs of buildings and **procurement**, procurement being the method by which buildings are delivered to the client, will be considered in detail in Chapter 7. The United Kingdom has witnessed a turbulent period of construction activity since the last edition of this book; relatively stable growth between 2001 and 2006 and then of course, the 'game-changer', more commonly known as the global economic crisis (see Figure 1.1), but allied to this has been an increasing focus on project budgets and, moreover, the ability to deliver these projects to the projected cost.

Sadly, several high-profile construction projects in the United Kingdom have been plagued with problems over programme and budget. With public sector construction projects, there is a strong emphasis on meeting the budget; so when the project runs into financial difficulties, the taxpayer and media become rather unsympathetic. Some classic examples include the following.

1.2.1 Wembley Stadium, London, UK (2000–2006)

The new national stadium at Wembley is a project that has been mired in controversy with questions over adequate cost planning and budget management. Initially, the cost of the

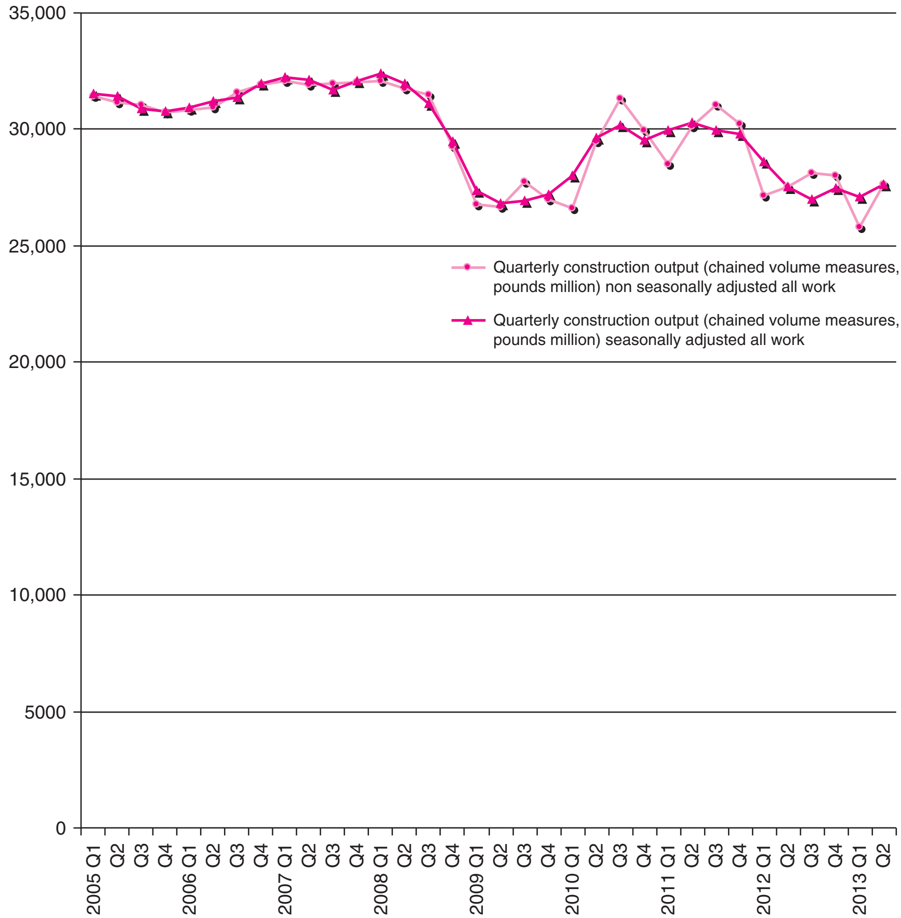

Figure 1.1 Quarterly construction output (NSA and SA) 2005–2013 (Office for National Statistics).

North London stadium was expected to be approximately £200 m. However, in the Summer of 2006, the projected cost had increased by some £715 m. The events of the Football Association and Rugby League Challenge Cups along with a host of other events were relocated to other stadia as the project rolled on beyond the anticipated completion date.

The project became the subject of intense media speculation and on 17 July 2006, the then Minister of State for Culture, Media and Sport, Richard Caborn (an MP), was asked to make a declaration on the target for practical completion (PC). He stated that he was confident that substantial completion of the stadium would be achieved in July 2006, sufficient to enable PC by September 2006. The stadium was actually handed over to the client in March 2007, just in time to host the Football Association Cup Final in May.

So, what happened to the cost plan? Readers of the eighth edition of this book will note that the contractors had disputed the projected final cost, arguing that the £715 m figure that was quoted was the 'cost shown to the banks so that they know that [we] can finance that amount should we need to'. In 2011, the BBC reported that the cost of the project to be £757 m.

A combination of factors lead to the problems faced by the project team; however, an article in *The Economist*[2] suggests that 'an unanticipated rise in the cost of steel (which doubled in 2004) and the extra labour required to ensure the building [was] ready for the May FA Cup Final [threw] the management's calculations out of kilter'.

The steelwork issue certainly had a significant impact not only on the cost plan but also the contractual arrangements between the principal contractor Multiplex and steelwork contractor Cleveland Bridge, UK. Early on in the project, Cleveland Bridge entered into a £60 m lump sum contract to design, fabricate, deliver and erect the structural steelwork at Wembley Stadium including the bowl and huge steel arch.[3] However, in the late 2003, Cleveland Bridge and Multiplex entered into formal dispute as the latter argued that it was haemorrhaging cash as a result of market conditions and specific project's issues and sought significant variation payments, or a change to a cost plus contract arrangement. This dispute continues in court as this book goes to press.

1.2.2 The Scottish Parliament Building, Edinburgh, UK (1997–2004)

Not unlike the National Stadium at Wembley, the construction of the new Scottish Parliament Building at Holyrood in Edinburgh was shrouded in controversy, resulting in a full public enquiry by the Rt Hon the Lord Frazer of Camille, QC. In May 1997, the recently returned Labour Government committed to holding a referendum on Devolved Government in Scotland. In the referendum held on 11 September 1997, almost 75% of those voting agreed that there should be a Scottish Parliament. A new building to house the Parliament was therefore required, and in a subsequent 'White Paper', it was estimated that the cost of constructing a new Parliament would be between £10 m and £40 m. This estimate was made prior to the identification of a location or a design.

Good cost planning requires critical engagement from all project stakeholders from the outset, and a unified voice of opinion from the client. This was not the case and it could be argued that on this project there was no client. However, one of the most catastrophic failures to affect the project in terms of cost and progress was the selection of the procurement route and his opening speech prior to publication of his report, Lord Frazer said:

> *As I have said in my introduction, while I have a number of sharp criticisms and recommendations to make on matters which ought to have been much better understood, there is no single villain of the piece. There were, however, some catastrophically expensive decisions taken and principal among those was the decision taken – not cleared with Ministers – to follow the procurement route of construction management. I have very real doubts if the extent of the risk remaining with the public purse was properly understood at the time it was adopted and I remain concerned that it was not clearly grasped by the Scottish Parliament for nearly two years after the Project was handed over to the SPCB when the*

Parliament gave up trying to have a 'budget' for the building. Any building constructed under the procurement model of construction management costs what it costs.

Lord Frazer's report could not be damning enough of the fact that the project simply did not have an appropriate cost plan. Inadequate briefing was in part responsible for this (some argue that there was no brief at all!) of course, so the importance of developing the brief and its relationship with the cost plan is covered in the first section of this book. The reader is also encouraged to refer to the references for further information on briefing.

1.2.3 The British Library at St Pancras, London, UK (1974–1988)

Exposition of the relationship between cost planning, procurement route selection and the brief was a key feature of the British Library project in London, which by project completion in 1988 had amassed a net increase in £58 million on the original planned cost.

Not unlike the other projects described in this chapter, a catalogue of errors occurred which led to the final cost of the project coming in at some £500 m. Principal among these was the decision to adopt the **construction management procurement strategy**. The National Audit Office (NAO) report heavily criticised this decision and, quite surprisingly, Lord Frazer did not allude to this in his 'Holyrood Enquiry' report. Had he done so, the media would no doubt have rallied against the decision-makers in which lessons clearly had not been learned. This unsuitable method of procurement had a fundamental impact on the cost plan, as well as the thousands of design changes and variations from the original brief systematic failures in quality and cost control during production and failures in the budgetary controls of contracts for the many different work packages undertaken by various sub-contractors. The lack of experience in using construction management allied with the complex and intricate nature of the architects and engineers' contracts, and the standard conditions for work contractors led to a situation that could not possibly sustain within the original cost plan constraints. The result – a damning enquiry and NAO report was said to be the most critical assessment of a public construction project yet.

1.2.4 The FiReControl project (2004–2013)

The previous case studies have identified major problems with the budget for the design and construction of the building specifically, but the procurement strategy will also have a major impact on 'whole life costs' of the project. This is particularly the case with projects that are characterised by complex stakeholders. FiReControl was a project initiated in March 2004, with the aim of achieving efficiencies in the handling of 999 emergency calls to Fire and Rescue Services across England and Wales. The project involved the design and construction of 9 new regional control centres (RCCs) that would replace 46 existing facilities. The problem with this project was not the buildings *per se*, but with the overall strategic objectives that had not been fully understood. This led, in 2010, to the cancellation of the whole project, with many completed RCCs laying empty and unused. The NAO report on the project summarised the main failings in a damning statement: 'This is an example of bad value for money. FiReControl will have wasted a minimum of £469 million, through its failure to provide any enhancement to the capacity of the control centres of Fire and Rescue Services after seven years. At root, this outcome has been reached because the Department, without sufficient mandatory powers, decided to try to centrally impose a national control system on unwilling locally accountable bodies'.

In 2013, The *Yorkshire Post* reported that the £14 m RCC at Wakefield in West Yorkshire had 'finally' secured a tenant after 'six years of standing empty, costing taxpayers £5000 per day'.

1.2.5 High Speed 2 (HS2)

Although not a classic 'building' project, this massive infrastructure scheme will have the potential to revolutionise rail travel in the United Kingdom. The proposals are to build a new high-speed line linking London with Birmingham (Phase 1) and then Birmingham with Manchester/Wigan and Leeds/York. The project is ambitious, but the uncertainties associated with the complex engineering work have already had an impact on the expected costs; a statement published by the BBC in 2013 highlights that 'in June 2013 the government revised the cost of the project upwards, due to an increase in the amount of tunnelling required on the route. This took the estimated budget from £32.7bn to £42.6bn at present values – with the cost of phase one increasing from £16bn to £22bn'.

Opponents of the High Speed 2 (HS2) project believe that these costs could rise still further as a consequence of the unexpected and unanticipated additional work that will be required to the associated buildings and infrastructure to allow the project to unfold. Perhaps the most controversial aspects of the HS2 proposals are the 'business benefits' that are identified within the business case – the Government are at pains to emphasise the value that such schemes bring to the nation and its economy but as we know, value is not that easy to quantify! With construction work due to start in 2017, it will be many decades before we do learn the true value of the investment in this project.

1.3 The cost planning process

Cost planning, as a process, is difficult to define concisely because it involves a variety of procedures and techniques that are used concurrently by the Quantity Surveyor (QS) or Building Economist. Traditional cost planning will usually follow the conventional outline design-scheme design-detailed design process. In a practical sense, the cost planning process starts with the development of a 'ball park' figure (or cost bracket) to allow the client to decide whether the project is feasible. More robust techniques for doing this are described in Chapter 5. This feasibility estimate is usually calculated on a unit cost method (e.g. cost per bed for a hospital, cost per student for a school). The estimate is then refined using the elemental method; the building is broken down into its component elements and sub-elements, usually using the Building Cost Information Service (BCIS) cost structure. The elemental method is a system of cost planning and control, which enables the cost of a scheme to be monitored during the various stages of design development.

A good cost planning system should ensure the following.

1. Ensure that the tender figure is as close as possible to the first estimate, or that any likely difference between the two is anticipated and within an acceptable range.
2. Ensure that the funds available for the projects are allocated effectively and economically to the various elements and sub-elements.
3. Always involves the measurement and pricing of approximate quantities at some stage of the process.
4. Aim to achieve good value at the desired level of expenditure.

Obviously, a direct benefit of good cost planning is to reduce project risk. Steps ought to be taken to ensure that the project development budget opportunities and threats are fully appraised are identified and assessed accordingly.

Ferry and Brandon, in previous editions of this text, describe the cost planning process in three phases:

- **Phase 1**: Defining the brief and setting the budget. In disciplines out of construction project management, this is commonly referred to as scoping or framing.

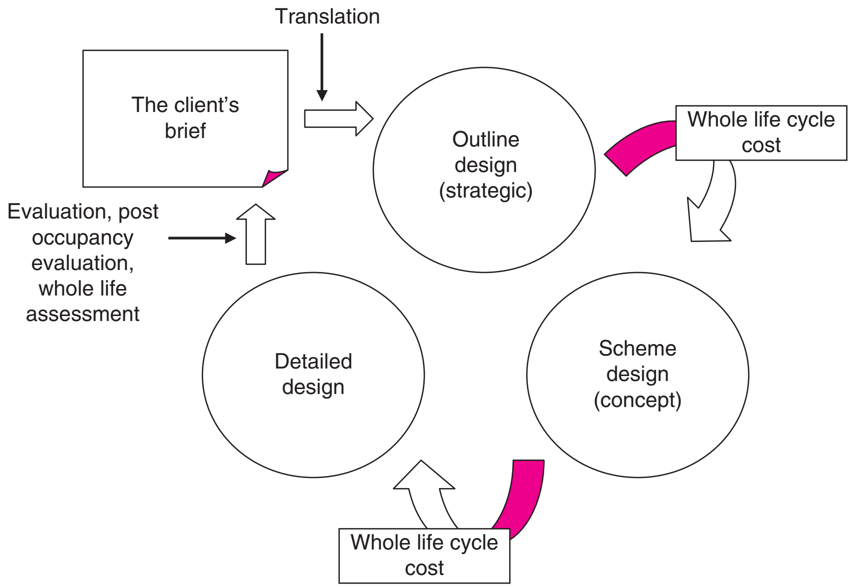

Figure 1.2 The conventional stages of the cost planning process including whole life cycle costing.

- **Phase 2**: The cost planning and control of the design process. This phase is of critical importance since decisions made at design have a direct impact upon whole life performance.
- **Phase 3**: The cost control of the procurement and construction stages. The latter part of this phase is still relevant today as it was when Ferry and Brandon first proposed the process. However, procurement has changed and decisions with regard to this are sometimes made prior to design, indeed during Phase 1. It is therefore essential that cost planning advice recognises the impact that certain procurement decisions will have one design and construction cost. This is addressed in Chapter 7.

Current thinking suggests that cost planning should continue beyond the conventional boundaries and take into account the whole life rather than the period up to PC. Figure 1.2 shows the typical cost planning process but, importantly, this is encapsulated within a whole life decision environment – in other words, it should include adequate appraisal of the long-term cost implications of design decisions (such as maintenance, energy and FM costs). This will be explored in depth in Chapters 5–7.

1.4 The profession of quantity surveying

The functions of the QS are broadly concerned with the commercial management of construction projects. This breaks down into two distinct areas of work: firstly, the planning and control of project costs; and secondly, the management of the terms and conditions of the form of contract agreed by the parties (Client and Contractor). As far as we are concerned in this book, it is only the first area which will be considered.

The methods employed in the planning and control of construction costs cover a range of activities which may include feasibility studies, cost planning, value engineering, cost–benefit analysis and life cycle costing, which all take place during the design stage of projects, calculation of interim valuations and final accounts, which include the cost estimation of variations, and changes are the procedures that take place during the construction stage of the project. QSs can also be known as construction economists, cost engineers or construction commercial managers.

The Quantity Surveying profession can trace its roots back to the rebuilding of London after the great fire in 1666. Prior to that date, buildings tended to be built on what we now call a design build arrangement, where the client would give the builder an outline of what they wanted, the Master Builder would work out the details, arrange all the various specialist tradesmen and forward the bills to the client at regular intervals. Clearly, the difficulty with this arrangement was that the client did not know how much the building was likely to cost before it was finished and if the client wanted several estimates or quotations,[4] each builder would need to separately calculate the amount of materials, plant and labour required, with the obvious duplication of effort and cost.

With so much rebuilding work required after the great fire, a more efficient system of calculating building costs and generating estimates was clearly required. Therefore, the independent 'Quantity Surveyor' was born, whose role was originally to consider the Architect's drawings (and specifications if they were lucky) and to develop a 'Bille of Quantityes' with the purpose of allowing any firm who wishes to tender for a project, to calculate that tender on the same basis and thus minimise any duplication of efforts. This service was originally paid for by the contractors tendering for the work, but over a period of time, the role became part of the client-side responsibilities to make sure that all tenderers were issued with identical tender documents.

Up to the beginning of the twentieth century, most large building construction work was either procured by the Government or by private individuals, where cost was not seen as the main criterion. Infrastructure work was slightly different, and the considerable amount of canal building in the eighteenth century and railway construction in the nineteenth century was undertaken at a considerable expense by corporate organisations. These companies (the railway companies prior to nationalisation) would borrow money from the capital markets to build the permanent way (or P-way as they referred to it as) and rolling stock and raised revenue through ticket sales to passengers and charging for freight. However, most railway construction projects were grossly over budget, and for all, his image as an icon of railway engineering, I. K. Brunel was constantly being sued by construction firms for non-payment of bills on projects where he had lost control of expenditure. Clearly, a further change was required.

The Quantity Surveying profession therefore took the initiative, spurred by the development of what is now the Royal Institution of Chartered Surveyors (RICS) in 1868, by developing procedures to control construction costs by accurate measurement of the work required, the application of expert knowledge of costs and prices of work, labour, materials and plant required. Sometime later, they would use their understanding of construction technology to be able to assess the implications of design decisions at an early stage to ensure that good value is obtained for the money to be expended.

The technique of measuring quantities from drawings and specifications prepared by designers, principally architects and engineers, in order to prepare tender/contract documents, is known in the industry as 'taking off'. The quantities of work taken off typically are used to prepare bills of quantities, which have been traditionally prepared in accordance with one of the published standard methods of measurement as agreed to by the QS profession and representatives of the contractors' organisations.

Although all QSs would have followed a similar course of education and training (for those entering the profession today, this is usually to degree level), there are many areas of specialisation in which a QS may concentrate. The main distinction among QSs is between those who carry out work on behalf of a client organisation, often known as a 'Professional Quantity Surveyor', 'Professional QS' or 'PQS', and those who work for construction companies, often known as a 'Contractor's Quantity Surveyor' or 'Contractors QS' or 'CQS'. The latter is usually responsible for all legal and commercial matters within the contracting organisation, and because of this many are now termed commercial managers.

1.5 Public sector building procurement

The innovations in procurement over the past two decades have radically changed the professional remit of QSs and other building professionals involved in providing strategic advice to clients on procurement and design. The design and economics of construction are inextricably linked with the procurement process, and this is recognised in the tranche of documentation issued by the Office for Government Commerce[5] (OGC) under the umbrella of 'Achieving Excellence in Construction'.

Achieving Excellence in Construction was launched in March 1999, by the then Chief Secretary to the Treasury, to improve the performance of central government departments, executive agencies and non-departmental public bodies (NDPBs) as clients of the construction industry. It put in place a strategy for sustained improvement in construction procurement performance and in the value for money achieved by the government on construction projects, including those involving maintenance and refurbishment.

Key aspects include the use of partnering and development of long-term relationships, the reduction of financial and decision-making approval chains, the improvement in skills development and empowerment, the adoption of performance measurement indicators and the use of tools such as value and risk management and whole life costing.

The next milestone in the development of public sector procurement is 2016, the deadline imposed by the UK Government for the integration of Level 2 Building Information Modelling (BIM). This is an exciting time for the profession and we explore the implications of BIM in Chapter 2.

With all these changes, QSs are now seen as the financial managers of the construction team who add value by monitoring the functions of time and quality, as well as the traditional function of cost. The role of the QS has therefore changed significantly in recent years from their humble origins and is now responsible for ascertaining a long-term view of building projects, assessing options and providing clients with comprehensive information on which to base investment decisions.

1.6 International dimensions

The profession of Quantity Surveying is a peculiarly British institution, due chiefly to the historical context outlined above. For those who care to remember as far back at the 1970s, this peculiarity was made the subject of a humorous sketch, the *Bookshop Skit*, written by John Cleese and Graham Chapman. In the sketch, a bookseller deals with a customer who seeks to buy the most obscure of book titles, ones that no ordinary bookseller could hope to have in stock – much to his annoyance and anger. Having batted away requests from the customer for *Olsen's Standard Book of British Birds* (minus the gannets!) and *The Amazing Adventures of Captain Gladys Stoat-Pamphlet and her Intrepid Spaniel Stig among the Giant Pygmies of Corsicato*, the customer then demands a copy of *Ethel the Aardvark Goes Quantity Surveying* – but much to the booksellers delight he discovers that he does have a copy to sell her!

The sketch ends with the bookseller reciting the opening paragraph to the customer as he thumbs open the first page *Ethel the Aardvark was trotting down the lane one lovely summer day, trottety-trottety-trot, when she saw a nice Quantity-Surveyor…* anyway, we digress!

Through emigration in the nineteenth and twentieth centuries, the British construction procurement system has been exported to Commonwealth countries, so that in English-speaking countries such as Australia, New Zealand, South Africa and Canada, there are well-established firms of QSs represented by their own national professional bodies. Clearly, the local construction industry in these countries has developed separately, which also shows that the skills of the QS have been found to be valuable. In Europe, the pre-contract and post-contract roles are generally split, so the feasibility and cost-planning function are taken by the Economist de la Construction in France or the Baueconomist in Germany. The post-contract function of valuations and final account preparation is often taken by the Resident Engineer, assisted by a technician cost engineer. In the United States, the situation is substantially the same, although in recent years many large firms of QSs are operating very successfully in the United States where clients see the considerable value of the QS core skills in technology, law and economics. Traditionally, these skills require different professions who do not necessarily have the detailed knowledge of the construction industry.

1.7 The future of cost planning

Cost planning, like any other discipline, within construction is continually developing and responding to the ever-changing demands of today's clients. In order to meet this challenge, there exists a basic set of competences that cost planners should acquire and continue to develop over their careers. In the United Kingdom, the RICS sets out these competences in both the Assessment of Professional Competence (APC) and Continuing Professional Development (CPD) requirements. This text is introductory and aims to provide that first step, but future cost planners must recognise the importance of the following:

- Understand the impact of early stage strategic decisions on the project life cycle costs and performance.
- Recognise the importance of sustainability through a wider understanding of how buildings perform in use; environmental and energy issues should act as the catalyst to a wider appreciation of whole life cycle costing.
- Harness the benefits of increased interdisciplinary collaborative working with other professionals within the client, design and construction teams.
- Engage with the design team from the outset in order to foster a greater understanding of the impact of design decisions on whole life cycle cost.
- Develop effective risk management strategies with the cost planning process.

In Chapter 2, we shall examine some of the recent developments that have taken place in the cost planning discipline from a BIM perspective.

Further Reading

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Lee, S., et al. (2011) Willis's Elements of Quantity Surveying, 11th edn, Wiley-Blackwell, ISBN: 10:1444335006.

Ostrowski, S.D.C. (2013) Estimating and Cost Planning Using the New Rules of Measurement, Wiley-Blackwell.

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1 The concept of value is based on the relationship between satisfying needs and expectations and the resources required to achieve them.
2 Project management: Overdue and over budget, over and over again, *The Economist*, 9 June 2005.
3 'Ruthless but lawful' *QS News*, Friday, 14 July 2006.
4 The difference between 'estimate' and a 'quotation' is very important. An estimate is only an indication of what the cost of the project will be and may change if, for example, material or labour prices change. A quotation, on the other hand, is a fixed price and will only change if the client varies their instructions.
5 The full 'Achieving Excellence in Construction' documentation can be downloaded from the Office for Government Commerce website at www.ogc.gov.uk.

Chapter 2

Building Information Modelling

2.1 Introduction

Perhaps one of the most important developments in the practice of cost planning is the advent of building information modelling (BIM). Proponents of BIM argue that the principles of improved collaboration and sharing of construction project data through an open and universal classification system offer the greatest opportunity to deliver projects on time, on cost and to the desired level of quality. The Cabinet Office published the Government Construction Strategy on 31 May 2011; the report announced the Government's desire that 'collaborative 3D BIM' (with all project and asset information, documentation and data being electronic) be mandated on its projects by 2016. This chapter is designed to provide a contemporaneous view of the current landscape of BIM from a cost planning position and draws on an international perspective to demonstrate the variations in the practice of BIM across the globe.

2.2 A brief history of BIM

The emergence of BIM could arguably be traced back to the early 1980s under the **Virtual Building** concept developed in Graphisoft's ArchiCAD; this was the catalyst behind a new software 'revolution' that allowed architects to create a virtual, three-dimensional (3D) representation of their designs, a radical departure from the standard two-dimensional (2D) format that was common.[1] Autodesk® has since emerged as a market leader in the provision of design software covering the range of built environment disciplines, although the focus was (and arguably still is) predominantly design focused.

Designers using 3D software were still, however, required to produce copious amounts of specification documents in order to express all the required information required by the project. It became apparent that the creation of a digitally constructed virtual building model, along with its associated data, was necessary. As a result, an advanced system had to be established to assist designers in storing the necessary data sets such as the building geometry and spatial data as well as the properties and quantities of the components used in the design to be included within the building model.

In simple terms, buildings were becoming increasingly complex, and with that complexity brought an ever increasing problem in sharing design information across the multi-disciplinary team including the client.

BIM emerged as the possible solution to this problem, offering a new way of working that enabled the capture of all necessary data within one global model that could be shared and understood by all project participants. The idea is simple, but the devil is in the detail!

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

2.3 Definition and concepts

As a starting point, it is useful to consider some of the definitions of BIM that have recently emerged. The professional institutions (Royal Institute of British Architects (RIBA), Royal Institution of Chartered Surveyors (RICS), Institution of Civil Engineers (ICE) etc.) have all developed strategies to respond to the BIM agenda, and it would be wise to consult the various institutional groups of special interests for up-to-date information, but as a starting point, the current definition of a 'building construction information model' (aka BIM) adopted in BS ISO 29481-1:2010 is

> *shared digital representation of physical and functional characteristics of any built object (including buildings, bridges, roads, etc.) which forms a reliable basis for decisions*

The emphasis of the International Organisation for Standardisation (ISO) definition is embedded in the notion that construction project data lie at the heart of the representation of a model that may be used by the collaborative team to enact a series of decisions that ultimately lead to the successful completion of the project. The RICS recently published a note to members[2] which emphasises this point:

> *A BIM model contains representations of the actual parts and pieces being used to construct a building along with geometry, spatial relationships, geographic information, quantities and properties of building components (for example manufacturers' details). BIM can be used to demonstrate the entire building lifecycle from construction through to facility operation*

We can infer from these definitions that BIM is a contemporary industrial transition from the traditional 2D standard drawing format to the format that provides a rich information model, consisting of multiple data sources, elements of which can be shared between all project participants and be maintained throughout the life of a building from inception to demolition/recycling. Advocates of BIM are keen to emphasise that the concept is not simply concerned with software tools and data classification systems, it advocates a collaborative working process characterised by well-managed information interfaces that provide a 'joined-up' decision-making process in a real-time format. It seems obvious, therefore, that a key facet of BIM is good project management coordination.

Adopting a BIM strategy in the early stages of a project should allow project participants to contribute to building a model that represents the whole building's components, interactions and performance (structurally and thermally say) before construction, therefore resulting in potentially significant improvements in safety, cost, value and carbon performance. BIM could have benefits for clients too, assisting the multi-disciplinary team in communicating design concepts in formats that are readily envisaged.

It is important to reiterate at this point that as far as the UK construction industry is concerned, all projects commissioned (on behalf of the Government) should be Level 2 compliant by 2016.

- Level 0 BIM involves producing information from 2D CAD files. This process is known as 'the traditional practice', which has been used for many years by the multi-disciplinary team.
- Level 1 BIM uses both 2D and 3D tools for object-based modelling. This process tends to be used by architects, usually in early project stages where 3D tends only to be used as a design tool for visualisation and presentation of designs rather than as a tool to control costs (say).
- Level 2 BIM involves producing an information model in a collaborative environment, and could be said to be 'object-oriented' in programming parlance. This level of working

represents the UK Government ideology, where 3D tools are used with 4D construction sequencing and/or 5D cost information by the multi-disciplinary team (including clients) to produce object-oriented models capable of manipulation in an optimal way.
- Level 3 BIM features BIM tools in a network-based integration system where the multi-disciplinary team work in an integrated and federated 'society' using 3D design tools, 4D construction sequencing, 5D cost information and 6D project life cycle management information. All of these tools are managed and sequenced by Industry Foundation Class (IFC) web services and standards.

2.4 Industry Foundation Class (IFC)

IFC is a data exchange method that specifies elements that are used in building construction in an agreed manner that define a common language for construction. IFCs provide a foundation for the exchange and sharing of information directly between software applications of a shared building project model.

2.5 BIM and the project life cycle

It is advocated that BIM takes a 'holistic' view of the project life cycle – supporting some of the ideas and concepts of whole-life costing (see Boussabaine and Kirkham 2004) and asset management (see PASS-55). A holistic approach requires an appreciation of the complexity of the interactions within a building throughout its life and also tools and methodologies that extend beyond the deterministic. It should take on a major role during the construction phase of a project as well as the post-construction phases and facility management, including eventual disposal.

2.5.1 The design phase

As mention earlier in this chapter, the adoption of BIM permits the creation of a virtual building model prior to construction; these models can be interrogated using a wide range of 'BIM tools' to ensure the standards of the following features that are met.

- Carbon production rates
- Use of energy
- Airflow
- Day lighting
- Simulating pedestrian use
- Fit-out design

All of these 3D features are design elements that can be found in other systems and design schemes; however, the BIM approach advocates the integration of 4D (time) and 5D (cost) information into the design decision-making process. 4D is a feature that combines the model with the timescale of each task within the project to set up progression in early stages and flag up in case of any potential clashes in the programme. 5D is a feature where all the costs information of the relevant Quantities, Labour and Equipment are added to the model to give a better understanding of the cost scale to aware all of the involved professionals.

In order to get all of these features working smoothly as required, a Model Manager is to be appointed to keep the scheme maintained and ensure efficient management of information processed throughout. The Model Manager also known as Information Manager is engaged directly to the design team on the client's behalf from the pre-design phase onwards to develop, track and manage the input of each designer into the project model ensuring that all of the designers are using compatible software within the software-sharing matrix in order to get the most up-to-date model supporting all individuals and trades to work on the right model at the right time.

2.5.2 The construction phase

After the design is completed, construction is ready to begin. As mentioned, during the design phase, cost estimate and time schedules are included within the model. This means that off-site pre-fabrication and pre-assembling, waste management, material deliveries, manpower and plants are all procured and scheduled to avoid any waste of time or money while getting the best quality of the job in hand ensuring project completion by the due date.

The BIM concept of visualising a primary construction model of the facility prior to its actual physical construction can be beneficial during the construction phase to reduce uncertainty, improve safety, address problems, simulate and analyse potential impacts. Professionals from all involved trades can input their critical information into the model before the beginning of construction, making work-streams harmonised throughout the construction phase. This means that any changes made to the model will result in a direct change to the associated data set; this will be communicated to all users within the project and inform the need for variations and required actions. Also, the aid of walkthroughs and accurate renderings in the BIM model improves the management of this process.

2.5.3 The operational phase

Facility managers constantly face the challenges of noticing faults within the facility after it is built and sometimes after the expiry of the warranty period given by the contractors, which can be a major waste of materials, time, labour and obviously lead to more costs. BIM can identify these faults in earlier stages while it is in the model or construction phase rather than exploring it on the physical building. BIM can also be used to improve information handling across all key project life-cycle stages, presenting opportunities for facility managers to access important information that may be used later on during the operation and maintenance phase, developing analytics for building services and structure/fabric performance. Post handover, BIM should allow the building's owner/operator to have access to all of the required and relevant information to enable informed decisions on building management and planned preventative maintenance.

2.6 The effect of BIM on the project life cycle

2.6.1 + Pulls

During a project's life cycle many common problems emerge when using the tradition way of working; however, the implementation of BIM has the potential to eliminate these inefficiencies within the industry.

The main problem is often one of communication and lack of understanding of the impact of design decisions across the professional disciplines within a typical construction project. BIM attempts to overcome the challenges to collaborative working by improving information flows in terms of timeliness and accuracy. This feature also enables these professional members to stay synchronised to improve accuracy and make knowledgeable decisions in advance which reduces waste and helps to ensure the project's success.

In addition to the features that were mentioned earlier in BIM's model and the solution that BIM provides to avoid the lack of communication and understanding, the use of BIM can permit the following criteria:

- Clients and contractors to obtain lower net costs and less time
- Reduction of subcontractors' costs and risks
- Safer and greener buildings throughout the life cycle
- Enhanced decisions through the improved visualisation of the 5D model
- Efficient recovery of information
- Increased coordination of construction documents with better understanding and appreciation between professionals
- Increased speed of delivery

2.6.2 – Pushes

Despite the benefits that it could bring to the industry, clients are still hesitant to embrace BIM. There are concerns that if contracts are to specifically require BIM, the potential pool bidders for a tender may be limited (because some contractors and designers are not yet prepared to fully adopt BIM for reasons including high costs of implementation – particularly with respect to extensive training, cost of technical expertise, costs of organising protocols and organising a network server to store and access the model.

Other issues around the implementation of BIM include legal barriers surrounding liability, uncertainties to the Intellectual Property Rights, digital information exchange and ownership of the model over time.

2.7 The effect of BIM on the role of cost planner

Measurements are usually taken from 2D construction drawings and specifications, however, advanced computer-aided design (CAD) drawing technology typically found in modern BIM software has the potential to improve the ways in which bills of quantities (BQ) are prepared. This data can then be used to automate BQ processes in compliance with the rules prescribed in relevant Standard Methods of Measurement (SMM) and New Rules of Measurement (NRM).

Some quantity surveyors (QSs) have expressed concerns that BIM could have a negative impact on their professional role; chief amongst these concerns is the potential overlap of BIM work streams with standard QS tasks and the automation of BQ data from within the BIM model. It is entirely possible that future developments in BIM technologies will see changes in the way that the cost planner works but it is important to recognise the role of the QS in managing the interfaces between client, contractor and the design team from a cost planning perspective – effective collaboration cannot be facilitated by software alone and the 'soft' side of BIM will be a major focus of opportunity in future years.

Studies in the United States have largely recognised the benefits of adopting BIM from a cost planning perspective. Typically, it has been suggested that BIM has can deliver up to 80% improvements in time (to prepare the cost plan) and increase accuracy by 3%. Other studies have emphasised that the benefits of BIM in clash detection where prior to construction, savings up to 10% (of project value) and 7% of project time could be achieved.

Quantity surveying, as a professional discipline, plays a critical role in the overall cost management process. Whilst measurement and costing are the essential 'tools of the trade', there is an expectation that the profession must adapt to challenges set out in the governments construction strategy. In PQS practice, many of the services provided by the surveyor go well beyond measurement, costing and where appropriate, BQ preparation. Procurement and contract advice are increasingly tasked to the QS but BIM may create new opportunities, potentially placing the QS at the heart of a multi-disciplinary team in much the same way that the CDM co-ordinator works in a health and safety context. Clients are increasing demanding in terms of the expectations of reliable and accurate cost plans, it seems obvious that the profession has a key role to play in this.

2.8 Issues surrounding the implementation of BIM

BIM is considered a way of working to construct a managed digital information model filled with data, this system could be used within the industry to control many issues we are facing today; but in order for BIM to be processed and efficiently implemented, it needs to be understood and revised to overcome the legal barriers that were mentioned earlier.

It is important to set out the legal issues before implementing BIM to ensure that the industry can collaborate without the worry of unpleasant legal consequences.

No doubt that implementing BIM requires changes to the contracts used within the industry to suit BIM requirements and protocols. The first contractual substance that has to be amended when implementing BIM is the contractual relationship between the consuming parties. At present, BIM requires the contracts in use to be an amendment to cover the legal issues that may arise from the collaboration of clients, consultants, contractors, sub-contractors, manufacturers and fabrication modellers to outline who has the reliance of data, who is reliable of any mistakes or errors, who has the full/limited access to certain parts or all of the model, confidentiality of shared information, who has the ownership of BIM process, ownership of risk management during model transfer and model ownership (final product).

These amended contracts should also include the new roles that BIM will introduce into the industry. For instance, the roles and responsibilities of Model Managers have to be identified and set out in the contract, outlining the relationship between the Model Manager and other team members to avoid conflicts and confusions to such a sensitive role.

These BIM protocols have to be introduced as a set of amendments to the main contract, this set has to be incorporated into the various agreements used for the project ensuring the same set of BIM privileges and requirements flowing through the different contracts to avoid clashes between the clauses of the principal contract and the legal terms of the BIM protocol. However, there are concerns that these changes may result in drafting a new form of contract especially at Level 3 of the UK BIM maturity index.

2.9 International perspectives on the development of BIM

2.9.1 Canada

The Institution of BIM in Canada (IBC) has taken the responsibility to lead and facilitate the full implementation of BIM into the Canadian-built environment where they had a keen interest in focusing on the primary stakeholders allowing them the right method and pace to understand their roles and responsibilities and to assess their capacity to contribute in this process.

2.9.2 India

India's fast growth of population and economics have boosted an increase in the building environment and made the perfect platform to implement BIM where now India has a strong manpower of qualified, trained and experienced BIM specialists who are not only implementing BIM technology in India's construction projects but also assisting on the implementation of BIM in Canada, United States, United Kingdom, Singapore and Middle East regions.

2.9.3 United States

BIM, also known in the United States as Virtual Building Environment (VBE) or Virtual Design to Construction (VDC) Project Manager, has seen widespread adoption across a range of projects from buildings to civil and defence infrastructure; it is the latter of these which the US contribution to BIM is most notable – COBie (Construction Operation Building information exchange). COBie is a data schema, which holds and transmits all information records in a simple format of spreadsheet or relational databases, to support the client's ownership and operation of a facility. The COBie data schema was initially developed by the US Army along with NASA and the Veterans Association to allow effective and immediate management of data on project handover. COBie manages project data in a simple structure, using different categories and specific codes to allow the user the most efficient form of access. This information data are linked to specific kinds of objects. Each object contains additional data such as documents, coordinates, geometry, physical features, economic and environmental impacts and so on.

BIM software vendors such as Autodesk (Revit), Bentley (Architect), Nemetschek (Vectorworks) and Onuma (Onuma Planning System) were successful in providing COBie design data directly from their applications during testing in July 2008. This means that data entered from participants can be automatically transferred, transmitted and updated into the COBie data schema in a consistent manner.

COBie is intended for use in both new and existing building and infrastructure projects. Just like the US federal agencies, the UK Government are also requiring the delivery of COBie data during design and during construction in order to eliminate duplicative data entry, eliminate paper reproduction costs, and improve the construction handover process (see soft-landings).

The US Government have established a system to ensure that BIM's policies do not conflict with construction contracts' policies and addressed the allocation of risks associated with the implementation of BIM, so that parties are aware of their roles and responsibilities from the beginning. No doubt, BIM can be an extreme benefit to the industry, but to process it requires a secure and a well-identified communication system. In essence, it is only as good as the people using it; now in the United States, BIM is encouraging parties to collaborate together constructively to find solutions with a carefully balanced act between minimising exposure to risk and liability.

2.9.4 United Kingdom

The UK Government have already shown its awareness of BIM's benefits in controlling cost, time and quality and the advantages it offers to everyone involved in the construction projects, including clients, designers, contractors, suppliers and facilities managers. On 31 May 2011, the Government showed its interest in BIM by publishing a construction strategy report which announced that the Government aim to adopt BIM's technologies, process and collaborative behaviours into all stages of the life cycle of projects worth more than £5 million by 2016.

This construction strategy report outlined a plan of the 5-year program that aims the following:

- Communicate and enhance the understanding of BIM by the widespread articles, seminars, workshops and publications within many existing businesses in the industry. And also to organise and provide many educational and training sessions to allow the new professionals

to have the correct knowledge and skills to blend with BIM applications to ensure that the new and old professionals within the industry are ready for the 2016 digital BIM switchover.
- Investigate the contractual and legal issues to find solutions to ownership, sharing, copyright, IPR and insurance and issue a framework to outline the legal process and procedures of BIM.

Despite the legal barriers that are stopping the UK Building Industry from fully adopting BIM, 1000 UK construction professionals participated in a survey by RIBA showed that there was an increase in construction professionals using BIM on at least some projects from 13% in March 2011, up to almost a third (31%) by February 2012. This shows that BIM technology has also been recognised by other organisations in the United Kingdom who have already used it to manage their projects. BIM has proven to increase the firm's position to secure a project and gain the clients decision over other contenders even though BIM is still not widely used, this could act as a more effective advantage when BIM is fully implemented in the United Kingdom. Some of these organisations handled the legal issues from the adoption of BIM by including BIM in the contractual agreement as an information base only.

In 2012, the RIBA (through the NBS) launched a free-access database to BIM objects in IFC data formats compatible with most of the main BIM software packages listed below.

2.10 Commonly used BIM software tools and vendors

The software market is changing rapidly, and consequently a range of BIM products are currently available to the design team, of which those most commonly used include:

- Autodesk Revit® software is widely marketed as a 'one-stop-shop solution' for BIM that includes features for architectural design, MEP and structural engineering, and construction. The software has the benefit of bidirectional associativity (this allows connections between objects to update automatically) and work-sharing so that multiple users can work on the model simultaneously. Autodesk Revit 360 is a collaborative tool that provides access to data storage, collaboration workspace and 'cloud services' to improve collaboration. In simple terms, 'cloud computing' involves a large number of computers connected through a real-time communication networks.
- Autodesk Navisworks® software is widely accepted as a BIM tool, given that it performs many of the functions that the spirit of BIM aspires to including coordination, sequencing and construction process simulation, and project analysis. The tool includes scheduling optimisation algorithms and assists with the identification of clashes and interferences. Up until quite recently, the industry perception of BIM was 'clash-detection', probably due to the popularity of tools such as this.
- Bentley Systems software functions in a similar way to Revit, it integrates the project model through a family of application modules such as Bentley Architecture (Microstation Triforma), Bentley Structures, Bentley HVAC and so on. The vendors suggest that interoperability is best achieved through the use of the whole family of tools rather than piecemeal adoption.
- Graphisoft's ArchiCAD 17 application is now enabled with BIMx (a graphical tool that enables the design team to present and communicate model data), and BIMserver is designed to make projects accessible through standard internet connections by optimising data exchange traffic.
- Nemetschek Vectorworks is Nemetschek Vectorworks Allplan 2013, which is a similar product to Bentley and is commonly used in Germany. It features a number of discrete

components can be utilised to develop a BIM work stream including Allplan Architecture, Allplan Engineering, Allplan BCM (the software for tendering, billing and construction cost planning) and Allplan Allfa which focuses on hard and soft FM.

2.11 Case study: HM Young Offender Institution Cookham Wood

HM Young Offender Institution (HMYOI) Cookham Wood is the first 'pilot' UK Government project on which BIM has been utilised through the tender and fully employed during contract stages. The project consists of a new three-storey houseblock to house 179 young people in single cells, together with an education facility, a new two-storey regime building offering vocational skills training and external works include three new fenced exercise yards, access roads and associated security fencing.

Benefits of operating with BIM include improved collaboration and design co-ordination; design efficiencies; reduced wastage in design, materials and on-site production; and greater benefits for asset management, custodial operation and ongoing maintenance of the facilities as well as a recorded £800,000 saved.

2.12 Key points

- BIM is not simply concerned with software tools. It is a 'way of working' that is designed to optimise the coordination of design and construction data over the life of the building.
- BIM has the potential to radically change the way in which the industry works; the new RIBA Plan of Work 2013 reflects this but traditional attitudes and cultural divides will continue to resist change in the short-term.

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Endnotes

1 The literature also suggests that position papers written by Autodesk in the mid-to-late 1970s intimated BIM concepts.

2 The RICS briefing note was written by Steve Pittard, Director of Causeway Technologies Limited, and Chairman of the RICS QS and Construction IT Working Group and is available through the www.rics.org.

Chapter 3

A Three-Stage Cost Planning Strategy

3.1 Introduction

In Chapter 1, we considered some of the fundamental aspects of cost planning; these concepts were developed further in Chapter 2 where we considered the impact of building information modelling (BIM) on the practice of the cost consultant. Clearly, the discipline is dynamic and ever changing, mainly due to the increasing demands placed on the design team by the client organisation and changes in procurement and contract. The new paradigm of 'software centred' service delivery has irrevocably changed the way that cost planners work in professional quantity surveyor (QS) and cost consultancy practice – but whatever methods or software tools are used to assist the cost planner, the conceptualisation of cost planning as a three-stage process is just as valid today, and thus a programme of cost planning and control should comprise the following.

- Stage 1: The client brief, procurement advice and the budget
- Stage 2: Cost planning and control of the design process
- Stage 3: Cost control of the production stages

We shall look at these stages briefly here and, throughout the rest of the book, develop the ideas and concepts that feature within them.

3.2 Stage 1: The outline client brief, procurement strategy and the budget

The importance of developing an effective client brief is now well versed, mainly because of the reforms that emerged from the Rethinking Construction[1] report. One key recommendation was the exploitation of more formalised approaches to developing the client's brief and ensuring that this information was translated effectively into the design. The traditional informal arrangements, usually between the client and the architect, were seen to be largely ineffective, particularly for larger and more complex projects with multiple stakeholders. The advent of BIM (and changes to the RIBA Plan of Work in 2013) has emphasised this, these developments have been a response to the problems of conceptualising project dynamics along traditional lines of thinking.

Today, in most construction projects, the brief is a formal statement of need or a document that sets out the client's objectives as well as the functional requirements of the building. It should be in sufficient detail to enable the construction team to execute the detailed design

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and specification of the work and is therefore an essential reference for the project design team. The new 'Stage 0' to the RIBA Plan of Work (we cover more of this in Chapter 9) reflects the importance of this issue.

Historically, systematic cost planning was first introduced at a time when the national building programme was largely in the public sector (the first edition of this text provides a fascinating insight into the history of cost planning in the United Kingdom). Budgeting was undertaken on the basis of government formulae for the cost of houses, schools, hospitals and so on, and the skill of the cost planner lay in optimising these in relation to the particular project. Today, however, budgeting is concerned much more with the concept of value for money, financing, revenue streams and corporate decision-making. The cost planning processes have evolved to be more client oriented and its importance in the overall project life cycle has grown accordingly. Later, we shall touch upon the concept of measuring value and value management techniques. The latter of these and cost planning, in general, has in some quarters been perceived as a method of specifying minimum performance standards (or, more cynically, cost cutting). This is not the case, the ultimate aim of value management is to ensure that the project is budgeted correctly for a desired standard and then to ensure that the resulting approved budget is spent effectively.

The traditional method of formulating and reconciling the client brief is through the customary time, cost and quality constraints. This method is common to many other project scenarios and is referred to in British Standard BS6079 Project Management. The requirement to identify the priority that these constraints assume is important; more often than not it will be the cost parameter which dominates – although many developers, for example, will also be focused on time since the project finance may be offset against anticipated future revenues.

At this stage, and depending upon the type of project and client, a decision may be made about the method of procurement. Traditionally, this will have been dealt with in Stage 3 (as advocated in previous editions of this text) but now, there is strong evidence linking project cost to procurement route – indeed, the examples given in Chapter 1 illustrate rather well the consequences of an incorrect procurement route selection decision. We will cover procurement issues in sufficient depth later. Interestingly, many clients (particularly ones that are experienced in the dealing with the construction industry) have developed bespoke procurement strategies and these may be specified from the outset; the **UK National Health Service ProCure21+**[2] strategy being an example of such an approach.

It is also useful for the cost planner to have an awareness of the resources being provided by the client to the project. The project cash flow will invariably be affected by the timing of payments by the client. Any potential problems should be identified as early as possible to allow mitigation strategies to be developed within the cost/risk management plan. Finance apart, the involvement of the client in the nuances of the project will also give useful clues as to which procurement route is most appropriate.

3.3 Stage 2: The cost planning and control of the design process

It is at this stage of the process that the effectiveness of the work carried out previously is tested. Like any project, the greater the quality of preparation work carried out at the pre-design stage, the lesser the likelihood being of major revisions and design variations. Ultimately, the effectiveness of the outline brief comes into sharp focus. At this stage, the key tasks are as follows.

- Development and preparation of the detailed brief
- Development of the design
- Cost control through the development of the design

It is unfortunate that in many cases, the amount of time and effort spent by the cost planner on each of these three aspects is often inversely proportional to their relative importance. Often, effort is almost entirely concentrated on the third aspect, with perhaps a little advice being given on the second. Sometimes the excessive effort required to keep the design development within cost limits actually stems from unwise decisions made at the earlier stages without the benefit of proper cost investigation. In most cases, if the procurement strategy is right, the design development will usually present few problems. At the early stages, the estimates are mainly based on past experience of a similar building with certain accommodation and of a certain specification level. Therefore, by adjusting this historical cost, the proposed building ought to be able to be built for a certain amount of money, and it is up to the project team to achieve this. As the design develops, the estimates are increasingly refined to ensure that the designers are kept within parameters, so this building as finally designed can be built for the original estimate/feasibility sum.

Estimates given at an early stage carry a considerable degree of risk, and as further information becomes available they are almost certain to become subject to amendment. What is important is that whenever this happens, the decisions to amend the cost, or to amend/abort the scheme, can be taken without abortive expenditure being incurred. Therefore, the estimates themselves should not be prepared in any more detail than is relevant to the current stage of progress of the design.

Although the establishment of the brief and the investigation of a satisfactory solution are shown as two separate and consecutive functions, there needs to be constant iteration and feedback. Design investigation may suggest modifications to the brief, which in turn will need to be investigated. This is all to the good and will probably result in improved performance. Even if it involves, as it will, a good deal of abortive cost-planning effort, the cost planner's work at this stage, is relatively inexpensive compared with that of the potential benefits and cost savings. The cost control of design development, on the other hand, demands considerable resources, and should not be carried out until a satisfactory solution has been defined and agreed. Substantial iteration between investigation of a solution and cost control of the development of design brings nothing but disadvantages. This is the principle involved in decision-tree analysis, where design decisions at the beginning of a project are relatively few but have a large effect on the design and cost, for example deciding on the foundations or the structural frame. As the design development progresses, the decisions become more numerous but have less individual effect on design and cost, for example the number and specification of internal doors.

In formulating the detailed brief, the cost planner should ensure that they co-operate, preferably on a team basis, with those professionals concerned with the actual building design; representatives of the client's organisation or the client's project managers; valuation surveyors, accountants and possibly planners. As the investigation of a satisfactory design proceeds further into the realms of building configuration, the cost planner will become increasingly involved with the designer and the design consultants, including perhaps a construction planner, to the gradual exclusion of the other parties.

As has been stated, the basic principle to be adopted is one of moving from the 'ball-park' estimating of the outline proposals stage to the detailed costing of production drawings in a series of steps. At each of these steps, the process must be monitored. Previous assumptions must be checked in the light of further design development, and any necessary modifications were made to the estimates or to the design before proceeding to the next stage. As the brief is developed in more detail, and as the design itself develops, it may become apparent that the building which the client wants, with a proper balance between economy and quality, will cost either more or (in theory at any rate) less than has been allowed. It should be possible to reduce or increase the quality of the specification to get back to the original figure, but the cost planner should not automatically assume that the client will want this to be done. The client organisation may be more concerned with getting the building they want than with a potential saving of 5% on the cost; on the other hand, they may not, but the decision is theirs. The difference between this approach and the situation (without cost planning) of a large and unexpected gap between estimate and tender is that clients make their choice consciously with a knowledge of the amount of money which their decision is costing (or saving) them. In this way, the time and expense involved in abortive detailed design work can be avoided.

The above process still assumes that there is a difference between the designers and the constructors, and that the constructors do not have any influence on the design process. Clearly, this is changing with the rapid rise of design and build procurement and other forms where there is an overlap between the design and construction roles. Having an early contractor involvement creates massive potential efficiencies in the design development process as the contractor's method statement can be developed concurrently with the design and the concept of 'buildability' is incorporated. In addition, the Construction Design and Management (CDM) Regulations 1994 created the role of the Planning Supervisor, whose function is to develop the Health and Safety Plan during the design stage to establish the potential hazards and risks associated with the site and the design. Having an early contractor involvement would allow many of these hazards and risks to be 'designed out', possibly at an extra cost.

3.4 Stage 3: Cost control of the procurement and construction stages

The original development of cost planning, as we have already noted, took place largely within the local authority and central government sectors, where because of the system of approvals in force at that time the amount of the tender was the crucial factor and there was less emphasis on the final cost. Today's clients are not satisfied with this procedure and clearly have a significant interest in the final account figure or 'out-turn' cost, as this is what they will actually pay for the facility on completion. Therefore, the principle of shifting concentration from estimating the tender figure to estimating the final cost represents a major shift in emphasis.

3.5 The role of the cost planner

The role of the QS has changed significantly since the economic trough of the early 1990s; the rise in alternative forms of procurement (notably PPP/PFI) will no doubt continue to evolve the role further. Historically, the QS was often not appointed until the architect (who acts as the surrogate client in the traditional procurement scenario) had prepared the production drawings, or, if appointed earlier, would play no part in the project until production drawing stage was reached and work would commence on the bills of quantities and other formal tender documentation. Today, the QS (or cost planner) is regularly appointed before any other professional consultant and accepts responsibility for the client's financial interests in the project or, in other words, assumes the role of project financial manager. When the cost planner is appointed, there are a number of issues which will have a bearing on the development of the project budget; it is therefore wise to ensure that these are adequately understood before proceeding further.

Who is responsible for the appointment? If the cost planner has been appointed on the recommendation of the client's architect and is a sub-consultant to them, relations with the client will tend to be conducted through that architect. However, if the appointment has been made by the client as a result of previous experience or outside recommendation, the relationship will usually be more direct. Apart from any other factor, a client who decides to appoint a cost planner directly will probably have an above average interest in costs, which will therefore play a predominant part in the scheme design.

Is the cost planner to be concerned with the total budgeting of the project or limited to particular areas, such as capital expenditure, or building and furnishing costs, or merely net building costs, or expected to do nothing more than merely give an estimate and then prepare a bills of quantities (BQ) or other contract documentation?

Who else has been appointed? If other appointments have not been made, the cost planner could assist the cost-orientated client in setting up the team of consultants, and this would obviously be of assistance in the context of total cost control.

What decisions have already been made, or steps taken? Any decisions, which have already been taken, or implemented, will obviously constrain any cost optimisation programme which the cost planner may generate. The cost planner should, therefore, be diligent in probing any of these decisions unless advice is definitely being sought or unless they are so fundamentally wrong as to make it impossible to carry out the task for which the cost planner has been appointed. It would only be in the most extraordinary circumstances, and where the cost planner was in a very strong position, those doubts should be cast on specialist professional advice which the client had already received from valuers, accountants, lawyers and so on.

Is cost control to continue until the completion of the project? In the past, it was not unusual for the cost planner's cost control role to finish at the point where a contract was signed with a contractor. In view of the many major problems that can occur subsequently, this was a very short-sighted policy and is generally no longer the case.

It will therefore be seen that the extent to which the cost planner will be able to use the various techniques described in this book depends not only upon the priorities of the client but also upon the terms and circumstances of appointment. A cost planner who has been entrusted with the overall cost management of a project must resist the temptation to make firm proposals to the client based upon their own elementary knowledge of property values, investment, taxation and so on. Cost planners are not experts in these fields (although a large QS/Cost Consultancy firm may well employ such experts) and the purpose of education in cost planning courses in this area is to make cost planners aware of circumstances in which these matters may be important, and to help them in briefing specialists and assessing specialist advice.

3.6 Cost planning practice

The complexity and quantity of work involved in cost planning vary considerably but the professional will aim to reduce the effort to a minimum. QSs intuitively understand which items are of cost significance, where short cuts can be taken, and where detailed and long drawn-out cost checks can be avoided. Cost significance will be touched on later in this book and forms a part of the methodology of whole life cycle costing. Experience will also show that the use of computers, standard forms and procedures can hasten the process. For this reason, and also because of the acceleration in working brought about by familiarity with cost and prices, in many larger practices and consultancies, the focus on cost planning will be within a separate department rather than it being done by the staff whom would ordinarily be involved in taking off activities (where this is appropriate).

The success of good cost planning is correlated to the sufficiency and quality of cost and performance data. There is an argument to suggest that those involved in taking off activities are perhaps more suited to the cost planning role generally, since it will give them familiarity with the project and thus make the actual QSs all of whom are fully experienced and practised in both cost planning and BQ preparation techniques. Whether it is as valid as it sounds is therefore open to question; certainly a number of public authorities who originally used this method subsequently changed over to separate departments. There is scope for experiment here, but if the cost planner and the taker off are two different people there must obviously be a close working relationship.

3.7 Key points

- Elemental cost planning should ensure that the tender amount is close to the first estimate, or alternatively that any likely difference between the two is anticipated and is acceptable.
- The cost plan should ensure that the finance available for the project is allocated consciously and economically to the various components and finishes.
- Elemental cost planning does not mean minimum standards and a 'cheap job'; it aims to achieve good value at the desired level of expenditure.
- The measurement and pricing of approximate quantities at some stage, is a feature of the cost planning, *per se*.

Further reading

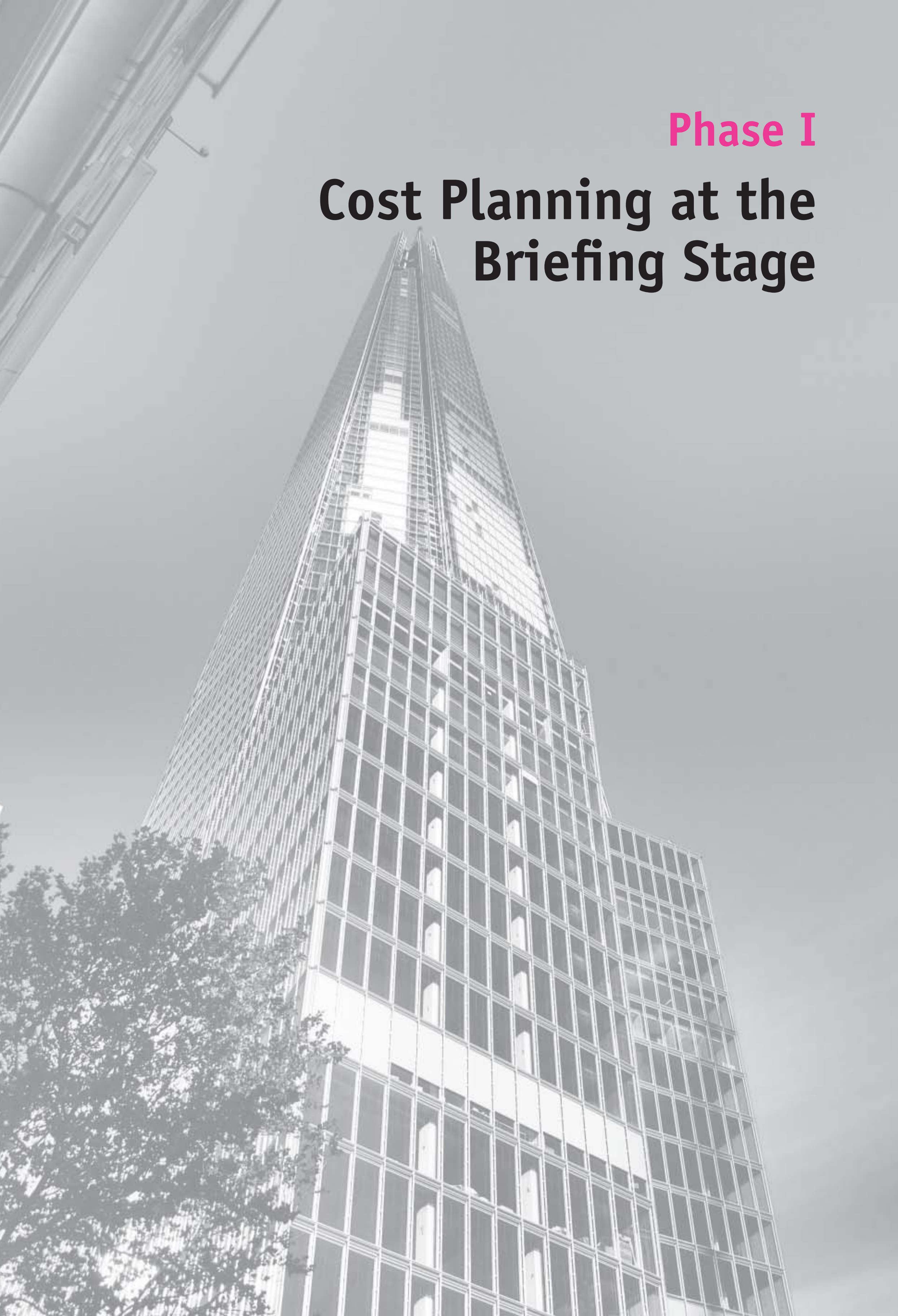
Barrett, P. and Stanley, C. (1999) Better Construction Briefing, Blackwell Science Ltd, London, ISBN: 0632051027.
British Standards Institute (2002) London, UK BS6079 Project Management.
Ferry, D.J. (1964) Cost Planning of Buildings, Crosby Lockwood & Sons, London.

Endnotes

1 Rethinking construction: The report of the Construction Task Force to the Deputy Prime Minister on the scope for improving the quality and efficiency of UK construction (commonly referred to as the Egan Report) is now under the auspices of the Constructing Excellence programme.
2 ProCure21+ was originally developed as a procurement system by NHS Estates. Subsequently, NHS Estates was disbanded and reformed as the Estates and Facilities Management Division. ProCure21+ uses a framework agreement approach to bring the NHS (client) and construction industry together to build publicly funded capital schemes. It is advocated that the ProCure21+ scheme enables the NHS to reduce tendering time while ensuring certainty on cost, time and quality constraints.

Phase I

Cost Planning at the Briefing Stage



Chapter 4

Developers' Motivations and Needs

4.1 Developers and development

The 'property boom' that had characterised the UK economy up until the 2008 global economic crisis led to a significant interest in **development** activity. This pervades commercial, residential and public sector building work that was seen as evidence of the growing underlying economic performance of the UK economy. Notably, the increase in **residential development** activity has been of significant interest. This had emerged primarily as a result of the growing lack of confidence in the performance of pensions and other financial products/services. This in turn had led to many individuals (or consortiums of individuals) seeking to invest in built assets – the tangible evidence of this being the proliferation of the 'buy to let' market, where individuals seek to acquire a portfolio of buildings that can be used to provide an alternative revenue stream through letting. Moreover, the critical shortage of affordable housing in the United Kingdom particularly that suited for 'first-time buyers' exacerbated the demand for rental accommodation. We do of course know that events in the United States were to create a butterfly effect that led to a near 'meltdown' in the global economy; this radically changed the game in terms of the availability of finance to fund portfolios of the kind described above. Nevertheless, this case provides one example of the motivation for development.

While the term 'developer' (the developer being the person ultimately procuring the building) is now common parlance, it is more often than not the case that this person or organisation is the traditionally defined 'client' or 'building owner', or in some parts of the world the 'proprietor'. In popular use, the term 'developer' is often restricted to those who build for profit *per se*, but this is not correct. Those who build for their own use or for social purposes are equally developers.

All types of development arise from a **consumer demand**.[1] Classically, there are two elements of consumer demand: **opportunities** and **preferences**. The opportunities element considers variables such as the affordability and consumption possibilities. Preferences element, on the other hand, considers the utility function (i.e. what does the consumer like, and by how much does the consumer like this good?). Then in terms of property development, consumer demand may be either of the following:

- **Direct demand**: a demand for commercial property space, for offices, for a town hall or library and so on.
- **Indirect demand**: a demand for something which will require building development in order to satisfy it (such as a demand for motor travel requires further motorway expansion,

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and an increased demand for aviation travel requires development of terminals and airport facilities).

But the demand must always be an **economic** demand. There must be someone (or group of individuals) who is willing to invest or who can be induced to do so. Developers, whether individuals or corporate public or private bodies, will be building either

- for profit, when their approach to cost will be governed by the way in which they expect to receive their reward, usually by leasing or by sale, or
- for use, when their approach will be governed by the actual units of accommodation that they require.

The archetypal example of development for profit is the **special purpose vehicle (SPV)** that is created in public private partnership (PPP) procurement scenarios. The SPV involves members of the PPP consortium committing equity to a scheme. The SPV is a 'temporary company' formed especially for the project. The SPV will then be supported by sub-contractors who deliver the individual elements of the PPP contract (e.g. construction, soft services, training). The equity holders in the SPV are simply speculative investors seeking the maximum return on investment. Ordinarily, they will have no interest in the function, design and layout of the building. They will of course have an interest in cost however!

4.2 Profit development, social development and user development

In considering cost targets, we may distinguish among the following:

- profit development, where it is intended that receipts from the disposal or use of the buildings will be more than cover costs;
- social development, which is usually in the publicly funded sector;
- user development, which covers such projects as a private house, or an office building for an insurance company's own occupation.

There is also mixed development, incorporating buildings of more than one of the above types. As the calculations involved in budgeting for all these types of development are similar, it is easy to forget that the basic situations relating to profit development, on the one hand, and social or user development, on the other, are fundamentally different.

4.3 Cost targets for profit development

The setting of cost targets for profit development (e.g. office blocks for letting, housing for letting or sale) is related to free enterprise economics, and even where grants, subsidies, taxation relief and so on are to be taken into account, the criteria are simple. Even if some non-quantifiable element, like preserving the environment, has to be taken into account, it will have to be assessed against its effect on profit. A calculation will soon show how much the developer can afford to spend under the heading of 'building costs' after other items of expenditure (see Chapter 8), such as land costs, professional fees and so on, have been taken into account. There is some flexibility because the standard of building will partly determine the rent or selling price that can be asked, but this is often dictated by the environment and by the cost of the land. It would obviously not be economic to erect a high-cost luxury building for sale or rent in an unpopular neighbourhood, nor to try a low-cost, low-income development in a fashionable district where land costs are high and there is a good income potential.

There is no room for 'hard luck stories' in carrying out profit development, but, on the other hand, there is the challenge of working in a real situation where 'time means money'. For example, take the case of an out-of-town retail complex development:

- early completion of the retail complex may involve substantial extra profits through early occupation or partial possession;
- late completion (e.g. after Christmas instead of before Christmas) could be financially disastrous if business plans for occupants include projections of Christmas revenue.

4.4 Cost targets for social or public sector user development

In social or user development, however, the main object of the exercise is the actual provision of the buildings. It becomes very difficult to set realistic cost targets since there is no definite limit at which an individual building ceases to be possible. In public sector building, in particular, it is usually possible (though not always politically expedient) to raise whatever sum of money is required for the purpose. Any constraint is usually at a higher level than the individual project, for example the proportion of the national budget, which is allocated to education, may determine the amount to be spent on school building as a whole.

Therefore, in order to determine a reasonable cost for this type of building, it is necessary to set artificial limits based upon the cost of similar buildings erected elsewhere. The gross floor area is too crude as a basis for the purposes of this comparison, and so various targets based upon user requirements have been established, often by the ministries responsible so as to ensure a nationwide standard. In the case of schools the unit of cost was the number of 'cost places' (a fictitious number of pupils calculated from the teaching space), while for hospitals the number of beds was once the basic yardstick.

These cost targets were usually determined by a set of artificial standards, which had to be adhered to. Although tight in some ways, these usually made exceptions for technical difficulties associated with a particular project. But here, we are not in the world of simple profit economics; the early completion of a school or library would usually be a financial burden to the authorities, however welcome it might be to the community.

The cost planning of social development projects, therefore, may resemble the playing of a board game such as Monopoly, where the architect and cost planners try to win according to a set of rules which have little validity in the real world outside. Sometimes, the rules may be very crude indeed, for example:

- A rule that money cannot be transferred from one fund to another (so that it is useless trying to save money on furnishings or running costs by spending extra on the building).
- A rule that money cannot be spent outside the financial year in which it is allocated.
- A rule that no major contract can be let except by competitive tendering on a firm bill of quantities (BQ) with no allowance for cost fluctuations.
- A rule that some financial considerations other than the contract amount are irrelevant.

In these circumstances, the skill in cost planning may consist of 'loophole' designing to take advantage of the regulations in the same way that a clever accountant takes advantage of the tax laws. An example of this, from outside the United Kingdom, occurred when a national system for cost control of flat building at one time gave a greater cost allowance for balconies than the actual cost of providing them. The blocks of flats built during this period can be identified by their lavish provision of unnecessary balconies.

It is recognised by government that unrealistic cost rules lead to bad design, and many far-sighted efforts have been made to do away with the cruder kinds of inconsistency:

- by allowing money saved in one direction to be spent in another;
- by trying to bring the assessment of running costs into the cost comparisons;
- by working out very complex cost criteria for such buildings as hospitals instead of 'so much per bed'.

These are commendable attempts to get nearer to reality, but while they have undoubtedly led to some improvement they also tend to make the 'game' more complicated, and the loophole finding as more of a challenge to the experts. It becomes increasingly difficult to avoid the 'balcony' type of inconsistency mentioned above.

The consequence of all this is that everybody can become so preoccupied with trying to meet tight cost targets by clever application of the rules, that they lose sight of the social purpose of the whole exercise. The attempts over the years to get as many houses, flats, schools and hospitals as possible out of the budget without the consumer checks on satisfactory standards (such as sales or economic rents), which exist in the private sector, have played a large part in creating the massive maintenance programmes with which many public authorities are now faced.

4.5 Cost targets for private user development

This is the third type of development that covers such projects as a private house or an office building for an insurance company's own occupation. User development incorporates some features of both profit and social developments. Because of this, it is most important to find out what the client's real cost priorities are and to get them defined.

4.6 Cost targets for mixed development

This type of development is a mixture of profit and social developments, with perhaps some user development. The cost of some of the buildings, or perhaps a proportion of the total cost, would be met by social funding and the rest is intended to make a profit. A common example of this type is a town-centred development incorporating shops and public amenities. The same remark about clients' priorities applies as in the previous case.

4.7 Cost–benefit analysis (CBA)

In order to overcome some of the difficulties previously outlined and to justify the public expenditure, the techniques of cost–benefit analysis were developed. Such analyses attempted to quantify all factors including the various social benefits and disadvantages, and were widely used in connection with traffic and airport schemes and with hospital building. Cost–benefit analysis might be applied, for instance, to a proposal to carry out works to remove a sharp curve and a speed restriction on a section of the railway network. The cost of the work could be offset by the saving in fuel, and against the wear and tear on equipment caused by braking and re-acceleration. However, it is possible that on these grounds alone, the project might not feasible. On the other hand, if the curve is removed, it might save 2 minutes each on a million passenger journeys a year – 30,000 man-hours are worth something, and if they are priced and included among the benefits the scheme might now be justifiable in relation to the national economy.

This is all very well, but the railway company is going to incur the costs and is not going to receive the financial benefit of the 30,000 man-hours, so organisations in their position cannot be expected to take this sort of exercise seriously. In addition to this, there are the problems of attaching money values to things, which cannot be quantified. As an illustration of this, what is the value of a human life? One approach would be to work this out on the basis of the financial contribution, which the individual person is expected to make to the economic life of the community, so that a surgeon might be worth hundreds of thousands of pounds while an unemployed labourer might have a negative value. Even on practical grounds, this right-wing approach is obviously unacceptable; if you attempted a cost–benefit analysis of a geriatric hospital on this basis, you would find that it would be cheaper to let people die and build a mortuary instead! Or, as another less extreme example, you could justify a ring road, which saved a few minutes for 'important' people while wasting the time of humble pedestrians.

It was therefore customary to take a notional figure representing the worth of an 'average' person. There was little wrong with this except that such figures, being notional, were conjured out of thin air and could be used in practice to 'prove' that a politically desired result was the right one. As an example, suppose a traffic improvement scheme was going to cost £100,000 a year and was estimated to reduce road accident deaths by three per year. If you cost a life at £50,000 the scheme would obviously be worthwhile; if you cost a life at £20,000 it would not be worthwhile.

This is not just a theoretical objection! In 1988, the UK Department of Transport for political purposes arbitrarily doubled the value for a human life used in its calculations – this simple stroke of the pen increased the benefit expected from its road schemes by an average of 4.5%, although nothing in fact had changed.

If you remember that the reduced number of deaths will be a guess anyhow, you can see that this sort of exercise is not really worth very much, and the more complicated it gets and the more social benefits that are quantified, the more questionable is the result.

A further difficulty is that by reason of the type of people undertaking these studies, the values assigned to non-quantifiables tend to be those of the cultured middle class; the relative values of preserving the environment as against damage, providing local employment, for instance, might not be those which a working family living in the area would choose.

Cost–benefit analysis in its extreme form is now largely discredited however, but its successor in the public domain, **option appraisal**, draws upon its techniques. Option appraisal can be applied to any proposal for public investment and involves the appraisal of all possible options (including the 'do-nothing' option). Cost–benefit analysis is used to evaluate those aspects, which have a clear money value, both of a capital and recurrent nature, but intangibles are merely assessed and shown separately. It is left to the administrators to make the subjective decisions, knowing the financial outcome of the more tangible parts of each option.

On a grander scale, the principles could be applied to the High Speed 2 (HS2) project that is referred to in Chapter 1. Reports published by both the National Audit Office (NAO) and KMPG offer potentially conflicting evidence regarding the costs and benefits of the HS2 scheme.

4.8 The client's needs

All building clients will have a set of needs (we shall look at methods for identifying and reconciling these needs in Chapter 5), some of which are more important to them than others. We have to look at these carefully, because it is common to be told, for instance, that a low cost is required, or that time is important, without these very basic requirements being defined in more detail – and it is the detail that decides the best way of tackling the project. So we will now look at the main time and money requirements, which the client may have, and the different forms which each may take, remembering that some clients may have more than one requirement under each heading.

4.8.1 Time requirements

- **No critical time requirements**: This is quite common, especially in social development.
- **Shortest overall time:** This is from the inception of the idea to 'turning the key'. This is likely to be the requirement on a simple profit development.
- **Shortest contract period from the time the builder is appointed**: This by itself is not often relevant to the client's needs, but it is surprising how often it is asked for.
- **Shortest contract period from the time that construction actually starts on site**: This is a reasonable requirement where, for example there is a delay in acquiring the property, or where people have to be moved out of property on the site before demolition can take place, or where the building work will cause inconvenience or disruption.
- **Early start on site**: This may be required where the payment of a grant or subsidy depends upon work having been started by a certain date. It is also sometimes asked for by a lazy or incompetent architect to give the client the impression that something is happening at last.
- **Reliable guaranteed completion date stated by contractor**: This may be wanted so that firm arrangements can be made well in advance for commissioning the building.
- **Firm completion date stated by client**: This may apply where the client is under notice to quit existing premises or where there is a particular event that the building must be open for, such as the beginning of the summer season for a hotel.
- **Early completion unwelcome**: It is often wrongly assumed that if a client says that time is critical, then early completion will be welcome. This is not necessarily the case; if the client's arrangements are being made on the basis of a particular date, early completion simply means that the client's money has to be wasted watching and maintaining an empty building, and also that the building has to be paid for earlier than anticipated.
- **Phased programme to fit in with plant installation**: This is especially important in the case of sophisticated projects such as TV transmitters or chemical works where the actual building work is only a small part of the total scheme.
- **Handing over in sections**: This is often very important in alteration works or in rebuilding, where people or processes from one section have to be rehoused elsewhere before work can be carried out in that section.

4.8.2 Cost requirements

- **No critical cost requirements**: This is not very common, but it can occur where the building is only a part of a major development project (e.g. the TV transmitter already mentioned) or where the first consideration is quality.
- **Low total cost of whole project**: By contrast, this is almost always said to be the main priority. However, very often one or more of the following criteria are actually the real ones.
- **Low whole life cycle cost** (Chapter 7): Some clients, notably those in the public sector, will either require evidence of low whole life cycle cost for compliance with procurement arrangements, or in the case of PFI/PPP (see chapter 8), due to the long concession period. This is also known as the optimum combination of capital and maintenance costs.

- **Low cost of building contract**: The concern here is to keep the lump sum building cost to the minimum, even if this does not minimise financing costs, administrative and supervisory costs, or costs of furnishing and maintenance. It is still quite often required on public sector projects where these things may come out of different funds.
- **Low cost in relation to units of accommodation**: This is a very usual cost requirement in both the profit and social sectors.
- **Good budgetary control of the project**: In many cases, it is important that the final cost should be as close as possible to the initial cost forecasts, even if this is not necessarily the lowest cost that the competitive market might produce at the time the actual orders are placed.
- **Good forecast of cost at contractual commitment**: This is required by clients who want an accurate forecast of final cost before committing themselves to major expenditure.
- **Best combination of capital and maintenance costs**: One would like to think that this was more common than it is – there are all sorts of reasons such as taxation, grants, cost yardsticks and so on, which tend to prevent these two things from being weighted equally (see Chapter 7).
- **Low capital cost**: A more usual requirement, especially if the building is going to be sold, or if running costs come out of a different fund.
- **Low maintenance cost**: Less usual, but may be required if maintenance is going to be inconvenient, for example by putting the building out of commission while it is going on.
- **Timing of cash flow**: This may be required in order to optimise the cost on a discounted cash flow basis (see Chapter 6) or else to phase in with the availability of the client's funds.
- **Minimum capital commitment**: This would be required if the client wanted the contractor to bear most of the cost until the building was handed over.
- **Share in risk of development**: A variation on the last, where the contractor is paid by a share in the profits; this has been used on large speculative developments.

4.8.3 Quality requirements

- **No critical quality requirements**: Generally, buildings such as factories, distribution depots and so on that are constructed using simple steel frames with minimal cladding and fenestration will fall into this category. The 'bus shelter' as it were.
- **High quality**: Often large corporations that are procuring a prestigious building such as a Head Quarter or Head Office will seek to specify the highest levels of quality in order to demonstrate corporate wealth. Hospital buildings will also have specialist areas such as operating theatres where the highest levels of quality and workmanship will have to be attained.
- **Medium quality requirements**: Most buildings are likely to fall into this category.

Under the provisions of **ISO15686-1 Service Life Planning**, designers are analyst involved in whole life cycle cost studies, who are encouraged to use the factor method for determining the service life of components. One of the 'factors' is workmanship, and thus depending upon the client brief, this factor would have to be modified accordingly.

The client, of course, may wish to combine three or four or more requirements from the above list; as a result there are many different sets of possibilities, and the way the project is undertaken should reflect the client's individual priorities and combination of needs. A standard solution should not be adopted simply because it is the one the design team are most comfortable with.

4.9 Key points

In the case of profit development:

- The only purpose of the development is to make a profit, and profit is quantifiable.
- If an adequate profit cannot be foreseen, the development will not be undertaken, however much it may be needed.
- Once a final decision has been made on potential levels of revenues, the cost will have been determined and must not be exceeded. Any variances from the cost plan in certain areas will have to balanced by a saving elsewhere.
- A misjudgement of either the costs or the expected receipts of a scheme will have exactly the same effect on its profitability; neither is more important than the other.
- If the expected profit is not made, the project will be a failure from the client's point of view, however pleasant or useful the resulting development may be.

In the case of social development:

- The cost is not a clear-cut measurement of the effectiveness of the project (as it is with profit development); the benefits of a hospital, clinic, school or police station are largely unquantifiable.
- Therefore, nobody really knows whether they ought to be spending twice as much money (or half as much) on buildings of this kind, and no amount of cost planning is going to give them the answer.
- The most that cost planning can do is to help use the total allocated funds more effectively within the current framework of rules, and accept that the basic values will be decided for political reasons.

Endnote

1 Consumer demand is considered within the context of the *Theory of Market Demand*, this is a well-established branch of economic theory and underpins a good deal of thinking in the economics discipline generally. An understanding of the properties of market demand is crucial to an understanding of the evolution of prices and the nature of economic equilibrium. The theory and study of consumer demand (in microeconomics) state that individuals use their finite resources to make purposeful choices. The theory assumes that consumers understand their choices (possibilities) and the prices (opportunity costs) associated with each choice. Furthermore, it assumes that consumers consider all the alternatives available and select the one that they like best. This later concept refers to the theory of utility.

Chapter 5

Client Identification and the Briefing Process: Aligning the Client Need with the Brief and the Budget

5.1 Introduction

In the earlier chapter, we briefly discussed the **client's requirements**. These can often be numerous and complex when they should be clearly defined and well scoped – the FiReControl project highlighted in Chapter 1 provides an 'elegant' example. It is the responsibility of the design team and other professionals who may provide cost advice to obtain as much information as possible from the client in order to understand not only the scope of the project but also the budgetary parameters in which it will operate. Therefore, the process of understanding the client through formalised methods is an important one. In this chapter, we shall discuss the types of clients that engage with the construction industry, the process of briefing and client identification, and how the client's brief should be aligned with the budget. Finally, we shall explore some simple budgetary examples, which bring together the content of the first part of this book.

5.2 The client

As early as 1966, the Tavistock Institute was drawing attention to the increasingly intricate nature of client organisations, contending that[1]

> . . that they were **complex systems**[2] of differing interests and that their relationship is seldom with a single member of the building industry . . . These client systems are made up of both congruent and competing sets of understandings, values and objectives. Much design and even building work has proved to be abortive because unresolved or unrecognised conflicts of interests or objectives within client systems have only come to light after the building process has been initiated.

The almost classical example of this, referring back to the Scottish Parliament project in Chapter 1, being the complexity of the client group involving the project sponsor, the MSPs,[3] taxpayers, parliament staff, the general public and so on – all exhibiting competing and

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

ambiguous requirements within the client system. Thus, ultimately led to an untenable situation where the project reached the point of almost critical failure on numerous occasions. We shall refer to this project again shortly when discussing the briefing process.

Since the 1960s, clients have demonstrated an increasingly demanding approach to dealing with the construction industry. This emerged through a series of influential reports such as the British Property Federation (1983),[4] the Latham Report (1994) and the Egan Report (1998). These reports were in parts, a variation on a theme, generally expressing dissatisfaction with building industry performance. The industry responded through a variety of innovative mechanisms; one such example being radical changes to traditional procurement systems through the use of design and build, management contracting/construction management, partnering, supply chain management and lean construction, for example. We shall explore these in greater depth in Chapter 8.

The Egan Report was particularly damning of the industry when it was released, contending that clients were highly dissatisfied with the construction industry due to the following reasons.

- Projects not being delivered on time
- Projects not being delivered on cost
- General dissatisfaction with the quality of buildings
- Poor relationships between client organisation and industry

Since then, however, a great deal of change has occurred and clients have established efficient systems of working with the industry through such mechanisms as **prime contracting** and **framework agreements**. These are discussed further in Chapter 8.

The extent of a client's knowledge and understanding of the construction industry and the processes involved in working relationships have a major effect on the client's ability to be effectively involved in the development process – consequently there is wide scope for possible client involvement. The service which the construction industry provides to a client should be designed to suit the particular needs and expectations of the client. There are two distinct aspects to a client's needs and expectations. Firstly, a client has various requirements of the building:

- its location, size, shape, performance and facilities;
- when it is available;
- its cost.

These will depend upon the functional requirements, which the building is to perform and the objective which it is intended to serve. The second aspect of a client's needs and expectations is the type and level of management service required.

5.3 Type and level of management service required by client

A client needs a particular type and level of management service to help them define and obtain the building required. It can be seen that depending upon the extent of the client's knowledge, the management service that a client expects may be quite different from the one that is needed! The type of management service that a client needs is determined largely by the extent to which they will be involved in the construction process themselves – this will be either a 'minimum client role' or an 'extended role' taking in a substantial part of the management of a project. Often it is better to consider these two extremes as a dimension (i.e. clients will tend or tend not towards high levels of involvement). The extent to which a client will be involved in the construction process depends upon both their ability and willingness to be involved.

A client's ability to be involved is dependent upon the amount of appropriate knowledge and resources that they possess. To be fully involved a client must

- have adequate knowledge of the construction industry and the construction process, relative to the nature of the project;
- be fully aware of what is involved in the role that they wish to play.

When a client does not have the appropriate level of knowledge, they will be less than fully involved and will require a more extensive service from their professional advisers. A number of previous studies (including early work by Higgin and Jessop (1965)) have used the terms **sophisticated** and **naive** when referring to the level of a client's knowledge and experience of the construction (and leadership) process. In reality, this is again a dimension issue as few clients can be classified as clearly one or the other of these definitions (i.e. most can be considered as being either relatively sophisticated or relatively naïve). Other researchers (Masterman and Gameson 1994 in Walker 2007) have classified clients by experience and end-use: secondary inexperienced, secondary experienced and primary inexperienced, primary experienced. All except the most sophisticated clients will be unable to inform the construction industry accurately of their own status in this respect. It is therefore mainly a matter of perception, the client's view of their level of sophistication may be quite different from that of an experienced construction professional!

Walker (2007) provides an excellent narrative on the importance of knowledge and awareness of the client role, and are not by themselves sufficient, the client must also have adequate resources of the correct nature to perform their project role successfully. The **level of involvement of the client** depends upon a 'willingness to be involved' as well as their ability. This is important because clients do display varying levels of willingness to be involved in the project. Chapter 8 gives a useful insight into this area.

In general, a client's willingness to be involved will reflect the knowledge and resources that they possess. However, other factors may also influence the preferred level of involvement.

- The **resources** that a sophisticated client possesses may be committed on other projects.
- A sophisticated client may recognise that it does not possess the particular **expertise or level of experience** appropriate to a specific project.
- The client may prefer to pass responsibility for the project onto others – especially where they foresee **a high degree of complexity, uncertainty and risk**.
- Conversely, even with the minimum of knowledge and resources, a client will attempt to **maintain maximum control over expenditure of funds**.

The final point is perhaps the most salient from the cost planning perspective. It is also inevitable that problems may arise when a naive client attempts to control a process about which it has very little knowledge and/or understanding.

5.4 Types of clients: 'user clients' and 'paying clients'

A thorough understanding of the **client organisation (system)** provides the foundations for producing the most effective brief. We have momentarily explored the contention that clients can be seen as somewhere between naïve and sophisticated; however, there is a more detailed consideration of the client organisation, which should be carried out in order to help develop the brief effectively.

Often the client is usually considered to be the person or organisation that will ultimately 'foot the bill' for the project. However, the design team must look beyond this and consider how their client's organisation is made up. One way of doing this is by thinking about client organisations as being made up of several different groups, each with its own specific agenda:

1. Policy makers: These will be senior members of the organisation with authority and responsibility for policy of what to purchase and how.
2. Purchasers: These could be either the administrators filling in the purchase orders or those responsible for the final recommendation.
3. Users: Those who ultimately use the product/service. May not be part of the purchasing organisation, for example tenants.
4. Appraisers: Those with specialist knowledge who can appraise the service and advise on KPIs. Appraisers may have defined the KPIs.
5. Influencers: Those who can influence the DMP by providing information and criteria for evaluation. May be internal or external.
6. Gatekeepers: Those who control the flow of information to others within the firm. Never underestimate the power of Secretaries!
7. Deciders: Those who finally take the decision to invest funds or purchase a facility. This may be a committee in a complex bureaucratic organisation.

Consider a typical retail organisation such as a leading supermarket chain, this type of organisation will regularly procure new buildings to increase or consolidate its market share. The client will obviously be concerned about capital cost minimisation, but will also be concerned about other factors which affect the business side operations such as anticipated opening time (impact on revenues), project schedule, local and environmental impact, car congestion, logistics and so on. So, if the design team focuses solely on the cost of the work and do not think of other imperatives, then the firm's other agendas could be ignored, perhaps leading to serious problems during the remainder of the project and future contracts!!! This concept is developed further in the following case study.

5.4.1 A case study: new railway station

This case study exemplifies this '**systems thinking**'. Consider a new railway station that is being constructed in a commuter suburb on the outskirts of a large regional city – the outline brief requires the construction of a set of four new platforms, station buildings including offices for staff and waiting areas for passengers, entrance concourse with retail facilities, car parks, public address and information systems and the construction of new permanent way, signalling and overhead line equipment (OHLE). The client system may on first inspection appear quite simple – it may be Network Rail or one of the train operating companies (TOCs) that are the 'paying client'. This is not the full story however and the client map will have to reflect the engagement of the 'user clients' and the other project stakeholders as stated earlier. However, an exemplar client map is shown in Figure 5.1, which shows the potential complexity of the client system and thus the importance of reconciling all of these within the brief. Within the map, the three groups of paying clients, user clients and other project stakeholders are included and their relationships with the key elements of the brief are shown. This example is rather simplistic and a proper investigation would perhaps reveal more complexity than what is shown here. However, it does serve as a useful example of how client systems need to be explored and thoroughly understood.

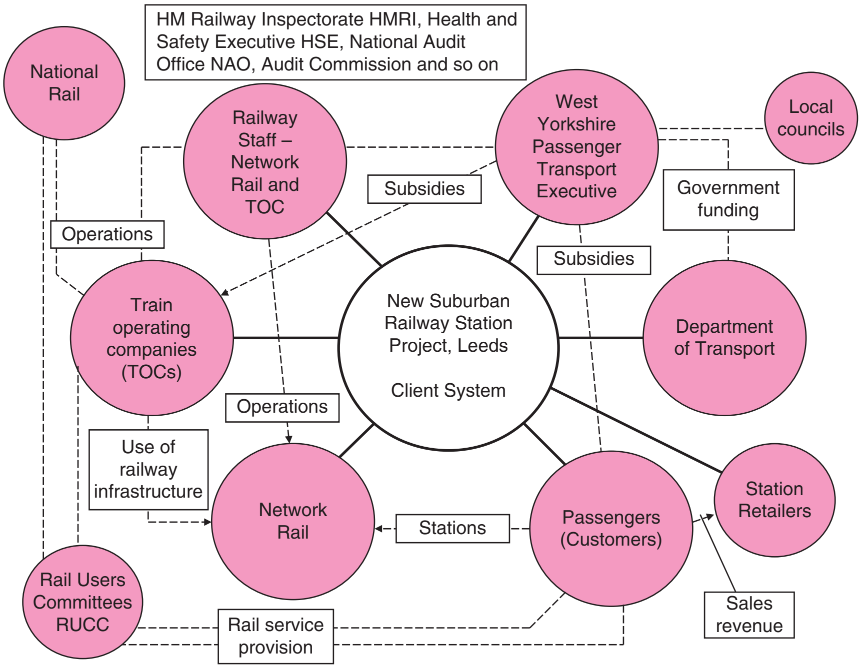

Figure 5.1 Simplified client system mapping.

5.5 The brief and the process of briefing

Briefing is a vital aspect of every construction project. It is the process by which the client's requirements are investigated, developed and communicated to the 'supply side' in the construction industry (Figure 5.2). Briefing of some kind always occurs in a construction project. However, the quality of briefing varies considerably and good briefing is not always easy to

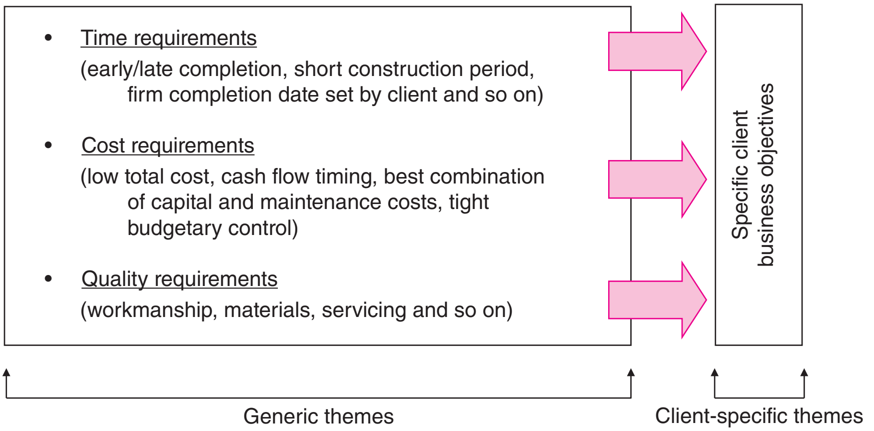

Figure 5.2 Translation of generic client requirements to specific business need.

achieve, but recent studies have suggested that improvements to the briefing process almost always leads to clients being more satisfied with the final building that they are handed over.

Buildings are expensive acquisitions and inevitably have an important effect on the operations of the organisations that occupy them. Poorly performing buildings may result in low productivity, an unsatisfactory working environment and low staff morale. In a competitive world, such shortcomings can be very serious. Furthermore, the costs of disposing of a poorly performing building and obtaining a satisfactory replacement can be high and sometimes prohibitive. A client with such a building may be stuck with it for the foreseeable future. Good designers will do their best to give clients the buildings they want. However, if they are unable to determine what clients really need their task is difficult, if not impossible.

Good briefing seeks to minimise the likelihood of a client receiving an unsatisfactory building by ensuring that project requirements are fully explored and as clearly communicated as possible. While good briefing cannot guarantee that a building will be perfectly adapted to its occupants, it can help avoid serious mistakes.

Briefing is often regarded as an **early stage activity** during which the client's requirements are written down in a formal document called the brief. This document should also provide the benchmark to guide the development of the designs. Early stage briefing is also vital since theoretically, potentially expensive design variations can be avoided by identifying all options at the outset. Figure 5.3 shows the relationship between cost and opportunity of change through the project life cycle. The message here is that if changes occur later in the life cycle, the ability to make the changes is constrained and the cost of doing so is much higher. This is not to say that the client, particularly the naïve or inexperienced client, cannot be expected to identify all the functional and performance requirements of the building at the outset. However, the client should not view the initial brief at the end of the process, it

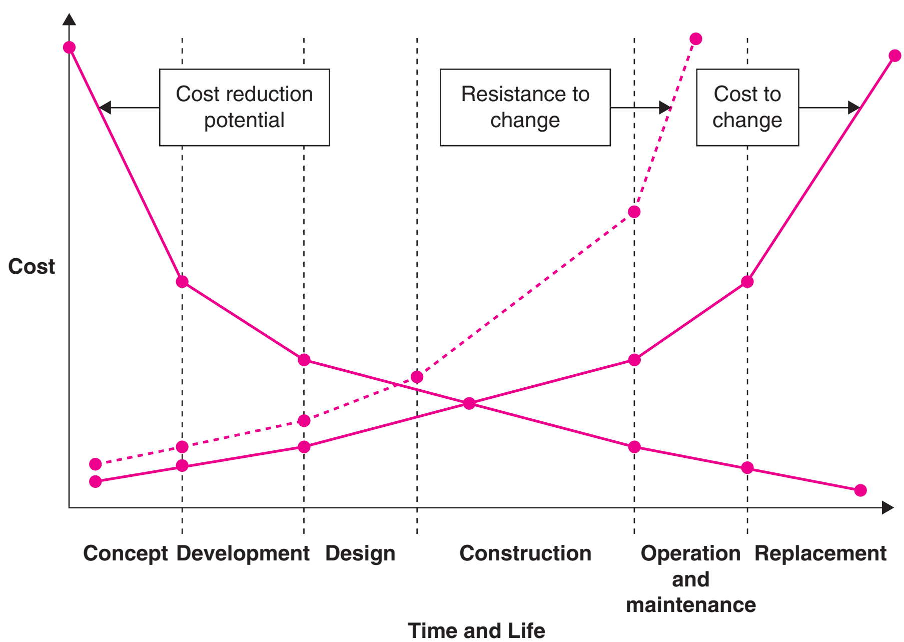

Figure 5.3 Relationship between cost and opportunity of change through the project life-cycle (based on BRE *Value from Construction – Getting Started in Value Management* guide and BS 3843:1992).

is simply folly to expect that a quality design will emerge from it without further effort. Full participation throughout the project is thus vitally important. While a clear initial brief can be a great asset it is not the end of the story. The important thing is to make decisions appropriate to the particular stage of project development. Strategic decisions will need to be made early on and the detail left until a later stage, and the client should not withdraw from the process once an initial brief has been drawn up.

Briefing looks beyond the micro-level; it requires a 'Blue Skies' thinking approach that encapsulates the business objectives of the client as a function of the need for a building. The briefing process is also about creating or adding value, to argue the case for a new building in terms of business process improvement represents a significant step forward in conventional thinking. The briefing process should not be underestimated however, developing an understanding of the client organisation complexities can be time consuming and costly.

5.6 Format and content of the brief

Ultimately, there is no verbatim method of producing a brief. There has been significant research in the general area of briefing and many proposals to improve the process from a qualitative and quantitative perspective – including the use of IT and decision support systems. Practically, the brief can come in a variety of guises and in the most basic form, it is purely verbal – as a set of instructions between the client and architect, for example. This is probably just about sufficient for the basic house extension, but for more complex projects, it should be something more substantial. Working drawings, the standard forms of contract, could also be technically viewed as briefing documents since these facilitate the transmission of information between the client and the design/construction teams. It is advocated though that a bespoke, formal document is constituted, and this should be designed in such a way that it is beneficial to all parties in the project. The **Constructing Excellence** (2004) guide to briefing identifies the following facets of good briefing.

1. **Establish the need to build**
   Is a new building required? It may be that refurbishment could be better, or indeed a change in business practice may negate the need for a building totally! – The designers should understand the business case.
2. **Adequate resources**
   In terms of both capital investment and client involvement. The client should resource the briefing stage fully to ensure delivery of the best product.
3. **Careful management**
   The client should ensure that the information they provide to the design team is clear and unambiguous. The design team should ensure that this is translated into correct design.
4. **Good teamwork**
   Interpersonal relationships are vital and, of course, the element of trust! Therefore, good communication channels must be established.
5. **Clear communication**
   The construction professional should avoid using confusing jargon and not expect clients to interpret complex engineering design documents, and vice versa of course.
6. **An approach appropriate to the project**
   The techniques of briefing should be bespoke. Take stock of the particular characteristics of a project and design an appropriate approach. Complex projects pose significant challenges, as opposed to those of a smaller magnitude.

7. **Involve the end-users**
   The client is not often the end-user, so differentiate between 'paying' clients and 'user' clients. It may require the designer to reconcile between the two. Do not assume that the paying client knows everything about their business.
8. **Formal information gathering techniques**
   More structured techniques may be required for complex projects such as hospitals, schedule of accommodation, environmental conditions and so on.

5.7 The clients budget

Having examined the briefing process, the next stage is to consider how the information that the process is likely to elicit can be translated into the budget planning phases. In this section, we shall look at the principal components of the budget and some simple techniques that may be used in order to 'build it up'.

5.7.1 Total cost

When any type of building development takes place the total expenditure on the project will be much higher than the **net costs** of the building fabric, and thus will also comprise the following: cost of land; legal costs of acquiring and preparing the site, and obtaining all necessary approvals; demolition or other physical preparation of the site such as decontamination, archaeology; building cost; professional fees in connection with the above; furnishings, fittings, machinery and so on; costs in connection with disposal (sale, letting, etc.) where the building is to be disposed of at completion; value-added tax on above items where chargeable; cost of financing the project (this principally represents interest on the money that has to be spent before any return is obtained by way of either income or use); cost of management, operational and maintenance where the building is to be retained by the client for use or only partially disposed of, or where the building is let to a tenant but the owner has accepted responsibility for some or all of these costs.

In commercial development, there is a very close relationship between how much the project will produce in revenue and its commercial value, the latter being largely the capitalised value of the former, and the total costs of the scheme must not exceed this commercial value. In social development, this relationship may be expressed by quantifying what are considered to be social benefits, but the issue is never so clear-cut and other criteria may be more important in assessing the amount that can be spent on the scheme.

5.7.2 Building cost

It is important to realise that 'building cost' is only one part of the client's total cost, and it may be thought that many cost planning exercises are unduly focused in this one item rather than with the whole package. There is some truth in this allegation, which is probably due to the fact that many of the techniques were developed in the public service in the days when building costs were closely examined but total costs were rarely considered. Today, this is rarely the case. In extreme circumstances, indeed, keeping the 'building cost' down may not be particularly important. For example, the cost of the land may be such an important factor in the costing exercise that everything else has to be fitted round it and the problem then is to get the maximum amount of accommodation that the planning authorities will allow, almost regardless of cost efficiency. Alternatively, the building may be only a part of the total project, as in the setting up of a TV transmitter station where the cost of the mast, electronic equipment and cable laying dominate the project and the transmitter building is of minor importance. In these circumstances, it would be inappropriate to consider the cost of the building in isolation – it is much more important that it should phase in with the general programme and that its completion should not be a source of worry to the engineer in charge. It may not be necessary to indulge in cost planning of the building at all. In the later stages of the cost planning process, building costs will dominate the calculations. At early budget stage, however, they can only be estimated very generally, because so little is known about the project.

5.7.3 Land values and development

One of the most important items on any developer's balance sheet is the cost of the land and we must consider this aspect first. Building development of any kind requires a plot of land on which it can take place and which, once used, will no longer be available for any other development, unless the first one is either demolished or converted. This makes building development quite different from other enterprises, because no developer can start work until the firm or organisation has acquired an interest in the land on which the development is to stand. This has all sorts of economic consequences, because the supply of land is largely fixed. As a now famous estate agent's advertisement put it: 'Buy now! They have stopped making it!' Like the prices of other commodities, land values are affected by the laws of supply and demand. However, unlike other commodities, the amount of land available in any one area is finite and cannot be increased at times of high demand by manufacturing at a higher rate, or importing from outside. This means that if there is a high demand in a particular area, the prices of land in the locality will rise very steeply, even though similar land may still be cheap 50 miles away.

5.7.4 Role of the valuer

Valuation surveyors are the experts on the value of land or buildings for investment and the income which various types of development can be expected to produce, but anybody who is involved in cost planning of buildings needs to have some knowledge of the factors affecting the costs of land for development.

5.7.5 Development value

The 'development value' of a piece of land is the difference between the cost of erecting (or converting) buildings on it and the market price of the finished development including the land. Nobody can commission building operations on a piece of land unless they have a financial interest in it; if possible they would wish to own it, so as to obtain the full benefit of the 'development value', although in some areas where land is in very short supply they may have to lease it.

The development value of the land will be determined by the following parameters:

- **Location**, both its geographical region and its local position in regard to amenities, communications and so on. Real estate agents and certain well-known television presenters often emphasise the importance of this by saying that the three most important factors in land value are '**location, location and location**'.
- **Restrictions on its use**, imposed by either the vendors in the form of covenants or the community in the form of planning restrictions.
- Any **easements**[5] that are associated with the land, such as a right of way across it.
- **The physical state of the land** whether it is level or very hilly, and whether there are buildings on it which need to be demolished.
- The current state of the **economy**.

5.7.6 Effect of building cost on land value

We can express the value of land for development as an equation:

Value of development = price of undeveloped land + building costs + profit

As we have seen, the value of the development in a free market is its worth to consumers (as compared to other things they can spend their money on), and this, in turn, largely fixes the price of the undeveloped land. The equation can therefore be better expressed as

Price of undeveloped land = value of development – (building costs + profit)

The people selling the undeveloped land should be just as capable of doing this calculation as the developer is, and will fix their selling price accordingly. It is therefore not really correct to say that the cost of land pushes up the price of housing or other accommodation; in fact it is the other way around – the market price of development pulls up the cost of land.

In conditions where there is a shortage of suitable building land and a constant rise in development values, as in the south-east of England, fluctuations in building costs will have little effect on land prices. However, if the situations were reversed and development values remained constant or even fell, then an increase in building costs would have the effect of reducing undeveloped land values. It is normally the price of 'undeveloped land' which is the result of the equation, when the other figures have been filled in.

5.7.7 Social considerations of land use

Most people agree that a completely free market in land for development is socially undesirable, and the setting of limits on the scale and nature of development under town and country planning legislation brings a measure of public control to the process. Even so, there is a strong body of opinion that wants to see the public obtain much of the benefit of any increased development value of private land, and this would certainly make it much easier to undertake social development in urban areas. The more radical members of this group simply dislike the whole idea of anybody making money which they have not actually earned, and it would be difficult to satisfy them, but the more moderate members base their arguments upon the loss of green land or other pleasant environment to the community when development is undertaken for profit. The fact that public expenditure on infrastructure (roads, services, transport systems, etc.) has often contributed to the rise in value. The way in which decisions taken by the planning authorities are handing windfalls to some lucky landowners and withholding them from others, thus providing strong incentives for undesirable (or even improper) influence upon those decisions. Several unsuccessful attempts have been made by British governments to deal with the problem, of which the most important were the Town and Country Planning Act of 1947 and the Community Land Act of 1975. However, these Acts tended to inhibit development of any kind, as landowners had little incentive to allow their land to be built on, and preferred to wait until a more right-wing government got into power and repealed the legislation. More recent developments include environmental legislation and new planning guidelines favouring 'brown-field' sites for redevelopment rather than building on hitherto undeveloped land. However, so that the community does not actually lose money over private development, the developer may often be asked to contribute towards infrastructure costs as a condition of the granting of planning approval, and sometimes a developer may make such an offer as part of the planning application. The agreement of these costs is obviously an area where the cost advisers on both sides should be involved. An interesting technique was used in Hong Kong in the 1980s, where the then colonial government was able to act unilaterally and the new underground railway system was largely financed from a tax on the increase in development values in the areas around its suburban stations.

5.7.8 Effect of land values on cost planning techniques

It is possible to try and optimise building costs by looking at such factors as low wall/floor ratios, the avoidance of multi-storey construction, the centralisation of services and so on in isolation from land costs. Where land prices are relatively low, or in a public sector organisation where land costs and building costs are not considered together, this may seem to be a perfectly valid way of looking at the problem. However, where development values and land prices are high the picture alters.

Example

Suppose that the current price of flats in a fashionable urban area is 20% building cost and 80% land cost (and profit) and a piece of land has been bought at a price which assumes that 20 flats can be built on it. If it proves to be possible to build more than 20 flats on the plot, the building cost of these extra flats would be only 20% of their market value, leaving 80% profit.

It would therefore be worthwhile to accept a less efficient building configuration to provide these extra flats. Even if this increased the building cost slightly, there would still be a handsome profit. In these circumstances, cost planning may develop into an exercise to secure the maximum number of accommodation units on a given site, at the same time optimising the design from the point of view of grants and subsidies (if there are any of these to be had). Unfortunately for the developer, a scheme which squeezes the utmost in hard cash out of the site is rarely acceptable to the planning authorities, who have more regard than the developer for the amenities and appearance of the neighbourhood. Their veto on a scheme is final, apart from the possibility of a lengthy and time-consuming appeal to the central government (which has the same general motivation). On such projects the costing and income appraisal of many alternative schemes will be required, and this will be the main cost planning contribution. Once a scheme has been approved by the authorities speed may be vital (because of the need to recover a massive investment as soon as possible), and the cost planner will be required to advise on a suitable contractual system to achieve speed with an appropriate measure of cost control. However, not all private development is of this speculative kind. The client organisation may be wishing to erect a building for their own use – as offices, warehouse, store and so on. In this case, the effect of high land costs on the cost planning exercise should be to cause an examination of the economics of possible alternatives. Such alternatives might include carrying out the development in a less expensive area, or possibly changing the client's requirements for a building by solving the problem in another way. An example of this might be to avoid the cost of branch warehouses by a system of daily distribution from the factory. It might be thought that there would be an advantage to a user-developer in building in a high cost area because the firm would always have the value of the site on its books, but there are many disadvantages in having too many of a firm's assets tied up in site values.

5.7.9 Grants, subsidies and taxation concessions

Action under town and country planning legislation is essentially passive, and while it can prevent undesirable development it cannot cause socially desirable development to be undertaken. It can certainly earmark a certain area for a particular type of development, but unless the development itself is to be carried out by a public agency, or unless it is obviously going to be highly profitable, the matter will rest there. In order to make such development attractive to a private investor, central or local government may sometimes offer special financial inducements. These are usually offered: on a sector basis (e.g. for hotel or other tourist building); on a regional basis; or both (e.g. for factories in an area of high unemployment). These incentives will need to be taken into account in preparing budgets for the type of development concerned and may be of crucial importance in deciding between alternative sites. The incentives may be of several different kinds: low rent or rates. Land (or even completed buildings) may be made available by a public body at a very low rent or with substantial relief from local authority charges, or both. This concession usually runs for a limited period of years, after which more normal conditions will apply, so that some kind of discounted cash flow analysis will probably be necessary. Grant towards capital costs. The Department of Trade and Industry used to provide grants towards the cost of factory building and plant located in 'areas of expansion', and an increasing number of authorities provide partial funding for development in the fields of tourism, leisure, conservation and so on. Taxation relief may be given under some circumstances on development and plant costs. The main disadvantage of taxation relief compared to a grant is that there must be a tax liability against which the relief can be set. It is therefore necessary to make a profit before the benefit can be obtained. The situation is always changing over the years as different political and economic priorities come into play. A most important factor in assessing the value of a grant is its timing in relation to the developer's expenditure, particularly whether it is a reimbursement or an advance. It should also be noted that other forms of financial encouragement, such as a subsidy paid for each person employed, may need to be taken into account in a development budget, even though strictly speaking it is not a grant towards the development itself. The extent to which government incentives may be nothing more than compensation for straightforward commercial disadvantages, such as high transport costs, will certainly emerge from the cost planner's calculations. It is also worth pointing out that it is possible for government to impose financial disincentives for types of development of which it does not approve. The lack of grants for industrial building in some regions can be seen as such. A more extreme example of disincentive in post Second World War years was the long-term discouragement of private rental housing development by the control of rents at uneconomically low levels. Although the UK government now wishes to reverse this trend, prospective developers need to be able to look ahead for more than the 5-year term of a government, and the treatment of housing (and other development matters) as a political football by the two main British parties has discouraged a stable property rental market that exists in other European countries.

5.7.10 Land costs and social development

In the past, the costs of site acquisition have usually been ignored in cost planning social development, at any rate as far as the cost planner is concerned. Without any profit a profit-investment appraisal cannot be prepared for such projects, and the cost of the land is just one of the many items on the expenditure side with which no comparison with income can be made. Also there are still many projects where the budgeting stage is bypassed, and the cost planner is concerned with nothing more than meeting a target for building cost which may have been set using some formula or other. However, there is an increasing tendency to use the profit-development type of calculation on any social projects, such as housing, where there is a real or hypothetical income.

5.8 Calculating building costs

Although building costs are only 1 of the 10 items making up the total budget, they are still likely in most cases to form the largest single item. However, it must be remembered that at this stage almost nothing is likely to be known about the building except its general size, and therefore it is pointless to go into detail about cost before any designing has been done.

This is the place to use one of the traditional 'single price rate' methods of estimating cost introduced in Chapter 1; the size of the building is measured in one form or other and the resulting quantity is multiplied by a single price rate to give the estimated cost.

5.8.1 The cube method

This was the traditional method. All quantity surveyors' offices used to keep a 'cube book'. Whenever a contract was signed the amount of the accepted tender was divided by the cubic content of the building and the resultant **cost per cubic foot** entered in the book. When an estimate was required for a new project, its volume in cubic feet would be calculated and an appropriate rate per cubic foot was taken from a previous job in the cube book. The method has largely died out as a result of a number of factors, the main factor being that the cost of a building is usually more closely related to its **gross floor area** than its cubic capacity. Even with a 'blunt instrument' such as a cube, it was necessary to have common standards of measurement so that the rate obtained from one project might be fairly compared with the other. The RIBA pre-metric set of rules was the one commonly accepted; these involved multiplying the plan area measured over the external walls by the height from the top of the concrete foundation to halfway up the roof if pitched or to 2′0″ at (0.60 m) above the roof if flat. Extra allowances were made for projections such as porches, bays, oriels, turrets and fleches, dormers, chimney stacks and lantern lights. This formula had little to recommend it except the vital matter of uniformity. Both the additional allowance for a pitched roof (which may well have been cheaper than a flat roof) and the allowance for fluctuations in foundation depth were very arbitrary. The Standard Form of Cost Analysis (published by the Building Cost Information Service of the Royal Institution of Chartered Surveyors) still makes provision for cubing but uses a different set of rules.

5.8.2 The superficial area method

This is an alternative single price rate method in which the total floor area is calculated. The convention usually accepted is that the area of the building inside the external walls is taken at each floor level and is measured over partitions, stair wells and so on. The resulting figure is known as the gross internal floor area. In cases where columns to frames are situated inside or beyond the external walls, these columns are ignored and the dimensions are still taken from the internal face of perimeter walls. Where there is no external wall at floor level (as in the case of freight sheds), the dimensions are taken from the external faces of columns. More recent than the cube method, the superficial area method first came into use in the 1940s and 1950s for such projects as schools and local authority housing where the storey heights were reasonably constant. It has the virtue of being closer to the terms in which the client's requirements are expressed, as the accommodation is more likely to be related to floor area than to cubic displacement. Sometimes when a very early estimate is required, the only data available may be the approximate floor area, so this method is still widely in use for budgeting as the first stage in a cost planning process.

5.8.3 The unit method

This technique is based on the fact that there is usually a close relationship between the cost of a building and the number of functional units it accommodates. By functional units, we mean those factors which express the intended use of the building better than any other. For example, it may be number of pupils in a school, number of vehicle spaces in a car park, number of seats in a theatre, number of people housed in a housing development and number of beds in a hospital ward. Several cost yardsticks operated by government departments were based upon this relationship and provided a benchmark of what was reasonable for a given scheme. After all, by costing a single functional unit instead of, say, floor area, the designer has greater flexibility in choosing between the quantity of building and its quality, and the funding organisation has the assurance that it has not paid beyond what is reasonable. We will consider an example of the more general use of the technique.

Example

Suppose a multi-storey car park for 500 cars had recently been constructed for the sum of £3,000,000. The cost per car space would obviously be {£3,000,000/500} = £6000 per car space. If a similar car park is to be built for 400 cars, then it might reasonably be assumed that the cost would be 400 × £6000 = £2,400,000, *ceteris paribus*.

5.8.4 Single price rate methods generally

Unfortunately all things are not usually equal and consequently a number of judgements must be made about:

- prevailing price levels (due to inflation and market conditions) at the proposed date of tender;
- site difficulties;
- specification changes;
- different circulation and access arrangements.

Once again, as with all single price estimates these adjustments to the analysed figure would be based on the cost adviser's judgement and are critical to success.

5.8.5 Cost of financing the project

Having looked at the role of land costs and building costs in relation to the project, it is now time to look at financing costs. This is the intangible component of total building cost; all the other things such as buying land, paying a building contractor, paying professional fees and so on involve paying money to somebody else in exchange for property or services. As soon as this tangible expenditure starts, however, the developer will be laying out money, and there will be nothing to show for it in terms of income (or use) until the building is ready for occupation or can be disposed of. Hence, the cost of lending this money to the development for a period of possibly several years becomes part of the cost of the development itself. When interest rates are high this financing cost can be considerable, as has already been pointed out, so the project should be planned to avoid unnecessarily early expenditure on any part of it.

5.8.6 Where the money comes from

The capital for the development may come from a number of alternative sources.

- Sources of finance for private development
- Bank overdraft: This is rarely available as a means of financing a whole development, but may be useful for short-term bridging purposes; the money would probably be lent on the security of the development.
- Loan from merchant bank or insurance company: This is similar to the last, except that it is possible to obtain longer term finance from these sources. Interest rates are usually somewhat higher.

- Capital account: Where the development is being undertaken for a firm's own use – such as factory, warehouse and so on – the capital for the development can be regarded as part of the general capital expenditure of the firm.
- Trading funds: Property companies will have funds for carrying on their business.
- Shares in the development: Speculative development is sometimes financed by paying the builder with shares instead of cash or by allowing the building firm to develop part of the site for itself. Alternatively, a 'joint venture' may be undertaken with another developer.
- Finance by the intended occupier: It may be possible to persuade the intended occupier to pay part of the sale price during the erection of the building. This is sometimes the case with houses that are built for sale.

5.8.7 Sources of finance for public (social) development

- Government funds: These will be available either as direct finance for government building (e.g. defence works) or as a grant or subsidy for other public sector or social building.
- Loans from government funds: These are usually available at a lower rate of interest than money raised on the open market, but are very restricted as to eligibility and amount.
- Issue of stock: Local authorities and public boards are empowered to issue fixed-interest loan stock on the Stock Exchange. Full market rates of interest have to be paid, and there is a long-term commitment to these which can prove very expensive if interest rates subsequently fall.
- Local authority mortgages: These are a useful way of raising money, as there is a firm commitment by both sides, but for a short period of 3–5 years only. Interest rates are usually a little higher than the current yield on gilt-edged securities.
- Loans from other funds: A public authority can borrow from its other funds (if it has any) for development purposes.
- General income: It is common for a local authority to raise money for development from its charges or council tax – this has the advantage that the money does not have to be paid back!
- The National Lottery and the National Lottery Charities Board (now called the Big Lottery Fund): Grants are also available for suitable projects by application to the Arts Council or the Sports Council for England. There is strong competition for money from these sources.
- The European Union: The so-called structural funds such as Objective One provide capital funding for development schemes in areas of the EU that are considered to be at risk from social and economic deprivation. Liverpool, in the UK, is one example of a city that has been transformed by the impact of this funding.
- Private developer: In large-scale urban redevelopment, a private developer can be required to undertake some social development in exchange for being allowed to pursue a profit-related scheme. Alternatively, a developer can be offered some profitable role within a social development if it contributes to the cost of the public part.

5.8.8 Budgeting for refurbishment work

Before drawing up a budget for refurbishment work, or work involving major alterations to existing premises, a number of difficult decisions have to be made, and it is necessary to consider very carefully how the work will be carried out before establishing even an initial budget.

5.8.9 Budgeting for new-build projects on very restricted urban sites

Such projects have many problems in common with refurbishment work, and reference to Chapter 19 would be worthwhile.

5.9 Some budgetary examples

Let us now look at some simple budget examples. These are in no sense typical in that every project has its own particular problems and priorities, but they give an idea of the type of basic calculations involved. The method of arriving at the various estimated costs has not been shown, as the concern here is how to manipulate the answers. The interest rates used for most of the calculations are based on a criterion rate of return, the return which the developer requires in order to make a reasonable profit.

5.9.1 A budget for a profit development for sale (24 town houses in a provincial city)

Costs		
Cost of land	£1,000,000	
Legal and professional cost of acquiring land, obtaining planning permission, and so on	£100,000	
Demolition of existing property	£60,000	
Building cost and professional fees in connection	£960,000	
Site layout, ditto	£40,000	
Agent's charges for selling	£1,020,000	
	£2,180,000	**£2,180,000**

Cost of finance(2 % per month compound interest – criterion rate of return)

Land, legal costs, demolition – finance on œ1,160,000 for 12 months	£313,200		
Building, professional fees and site layout – finance on £1,000,000 for 4 months (av)	£80,000		
Agent's fees are paid after sale, no finance charge	–		
	£393,200	**£393,200**	**£2,573,200**

5.9.1.1 Income

Minimum economic selling price of each house would therefore be £2,573,200/24 = £107,210 (say £108,000).

Anything less than this will not produce the criterion rate of return, and if there is any doubt about obtaining such a figure, then the development should not go ahead based on the information provided here. It will be seen that instead of discounting all expenditure and receipts to the commencing date of the scheme, they have been carried forward to the end of the scheme and compound interest added. This has the same effect – it is easier to do it this way in this instance as it is the future selling price which we are interested in and not present value.

5.9.2 A budget for a profit development (for rental offices)

Costs		
Cost of land	£500,000	
Legal and professional cost of acquiring land, obtaining planning permission, compensation and so on	£170,000	
Demolition	£60,000	
Building cost and professional fees in connection	£1,700,000	
	£1,430,000	**£1,430,000**

Cost of finance (2%per month compound interest – criterion rate of return)

Land, legal costs – finance on £670,000 for 36 months	£696,800	
Demolition – finance on £60,000 for 18 months	£25,800	
Building, professional fees, and site layout – finance on £700,000 for 10 months (av)	£154,000	
	£876,600	**£876,600**
Total capital cost at completion		**£2,306,600**
	(say)	**£2,310,000**

Income		
Annual income from rents (figure given by valuer)	**£600,000**	**£600,000**
Less		
Allowance for vacant tenancies (voids)	£50,000	
Maintenance, repairs and redecorations (excluding tenants' responsibilities)	£30,000	
Cleaning, heating, lighting and council tax on public part of building (staircases, entrance halls)	£50,000	
Management expenses, including caretaker, arranging lettings and collecting rents	£18,000	
Sinking fund to replace capital at end of 40 years at 2.5% pa on £2,310,000 less cost of land (which will still be there when the building is demolished) £1,810,000 at 1.5p	£27,150	
	175,150	**175,150**
Net annual income		**424,850**

This gives a return of 18.4% on the capital of £2,310,000.

Alternative format for last budget: An alternative way of setting out this last budget would be to start with the estimated income as the criterion. This is the approach a developer would be likely to favour.

5.9.3 A budget for a profit development (alternative approach)

Income	
Estimated annual income from rents	£600,000
Less expenses (excluding sinking fund)	£148,000
	£452,000

Note: The cost of the sinking fund cannot be accurately assessed at this stage, as the capital value of the buildings and so on is not known. It could be approximated thus: capitalised value of income at 18.5% is approximately £2,443,000. Say 25% of this represents residual land value, which will not need to be replaced.

Sinking fund to replace £1,832,000 at end of 40 years at 2.5% (at 1.5 p)	£27,483
Estimated net annual income	**£424,517**
Net value of 40 years' annual rent £424,517 at 18% (criterion rate of return) at £5.40	£2,292,400

This represents the capitalised value of income at the date of completion in 36 months time. Discounted to present value at 2% per month at 49.0 p, PV of income = £1,123,270.

Costs	
Estimated legal and other costs of acquiring land	£170,000
Estimated cost of demolition of existing buildings (PV of £60,000 in 18 months time at 2% per month = 70.0 p per £)	£42,000
Estimated cost of building and professional fees (PV of £700,000 in (average) 26 months time at 2% per month = 59.8p per £)	£418,600
	£630,600

The maximum amount which can be paid for the land at the present time to give the required rate of return would therefore be £1,123,270 (PV of income) minus £630,600 (present value of expenses) = £492,670 (say £500,000). At this stage, the calculations would have to be based on the minimum amount of accommodation for which the client could expect to get planning permission, unless an outline scheme had already been approved. It should be noted that taxation provisions, which are constantly changing, have been ignored in these calculations but cannot be ignored in practice.

5.9.4 Sensitivity analysis

It is possible to examine the effect of changing the values of the variables either singly or in combination within this model using sensitivity analysis. This will enable those variables or assumptions, which are significant to the calculations, to be identified and quantified. Very often in profit development, the overall time for designing and building the project is of supreme importance, and simulations (ordinarily using Monte Carlo techniques) might well be carried out to assess the effect on construction costs and financing charges of different timescales and fast-track methods of procurement. Certainly it will be seen in the above examples what a large proportion of the total cost is represented by financing charges. It would be easy to reduce the length of the programme on paper, the more important matter is whether this would be achievable in practice, allowing for all the things that can go wrong.

5.9.5 Need for caution

Schemes founded on over-optimism tend not to have a happy outcome. In fact, some developers require that budgets be prepared on a 'mid-to-worst-case' scenario, knowing that construction costs tend to escalate but funding has to be obtained 'up-front'. In a recent case, the developer actually told the cost planner to presume a figure for construction costs which was likely to reduce during the design development and construction stages, and which would not be exceeded without very good reason.

5.10 Key points

- The total expenditure on the development will be much higher than the net cost of the building fabric, and will include cost of land, legal costs, demolition or other physical preparation, professional fees, furnishings and fitting out, VAT, cost of leasing or selling, cost of finance and costs of maintenance or disposal.
- Building development of any kind requires a plot of land on which it can take place, and which, once used, will no longer be available for any other development, unless the first one is either demolished or converted.
- The 'development value' of a piece of land is the difference between the market price of the finished development including the land and the cost of erecting (or converting) buildings on it.
- Where land costs are very high, cost planning may develop into an exercise to secure the maximum number of accommodation units on a given site, at the same time optimising the design from the point of view of grants and subsidies (if there are any of these to be had).
- As soon as tangible expenditure on land purchase, building work and so on starts, the developer will be laying out money, and there will be nothing to show for it in terms of income (or use) until the building is ready for occupation or can be disposed of. Hence, the cost of lending this money to the development for a period of possibly several years becomes part of the cost of the development itself.

Endnotes

1 Tavistock Institute (1966) Interdependence and Uncertainty: A Study of the Building Industry, Tavistock Publications, London.

2 The theory of complexity and complex systems has become an important part of Management Science, for information on the application of complexity theory within the built environment, refer to CIB TG62 Complexity and the Built Environment at www.cibworld.nl and http://pcwww.liv.ac.uk/~kirkham/CIBTG62.htm.
3 MSP – Member of the Scottish Parliament.
4 British Property Federation (BPF) (1983) The British Property Federation System for the Design of Buildings, British Property Federation, UK.
5 An easement is the right to do something or the right to prevent something over the real property of another.

Chapter 6

The Economics of Cost Planning: The Time Value of Money and Cash Flow

6.1 The time value of money

Anything that involves the forecasting, estimating or prediction of costs into the future is governed by the concept of what is known in economics as the 'time value of money'. Strangely, many people find this confusing, but in reality it is simple and is usually exemplified in the following example:

> You are offered the option of accepting £100 today, or £100 in a year's time. Which option would you accept *ceteris paribus*[1]?

Naturally, most rational consumers (or persons for that matter) would accept the £100 today rather than in a 1 year time. There are many reasons why this is the case such as risk, uncertainty and **opportunity cost**.[2] However, what is clear is that a sum of money in the future will always be worth less than the same sum today, and this will depend on the length of time between options, future risk, and uncertainty and future interest rates. The determination of this future sum is obtained by the use of standard **present value** (PV)calculation methods. We will cover the standard formulae later in this chapter.

The concept of PV is a fundamental aspect of whole life cycle costing (WLCC) since this technique involves the forecasting of future sums over longer periods of time. WLCC is covered in greater depth in this chapter. However, in the shorter term, cost planners are often required to perform calculations on a monthly or even weekly basis, and consequently, annual interest rates are difficult to deal with. Cost planners will generally use an equivalent rate for the period, dividing the annual rate by 12 (months) or 52 (weeks). Naturally, this is interpolating to some extent since it ignores the effect of **compounding**.[3] The exact annual equivalent of a monthly interest rate i is not $12i$ but $(l + i)^{12} - 1$. The yearly equivalent of 1% per month is therefore 12.68%, and conversely the monthly equivalent of 12% per annum is 0.94888%. Where comparisons between two or more alternatives are being considered, this difference is rarely of much significance, but it should be allowed for if specific annual interest rates are an important factor.

6.2 Interest: the cost of finance

The issue of interest and financing charges will normally apply to all construction projects. Large, complex-building procurements will particularly require some form of financing in order

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

to allow the developer to realise the project. This is due simply to the fact that significant funds are normally necessary to resource a project in terms of materials, labour, plant, land fees, professional fees, insurances, taxation and so on.

The cost of borrowing money is quantified by the 'interest rate'. Some economists will describe the interest rate as a measure of the 'rent' paid to borrow a sum of money. Why does borrowing money always involve interest? In the classical economic scenario, the lender must be incentivised to release funds for others to borrow – this incentive comes in the form of a 'compensation' to take into account the lenders decision to defer consumption of the principal. The original amount lent is normally referred to as the 'principal', and the percentage of the principal which is payable over a period of time (usually 1 year) is the 'interest rate'.

In the United Kingdom, the Bank of England is responsible for setting interest rates; hence, the rate is often referred to as the **Bank of England base rate**. Since 1997, the Bank of England Monetary Policy Committee (MPC) has held sole responsibility for setting interest rates in an attempt to de-politicise economic decision-making. Since 9 March 2009, the rate stood at 0.5%. However, the cost of borrowing money can depend on a variety of circumstances, and often this cost will be encapsulated in a rate well above the Bank of England base rate. This is loosely referred to as a creditworthiness premium, which is based on an assessment of the lender's ability to repay the principal plus the estimated accrued interest. Other factors such as liquid assets, credit history, guarantors and so on will affect the interest rate – this can sometimes be a major problem for small contractors who experience regular problems with cash flow and timing of payments. In other words, it represents a **risk premium** set by the lender. **Risk** is an important concept in construction (it is distinct from uncertainty) and represents (in this context) a quantification of the probability of default. The higher the probability of default, the higher the risk premium, and vice versa. The risk premium can be found by comparing the project with the rate of return required from other projects with similar risks.

On a macro scale, interest rates are used as a method of controlling inflation within the economy. The higher the rate of interest, the more attractive the investing/saving becomes over spending. This reduces demand in the economy and should in turn lead to a steady state or fall in prices. In some countries, this can be a real headache for cost planners who must account for potential cost increases in raw materials such as steel. The Far East, for example, has experienced highly volatile raw material process over the past decade.

Cost planners should, where possible, understand the national/international supply/demand for key materials. In some specific cases, cost planners have advocated the purchase of raw materials well in advance of the start of a project in order to mitigate the effects of a potentially significant price hike further down the project life cycle. This will of course affect cash flow and increase costs for storage and security – this decision would need to be assessed on its individual merits.

Cost planning is not so much a science as an art, one which is perhaps impossible to truly master given the externalities impacting on construction projects.

6.3 Do we always take interest into account?

Yes. Interest and finance charges apply to all projects and developments, simply because the capital used to fund the project is either being borrowed and is thus attracting interest charges, or the developer's own money, which because it has been spent on the development is not available for investing elsewhere and is therefore not accumulating interest (opportunity cost). Strangely enough, although most cost planners are aware of this factor, some clients' accounting systems do not recognise it and so, in practice, cost planners are not always able to demonstrate any benefit from optimising payment in relation to time. However, private developers in particular are certainly aware of the importance of the timing of income and expenditure. And building contractors have always recognised its significance, even if they have not always been able to formalise their methods of dealing with it.

6.4 The importance of understanding the cost/time relationship

The construction industry delivers some of the most prestigious public projects from roads and bridges to schools, hospitals and corporate developments. Many of these projects will take years to complete, and such will be susceptible to market forces such as inflation and interest rates. With the increasing complexity of large building projects, it is not uncommon for some years to elapse from the start of expenditure on the project (outline design) through to the time when practical completion/handover is achieved or the building becomes a revenue-earning asset.

The interest rate is a key variable in the cost/time relationship as this has a direct impact upon the construction industry generally. The demand for construction work is usually cyclical and regionally volatile. During periods of high demand for products and services in the economy, interest rates will more likely than not rise at some stage to check the demand. This will have a knock-on effect for projects, which are heavily financed of course. Therefore, cost planners engaged on long-duration projects will require extra diligence when assessing likely changes in the economy among local, national and international bases.

Many larger contracting organisations now employ in-house economists who monitor market trends in order to help cost planners deal with inflationary issues. There has also been a large increase in the number of companies (many part of a prequalified supplier (PQS) organisation) that concentrate on providing specialist cost advice to clients.

6.5 The application of simple development economics in cost planning: terminology and nomenclature

Conventionally, the cost planner will be required to perform calculations to account for future project income and expenditure. On shorter project durations, the selection of the appropriate methods of evaluation is not as critical as it is on long-duration schemes. Public Private Partnerships (PPPs) and, in particular, private finance initiative (PFI) schemes are examples of the latter. In this instance, cost planners are typically involved in the cost plans of a 25-year concession period, which involve not only design and construction costs but also operational and maintenance expenditures such as energy and facilities management services. In this context, the 'sums' become slightly more complex! This subject is covered in greater depth in Boussabaine (2007). Notwithstanding, cost planners should be competent in the use of standard tools and methods, which are appropriate for any type of scheme – these are covered in the remainder of this chapter.

6.5.1 Simple interest and compound interest

Simple interest (equation 6.1) is the amount of interest paid on the principal only. If a sum of money is invested for a number of years it will have earned some interest by the end of the first year. Compound interest (equation 6.2) assumes that this earned money is immediately added to the principal and re-invested on the same terms, this process being repeated annually. Many forms of actual investment provide for doing this automatically, but it is in any case the correct method to use when making investment calculations, since it should not be assumed that money would be allowed to lie idle. Note that this formula is also useful for extrapolating inflation rates over a period of years.

$$\text{Simple interest} = P \times i \times n \tag{6.1}$$

$$\text{Compound interest} = P(1 + i)^n \tag{6.2}$$

where P is the principal, i is the interest rate and n is the time (number of years).

Worked example

A property developer decides to invest £128,000 in a guaranteed bond at 0.5% compound interest to offset against future maintenance costs for his estate portfolio. Calculate the value of this investment after 12 years?

Using equation 6.2 ⇒ £128,000 × $(1 + 0.005)^{12}$ = £135,894.75

6.5.2 Future value and present value

In cost planning, there will invariably be a need to calculate the value of sums of money in the future and also to be able to convert future sums to today's value. In order to do this, we use the **future value (FV)** and **PV** formulae, respectively.

6.5.2.1 Future value (FV)

FV measures what money is worth at a specified time in the future assuming a certain interest rate. Like in the previous example, equations for FV are available for simple and compound interest:

$$\text{FV(without compounding)} = P(1 + in) \tag{6.3}$$

$$\text{FV (with compounding)} = P(1 + i)^n \tag{6.4}$$

where P is the principal, i is the interest rate and n is the time (number of years).

Furthermore, it is possible to calculate the FV of a sum of money invested at regular intervals over time, this is known in economics as an **annuity**. An annuity is a flow of fixed payments over a specified time period. So instead of the worked example given before where a single sum is invested, an annuity involves a sum of money regularly invested at a specified time.

Annuities fall into two groups, annuity-immediate (ordinary annuity) and annuity-due. The former is where payments are made at the end of each period, and the latter is where payments are made at the start of each period. Thus, the FV of an annuity-immediate and an annuity-due is given in equations 6.5 and 6.6, respectively:

$$\text{FV} = A \times \frac{(1 + i)^n - 1}{i} \tag{6.5}$$

$$\text{FV} = A \times \frac{(1 + i)^n - 1}{i} \times (1 + i) \tag{6.6}$$

where A is the annuity payment, i is the periodic interest rate and n is the time (number of years).

Worked example

The sum of £2850 is invested annually into an account, again at a compound interest rate of 0.5%. The period of the investment is 9 years. Calculate the value of the investment at the end of Year 9 – assuming the investment is made at the end of each year.

Using equation 6.5 FV $= £2850 \times \frac{(1+0.005)^9-1}{0.005} = £26169.03$

If the investment is made at the start of each year, since each annuity payment compounds one extra period, the value of an annuity-due is equal to the value of the corresponding annuity-immediate multiplied by $(1 + i)$.

Using equation 6.6 FV $= £2850 \times \frac{(1+0.005)^9-1}{0.005} \times (1 + 0.005) = £34027.02$

6.5.2.2 Present value (PV)

PV of a future cash flow is defined a sum money at some time in the future, discounted[4] to today's value (accounting for the time value of money). HM Treasury (HM Treasury 2003) defines PV as the FV expressed in present terms by means of discounting. In this chapter, we shall explore in greater depth the importance of the discount rate calculation methods. The calculation of PV is important in cost planning as it allows us to appraise options on a like-for-like basis.

In the compound interest example (6.2), the proof shows that £128,000 invested for 12 years at 0.5% compound interest grows to £135,894.75. The inverse of this is simply that the PV of £135,894.75 in 12 years time at 0.5% interest is £128,000. Therefore, PV of £1 is expressed mathematically as the reciprocal 6.7

$$\text{PV} = \frac{1}{(1+i)^n} \tag{6.7}$$

Worked example

Calculate the PV of £1200 in 35 years time, discounted at 15% per annum.

From equation 6.7, PV (£1) $= \frac{1}{(1+0.15)^{35}} = £0.008$

Thus, £1200 × £0.008 = £9.60

In this example, you can see that over a very long period of time, the value of the principal diminishes significantly. With high interest rates, this is to be expected. In reality, the HM Treasury *Green Book* gives guidance on the use of discount rates and time. It recommends that the test discount rate becomes 3.5% for Years 0–30, 3.0% for Years 31–75, and 2.5% thereafter (in the public sector). This is basically to mitigate the effects of what are shown in the example above. These kinds of long-term predictions would, however, be more common in whole life cycle cost appraisals rather than conventional short-duration project cost planning *per se*.

6.5.2.3 Present value of £1 payable at regular intervals

In equation 6.7, we calculated the PV of a sum of money at a point in the future. However, just like in equations 6.5 and 6.6, the cost planner may be required to calculate the PV of regular future payments or receipts. Therefore, the PV of £1 payable at regular intervals is given

$$\text{PV of £1 payable at regular intervals} = \frac{[(1+i)^n - 1]}{[i(1+i)^n]} \tag{6.8}$$

Worked example

Calculate the PV of £1200 payable annually for 10 years assuming an interest rate of 8% per annum?

From equation 6.8 the PV of £1 paid annually is £6.71. The PV of £1200 annually is therefore £1200 × £6.71 = £8052. This is the sum, which would have to be invested today at 8% compound interest in order to discharge an obligation.

It is interesting to see what difference would result if the money were to be paid in quarterly instalments of £300 instead of at the end of each year. 8% per annum is equivalent to 2% per quarter so from equation 6.7 the PV of £1 over 10 × 4 = 40 periods at 2% is £27.36. Therefore, the PV of £300 paid quarterly for 10 years is

300 × £27.36 = £8208 compared to £8052 for the yearly payments of £1200.

6.5.3 Annuity purchased by £1

This is the reciprocal of equation 6.8, and gives the annuity (or regular annual payment) purchased by a lump sum payment of £1. At the end of the given number of years, the money will be exhausted. It is therefore useful for calculating the annual equivalent of a given present-day lump sum (whereas equation 6.8 calculated the present-day lump-sum equivalent of a given annual amount).

$$\text{PV of £1 payable at regular intervals} = \frac{[i(1+i)^n]}{[(1+i)^n - 1]} \quad (6.9)$$

Worked example

What annual saving in maintenance costs over a period of 10 years would justify an increase in capital costs of £90,000, assuming an interest rate of 8%?

The annual equivalent of £1 from equation 6.9 is 14.9p. The annual equivalent of £90,000 is therefore £90,000 × 14.9p = £13,410. If the saving in maintenance costs exceeds this amount, then the additional capital investment of £90,000 would be justified.

6.5.4 Sinking fund

A sinking fund is a method by which an organisation sets aside money over time. More specifically, it is a fund into which money can be deposited, so that over time its preferred stock, debentures or stocks can be retired. In general finance, sinking funds have the benefit of the principal of the debt (or at least part of it), being available when due. Naturally, sinking funds can be used as a risk premium reduction tool since the fund reduces the risk of default on maturity of the debt. The equation for sinking fund 6.10 is the reciprocal of equation 6.5 since it returns the value of how much must be invested each year to accumulate a certain sum over a certain number of years. Sinking funds are useful when planning life cycle replacements for equipment such as M+E services.

$$\text{Sinking fund £1} = \frac{1}{[(1+i)^n - 1]} \quad (6.10)$$

Worked example

How much must be invested at the end of each year at 7% per annum to amount to £20,000 at the end of 12 years?

From equation 6.10, 5.6p has to be invested each year to realise £1 after 12 years. For £20,000 to be realised therefore, again from equation 6.10:

$£20,000 \times 5.6p = £1120$ per annum sinking fund

6.6 Project cash flow

The basic economic concepts described in the earlier part of this chapter must be conceptualised within the wider context of how cost planners need to be aware of the importance of timing various payments and receipts into a construction project (this is critical on long-duration schemes such as PFI). These techniques are the foundation of sound project management and planning. The integrated process of planning these payments and receipts is conventionally referred to as **cash flow** management.

Simply, cash flow is the difference between income coming into a project and expenditure going out. A project is in a position of negative cash flow when more money is going out of the project than coming in, and vice versa. Table 6.1 gives a basic example for period 1. For n number of periods, you would be able to produce an X–Y line graph showing cash flow visually over the project duration. For large international contracting organisations, cash flow is not so much a problem (assuming normal economic conditions) since these companies are involved in many other ventures, which provide for a relatively stable overall company balance sheet. However, for smaller contractors, cash flow can be critical and be the difference between being in business or not. Poor cash flow is the antithesis of good business performance for most small contracting organisations, so accurate and effective cost planning is all the more critical.

The principal of cash flow is basic but the complexities of the process within are not so. Consequently, work on cash flow modelling has been the focus of a good deal of research in the UK industry with notable contributions from Kaka and Lewis (2003), Boussabaine and Elhag (1999), Lam et al. (2001) and Blyth and Kaka (2006). There are a wealth of other factors, which will affect cash flow including material prices, labour rates and availability, the general economy, energy prices and, interestingly, the procurement route selected.

While the examples of research referenced earlier deal with the mathematical and scientific nuances of cash flow forecasting and modelling, there are a good deal of techniques that cost planners can adopt to help control project costs on a practical level including:

1. **Adequate cash forecasting:** One of the prevalent issues on construction projects is failing to adequately project cash requirements in the future. In many normal retail scenarios, cash transaction can be swift (i.e. within minutes) – but in construction, there can be delays in receiving payments for such reasons as credit holidays or debtor problems.
2. **Plan for infrequent expenses and variations:** Cost planners should forecast expenses that are not due every month, such as annual insurance premiums. Variations in the project can also be a key problem in terms of cash flow – steps should be taken at the briefing stage in order to minimise the impact of variations.
3. **Cost control:** Forecasting is only half the story of the cost plan, of equal importance is the control, so the cost planner must monitor project income and expenditure efficiently.
4. **Reduce debtor days (credit holidays):** Longer credit periods for payments will inevitably lead to cash flow problems. The planner must strike the right balance between creditor days and debtor days, ideally these should be equal in order to balance out cash flow but if the payments are being made quicker than received then it can create difficulties.
5. **Just-in-time:** Cash flow can be affected by materials being purchased but not used on time. Delays in valuation certificates being issued will invariably affect the cash flow profile

Table 6.1 Example cash flow statement for period 1.

Description	Cash in (£)	Cash out (£)	Net cash flow (£)
Loan from finance institution	£1,456,000		£1,456,000
Sale of previous assets to finance project	£312,500		£1,768,500
Prime cost items		£789,000	£979,500
Design and professional fees		£80,000	£899,500
Land charges		£40,000	£859,500

for the project. Just-in-time ordering is a system where materials are ordered more or less on the project's critical path. Sometimes, however, this is not cost-effective so caution must be exercised.

6.7 Discounted cash flow techniques

Earlier in this chapter we introduced the concept of discounting as part of PV calculations. These techniques form the basis of what is known commonly in finance and economics as the **discounted cash flow** (or DCF) technique. HM Treasury defines DCF as 'a technique for appraising investments. It reflects the principle that the value to an investor (whether an individual or a firm) of a sum of money depends on when it is received'. DCF methods determine the PV of future cash flows by discounting (as shown in the worked example for equation 6.7). This is necessary because cash flows in different time periods cannot be directly compared because of the time value of money notion.

6.7.1 Discounting

Discounting is a method used to convert future costs or benefits to PVs using an applied discount rate and is the cornerstone of the time value of money concept. Discounting is often confused with inflation but they are separate concepts. The discount rate is therefore not the inflation rate but is the investment premium over and above the rate of inflation. In techniques such as WLCC however, it is a standard practice to exclude inflation effects. Inflation or cost escalation would only be considered where there is evidence to suggest that inflation in the prices of one element within a model would be significantly higher than the other elements. In other words, the assumption is that inflation will affect all prices equally so all values are expressed in constant prices at a given date.

For the cost planner, setting the correct discount rate is one of the key decisions since the value is common through the whole DCF calculation. All PVs are based on the discount rate, as is the calculation of indicators such as **net present value (NPV)** (see Section 6.7.3.1).

The discount rate is set by the client and includes the degree of risk on return required in a commercial context, or the rate of interest payable where loans are required to finance the construction work. If it is set too high, future costs will appear insignificant and will be favoured by the calculation. If it is set too low, higher capital costs will be discouraged, but high operational costs may result. If inflation is taken into account in the discount rate and if rates are substantially different in practice, the calculation may lead to inappropriate choices.

6.7.2 Dealing with inflationary issues

One can use either real or nominal discount rates in the cost plan. If one uses real discount rates, each expected future cash flow is forecasted at today's prices. The discount rate used to convert these 'constant price' cash flows to their PV is based upon the real rate of interest (this is the nominal rate of interest – expected rate of inflation) plus a risk premium. Nominal discount rates, on the other hand, see future cash flow forecasted in terms of the expected quantity of goods or services multiplied by the unit price expected to prevail at the time of the expenditure (future prices). The discount rate used to convert these cash flows to their PV is based upon the nominal rate of interest (required real rate of interest + expected rate of inflation) plus the risk premium.

To calculate the nominal discount rate,[5] if the real discount rate and inflation rate are know, one uses the following formula 6.11:

$$R = [(1 + r) \times (1 + i)] - 1 \tag{6.11}$$

where R is the nominal rate of interest or discount rate, r is the real rate of interest or discount rate and i is the annual implied inflation rate.

In public sector projects, HM Treasury *Green Book* advocates the use of a **3.5%** discount rate. This calculation is based upon what is referred to as the **social time preference rate (STPR)** and is defined as the value society attaches to the present, as opposed to future, consumption. STPR is a rate used for discounting future benefits and costs, and is based on comparisons of utility across different points in time or different generations. The STPR has two components (HM Treasury 2003):

- The rate at which individuals discount future consumption over present consumption, on the assumption that no change in per capita consumption is expected, represented by; and,
- An additional element, if per capita consumption is expected to grow over time, reflecting the fact that these circumstances imply future consumption will be plentiful relative to the current position and thus have lower marginal utility. This effect is represented by the product of the annual growth in per capita consumption (g) and the elasticity of marginal utility of consumption (μ) with respect to utility.

The equation for calculating the STPR is therefore given by equation 6.12

$$r = \rho + \mu \cdot g \tag{6.12}$$

where r is the real discount rate, ρ is the catastrophe risk and pure time preference[6], μ is the elasticity of the marginal utility of consumption and g is the output growth.

Thus, the real discount rate in the *Green Book* is $r = 0.015 + 1.0 \times 0.02 = 3.5\%$.

6.7.3 DCF methods of appraisal

There are many methods of appraisal that lie at the disposal of the cost planner, many are esoteric to the purposes of this book, so we shall concentrate on some of the most common methods, these being

- NPV
- internal rate of return (IRR) and the adjusted IRR
- net savings (NS)
- equivalent annual cost (EAC)
- discounted payback (simple payback also covered)

6.7.3.1 Net present value (NPV)

The NPV method is one of the most well-known methods of financial appraisal and is defined in the *Green Book* as 'The discounted value of a stream of either future costs or benefits … (NPV) is used to describe the difference between the present value of a stream of costs and a stream of benefits'.

The NPV method is useful for evaluating various competing long-term projects and is used widely in WLCC in particular. It measures the excess or shortfall of cash flows, in PV terms, once financing charges are met. Strictly speaking, all projects with a positive NPV should be undertaken. However, in reality, NPV will not be the only decision-making criteria – there are always other intangibles that would be considered as well (we use multi-criteria decision-making (MCDM) techniques to deal with this).

NPV is given by the formula

$$\text{NPV} = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} \text{ or } C_0 + \frac{C_1}{(1+r)^1} + \frac{C_2}{(1+r)^2} + \frac{C_3}{(1+r)^3} + \dots \frac{C_t}{(1+r)^t} \tag{6.13}$$

Worked example

This example will require the use of equations 6.7 and 6.13. In this example, a developer wishes to consider three short-term investment options. Each investment option has the same capital cost but different anticipated future revenues. Thus, the capital cost of each investment is £175,000[7] and the yearly cash flows are shown in Years 1–5 in the following table (£000):

Year	**0**	**1**	**2**	**3**	**4**	**5**
Investment Option A	(175)	10	20	56	76	37
Investment Option B	(175)	35	25	30	56	12
Investment Option C	(175)	50	25	30	50	34

When carrying out NPV calculations, the first year in which capital is invested is always referred to as Year 0. Then each year, cash flows from 1, … , *n*. When carrying out the NPV calculation, the initial capital invested is treated as a negative number (shown in parenthesis) as shown in the table.

So let us assume that we are required to calculate the NPV of each investment option at a discount rate of 7%. You should therefore adopt the following method.

1. Using equations 6.7 or the PV (£1) table in the Appendix, you should calculate the PV of £1 for each year (1–5), this will give

Year	**0**	**1**	**2**	**3**	**4**	**5**
Discount factor at 7%	1.000	0.935	0.873	0.816	0.763	0.713

2. Next, simply multiply each yearly cash flow by the yearly discount factor calculated from the earlier table. For example,

$$\text{For Option A, in Year 1 PV} = £10{,}000 \times 0.935 = £9350$$

$$\text{For Option B, in Year 1 PV} = £35{,}000 \times 0.935 = £32{,}725$$

3. Once you have calculated all of the PVs for each year, sum these up beginning with the initial capital outlay so this would be (Option A): −£175,000 + £9350 + … = NPV
4. Complete the remaining calculations yourself and make sure you are able to calculate NPV correctly. **The preferred project is of course the one that returns the highest NPV because we are dealing with the net difference between income and outlay!** Also try working out the simple payback for each project (solution at the end of the chapter).

6.7.3.2 Internal rate of return (IRR) and adjusted internal rate of return (AIRR)

The IRR is disputed by many as simply a theoretical arithmetic result as opposed to an economic measure of performance (see AIRR). The IRR of a project can be defined as the rate of discount (r) which, when applied to the project's cash flows, produces a zero NPV, so, in general terms, the IRR is the value for r which satisfies the expression:

$$\sum_{t=0}^{N} \frac{A}{(1+r)^t} = 0 \tag{6.14}$$

The decision rule for IRR is that only projects that have an IRR greater than or equal to a predefined cut-off point should be accepted. This cut-off rate is usually the market rate of interest (i.e. the discount rate that would have been used if an NPV analysis were undertaken instead). All over investment project opportunities should be rejected. The logic behind IRR is similar to that of NPV. The market interest rate reflects the opportunity cost of the capital involved. Thus, to be acceptable, a project must generate a return at least equal to the return available elsewhere on the capital market.

The adjusted internal rate of return (AIRR) is a measure of the annual percentage yield from a project investment over the project life. Like the NS, it is a relative calculation that needs a base case for comparison. AIRR is used to compare against the minimum acceptable rate of return (MARR), which is the smallest amount of revenue considered acceptable for an organisation to undertake a project. Typically, MARR is equal to the cost of capital plus a return; sometimes referred to as the hurdle rate.

This is generally equal to the discount rate used in the calculations. If the AIRR is greater than the MARR, then the project can be defined as economic; if it is less, then it is deemed unworthy of investment. If AIRR is equal to the discount rate, this is breakeven and hence economically neutral. AIRR can be used in the same fashion as SIR.

The AIRR, in contrast to the IRR measure, explicitly assumes that the savings generated by the investment decisions can be reinvested at the discount rate for the remainder of the service life. If these savings could be reinvested at a higher rate than the discount rate, then the discount rate would not represent the opportunity cost of capital. IRR implicitly assumes that interim savings can be reinvested at the calculated rate of return on the project, an assumption that leads to an overestimation of the project's yield if the calculated rate of return is higher than the reinvestment rate. AIRR and IRR are only the same if the investment yields a single, lump sum payment at the end of the service life, or in the unlikely case when the reinvestment rate is the same as the IRR.

As discussed earlier, some dispute IRR as a performance measure in that more than one rate of return may make the value of the savings and investment streams equal, as required by the definition of the IRR. This may be the case when capital investment costs are incurred during later years, giving rise to negative cash flows in some years. The formulae for calculating AIRR is given by

$$\frac{\sum_{t=o}^{N} S_t(1+r)^{N-t}}{(1+i)^N} - \sum_{t=0}^{N} \frac{\Delta I_t}{(1+r)^t} = 0 \tag{6.15}$$

where S_t is the annual savings generated by the project, reinvested at the reinvestment rate, r is the discount rate and $\Delta I_t/(1+r)^t$ is the PV investment costs on which return is to be maximised.

6.7.3.3 Net savings

The NS method calculates the net amount in PV terms, which an investment decision is expected to save over the specified time period. As NS is expressed in PV terms, it represents savings over and above the amount that would be returned from investing the funds at the minimum expected rate of return (i.e. the discount rate). The NS for a project, relative to a designated base case, is calculated by simply subtracting the cost of the alternative project under consideration (X_1) with that of the base case (X_2).

$$\mathrm{NS} = X_1 - X_2 \tag{6.16}$$

Generally, if the NS value returned is greater than zero, then the project under consideration is economically cost-effective relative to the base case. The use of NS can also be extended to individual cost differences between the base case and the alternative. Examples such as capital costs, maintenance cost and so on can benefit from this. This however does require additional calculations as opposed to the simple method above; it is useful, as this value is needed in the calculation of other methods such as savings-to-investment ratio (SIR) and adjusted internal rate of return (AIRR). Calculating NS using individual cost differences is useful as a check to ensure that SIR and AIRR calculations are based on correct intermediate calculations. That is, the NS should be exactly the same whether computed by the comparison of projects or by using individual cost differences. For the latter, the following equation can be employed in the calculation of NS:

$$NS_{X_1:X_2} = \sum_{t=0}^{N} \frac{S_t}{(1+r)^t} - \sum \frac{\Delta I_t}{(1+r)^t}$$

where $NS_{X_1:X_2}$ is the NS, in PV, of the alternative (X_1), relative to the base case (X_2), S_t is the savings in year t in operational costs associated with the alternative, ΔI_t is the additional investment-related costs in year t associated with the alternative, t is the year where base date $t = 0$, r is the discount rate and N is the number of years in study period.

6.7.3.4 Equivalent annual cost (EAC)

At the early stages of a briefing exercise, it may be the case that the possible investment projects under consideration may be of unequal time periods. When this is the case, then simply comparing the NPV of each project is incorrect. This is simply because there is a possibility that the net cash inflow generated from the shorter duration project could be reinvested elsewhere for the remaining time difference, thus generating additional NPV which may total more than other project NPV. This fact is often ignored because only the NPV of projects at the end of their respective lives are compared. When this is the case (and assuming that each project carries the same level of risk), then the equivalent annual cost approach (EAC) can be used (Idowu 2000).

EAC calculates the PV of costs for each project over time t, expressing the PV in an annual equivalent cost using the appropriate annuity factors for each cycle. The annual equivalent of NPVs of the two or more projects can then be compared. Having calculated the EAC for each cycle and each project, then compare the EACs. The project that has the lowest EAC over the cycles is the better one if lowest outlay is the objective or the higher EAC would be preferred if the highest revenue were the objective. The use of EAC is generally in very early stage project feasibility assessments rather than in conventional cost planning but is closely related to the concepts of NPV, so cost planners should be aware of the power of EAC when dealing with unequal project life spans for the purposes of comparison.

6.7.3.5 Discounted and simple payback

Both simple payback and discounted payback are the most basic measures of the amount of time it takes to recover the initial investment in capital. Both are expressed as the period of time that has elapsed between the beginning of the study period and the time at which cumulative savings are just sufficient to cover the initial capital cost of the investment decision. An exemplar development appraisal using simple payback is shown in the worked example. It is rarely used in contemporary cost planning since the problem of both measures is that it is not valid for comparing multiple, mutually exclusive project alternatives, nor for ranking of alternatives either. The irony of this is that cognitively, many of us consider payback when we purchase something (i.e. a new domestic wind turbine or domestic photovoltaic system). As a rule of thumb, it is best employed as a screening method for projects that are so clearly economical that a fuller cost planning exercise of the project is uneconomical and unwarranted. The general formula for calculating discounted payback on an option appraisal basis is given by

$$\sum_{t=1}^{y} \frac{(S_t - \Delta I_t)}{(1+r)^t} \geq \Delta I_0 \qquad (6.17)$$

where y is the minimum length of time over which future net cash flows have to be accumulated in order to offset initial capital cost investment, S_t is the savings in operational costs in year t associated with an alternative project, ΔI_0 is the initial investment costs associated with the alternative, ΔI_t is the additional investment-related costs in year t, other than investment costs, r is the discount rate and n is the time.

Worked example

PROJECT:	Office Development, Sometown	
Estimated income		
Gross area (m^2)	4200	
Lettable %	80	
Annual rental (£/m^2)	210.00	
		Annual income = £705,600 *Area × Rental × Lettable % /100*
Estimated costs		
Land cost	1,600,000	£1,600,000
Fees, duties, etc. %	3	£48,000 *Land cost × Fees etc. /100*
		Total land cost = £1,648,000 *Land cost × (1 + Fees etc. /100)*
Building cost (£ per sq m)	1,125.00	£4,725,000 *Building cost × Gross floor area*
External works	70,000	£70,000
Demolition	30,000	£30,000
Prof. fees etc. %	12	£579,000 *(Building + Externals + Demolition) × Prof. fees /100*
		Total construction cost = £5,404,000 *(Building + Externals + Demolition + Prof fees)*
Pre-constr'n period (yrs)	1.00	
Construction period (yrs)	1.83	
Interest rate % (p.a.)	7.50	
Land interest	£386,184	*Interest on total land cost over the entire development period compounded quarterly*
Construction interest	£380,910	*Interest on total construction cost assumed over half construction period compounded quarterly*
Charges, legal, etc. %	1	£70,520 *Percentage charge on total loan, i.e. Constr'n cost + Land cost*
		Total finance cost = £837,614
Marketing & agents' fees etc. %	20	£141,120 *One-off costs based on percentage of annual rental income*
		Total letting cost = £141,120
		Grand total cost = £8,030,734 *Land + Building + Finance + Letting*
Notional payback period		
		Period (years) = 11.38 *Grand total cost/Annual income*

6.8 Key points

- Due to our preference for money today rather than the same sum in the future, costs planning is governed by the time value of money concept.
- Discounting is the process of recognising this phenomena.
- Most standard methods of appraising and planning the costs of projects (particularly long-duration schemes) use discounting methods – such as the DCF techniques.
- The cost of borrowing money is quantified by the 'interest rate'.

Endnotes

1 *Ceteris paribus* is the classical economic term meaning 'other things being equal'.
2 The opportunity cost is the cost of something in terms of an opportunity forgone (and the benefits that could be received from that opportunity). As an example, consider a local authority (LA) that wishes to procure a new social housing scheme on some land owned by the LA. The opportunity cost is the value that is forgone in selecting this option. So, in procuring the new housing scheme, the local authority has forgone the opportunity to procure something else.
3 Compounding describes the situation where a sum of money (principal) is invested for a number of years and it is assumed that the interest earned each year is immediately added to the principal and re-invested on the same terms, this process being repeated annually.
4 Discounting is a technique used to compare costs and benefits that occur in different time periods. It is a separate concept from inflation, and is based on the principle that, generally, people prefer to receive goods and services now rather than later. This is known as 'time preference' (HM Treasury *Green Book*). Detailed consideration of discounting is covered in this chapter.
5 If a nominal discount rate is used, then future cash flows are escalated by a factor (known as the relative price of escalation). The future values are then said to be presented as prices expected to prevail at the time of the expenditure. For example, if one assumes a real discount rate of 3.5% and an annual inflation rate of 2.5%, then the nominal discount rate is 6.09%. If one assumes that future cash flows are going to escalate at the same price as inflation, then one uses a relative escalation rate of 2.5%. If one expects the cash flows to escalate faster than the inflation rate, then one uses a higher relative price of escalation (e.g. 5%).
6 From HM Treasury Green Book (2003) 'The first component, catastrophe risk (L), is the likelihood that there will be some event so devastating that all returns from policies, programmes or projects are eliminated, or at least radically and unpredictably altered. Examples are technological advancements that lead to premature obsolescence, or natural disasters, major wars and so on. The scale of this risk is, by its nature, hard to quantify. The second component, pure time preference (δ), reflects individuals' preference for consumption now, rather than later, with an unchanging level of consumption per capita over time. The evidence suggests that these two components indicate a value for of around 1.5 per cent a year for the near future'.
7 It is conventional to show the initial capital outlay in Year 0 in (parenthesis) or as a negative number.

Further reading

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Boussabaine, A.H. and Elhag, T.M.S. (1999) Applying fuzzy techniques to cash flow analysis. Construction Management and Economics, 17(6), 745–55.

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Lam, K.C., Hu, T., Ng, S.T., Yuen, R.K.K., Lo, S.M. and Wong, C.T.C. (2001) Using an adaptive genetic algorithm to improve construction finance decisions. Engineering, Construction and Architectural Management, 8(1), 31–45.

Solution to worked example 5.7

Year	**0**	**1**	**2**	**3**	**4**	**5**
Cash flow	(100)	30	30	30	50	10
Discount factor at 12%	1.000	0.893	0.797	0.712	0.636	0.567
Present value	(100)	26.79	23.91	21.36	31.80	5.67

Thus, NPV = £9530 and payback = 3.2 years (−100 + 30 + 30 + 30 + 10) so 3 years and 10/50 which is 0.2 of a year. Also can be given as 3 years and 2.4 months.

The preferred project on financial grounds is Project C as the NPV is the highest. This means it generates the required return of 12% plus £9530 more. Project B pays back most quickly, but would actually destroy value as the NPV is negative, i.e. it does not even give the required 12% return. So it would be financially better to invest the money in Project C as it gives the highest return, measured as NPV, of the three options. It has a slightly longer payback than Project B, but shorter than Project A.

Chapter 7

Whole Life Planning: The Methodology of Whole Life Cycle Costing and Design for Sustainability

7.1 Introduction

Whole life cycle costing (WLCC) is a methodology that involves the systematic analysis of the long-term cost implications of procurement decisions, whether for new capital projects or in the development of asset maintenance strategies for existing buildings. WLCC studies take into account not only the upfront capital costs of a project but also the costs that will accrue throughout the life of the building such as maintenance, energy and finance costs. In summary, WLCC is concerned with assessing the cost of an asset from 'cradle to grave'.

This chapter explores the concept from first principles and explains the methodology and application of appropriate mathematical and financial tools. The issues relating to risk and uncertainty will also be developed with some practical examples of WLCC modelling. The use of the formulae in Chapter 5 is demonstrated and we also consider the impact of government procurement regulations on WLCC decision-making. It is perhaps pertinent to begin this chapter with some disambiguation, since many believe that WLCC is basically the same as the more well-known life cycle costing (LCC) – recent research suggests this not to be the case.

7.2 History of WLCC

The underlying thinking behind the 'whole life' movement as an appraisal methodology has enjoyed a relative renaissance within the construction and civil engineering sectors over the past decade. Renaissance is possibly an apposite depiction, given that the fundamentals of WLCC within the United Kingdom are entrenched in the early 1970s 'terotechnology initiative' carried out by the then Department of Industry. This report became the focus of significant interest within both academe and industry. Major manufacturing companies assumed a lead role in the development of terotechnology processes with organisations such as Rolls Royce and Royal Ordinance being prominent. The 1990s witnessed the crystallisation of this work by defining LCC in British Standard BS 3843 (1992) as well as a raft of publications dealing with specific industry themes. While BS 3843 brought an element of standardisation to the process

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

in the United Kingdom, it did not act as the catalyst that many observers expected. Concurrently, the use of LCC techniques in the United States developed rapidly through the US Federal Energy and US Department of Defense procurement programmes. Current research and practice have led us to WLCC, the principal differentiation being the movement from a static methodology to a dynamic asset management tool. Notwithstanding, the construction industry perception of WLCC is that of a politically driven albatross hung around the necks of practitioners, or of a nebulous concept with little value to procurement decision-making.[1] Clearly, further work is required to challenge this common perception.

The catalysts behind WLCC decision-making are numerous but dissipative; the sustainable design movement has irrevocably entrenched the need for a 'whole life' or a holistic approach to evaluate the procurement of built assets. Within the United Kingdom, government policy has aligned itself with whole life thinking through a tranche of policy and legislative mechanisms issued by the Office for Government Commerce with the finer details of economic fiduciary covered by HM Treasury *Green Book*. The current situation within the construction sector is confusing and variable. Practitioners have argued that increased 'take-up' of WLCC methods was frustrated by the lack of standardisation (save for BS 3848 (1992)) and no common cost breakdown structure (CBS).

Since the publication of BS 3843 and ISO 15686-1, LCC has been the focus of significant research investigation, not just within the United Kingdom but internationally (particularly within the EU and the United States). The various problems that were associated with early LCC models such as complexity, uncertainty (due to the nature of forecasting) and data collection have been addressed in the new generation WLCC models (or otherwise known as whole life costing). We will look at these issues later in this chapter.

Today, publishing whole life cost (WLC) data has become a major part of the UK government's commitment to transparency in assessing value for money of major government projects leading up to the new BIM requirements in 2016. The Cabinet Office established the Major Projects Authority (MPA) in 2011 arming it with 'tough new powers to improve the performance of Government's major projects'. The annual report of the MPA includes published quarterly WLC data across all government departments (see Table 7.1).

7.3 Definitions and disambiguation

British Standard BS 3843 (1992) defines LCC as

> *The costs associated with acquiring, using, caring for and disposing of physical assets, including feasibility studies, research and development, design, production, maintenance, replacement and disposal; as well as all the support, training and operations costs generated by the acquisition, use, maintenance, and replacement of permanent physical assets*

In 2000, this definition was revised and incorporated into **ISO 156868 Part 1 – Service Life Planning (and revised in ISO 15686-1:2011)**, a standard that identifies and establishes general principles for service life planning and a systematic framework for undertaking service life planning of a planned building or construction work throughout its life cycle (or remaining life cycle for existing buildings or construction works).

> *The systematic economic consideration of all agreed significant costs and benefits associated with the acquisition and ownership of a constructed asset, which are anticipated over a period of analysis expressed in monetary value. The projected costs or benefits may include those external to the constructed asset and/or its owner (Note may include finance, business costs; income from land sale)*

Table 7.1 Departmental aggregated project whole life costs (£ million) for Q2 12/13 (with exemptions).

Department	Whole life costs (£m) for Q2 12/13 (with exemptions)
Ministry of Defence	88,147.34
Department for Work and Pensions	26,506.25
Department for Education	6699.00
Department for Transport	46,573.59
Department of Health	19,229.59
Home Office	6663.11
Department of Business, Innovation and Skills	13,200.68
Department for Energy and Climate Change	81,546.14
Her Majesty's Revenue and Customs	1221.30
Office for National Statistics	521.00
Ministry of Justice	7735.69
Department for Culture, Media and Sport	1464.70
Cabinet Office	1217.83
Department for Food, Environment and Rural Affairs	3968.75
Foreign and Commonwealth Office	347.93
Department for International Development	423.47
Department for Communities and Local Government	115.21
Her Majesty's Treasury	19.56
National Savings and Investment	–
Exemptions	48,135.91
Total	353,737.05

Source: Cabinet Office.

ISO 15686 defines the life cycle to include 'initiation, project definition, design, construction, commissioning, operation, maintenance, refurbishment, replacement, deconstruction and ultimate disposal, recycling or re-use of the asset (or parts thereof), including its components, systems and building services'. And defines LCC as

A technique that enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs

Boussabaine and Kirkham (2004) in their work on WLCC defined it as

… a dynamic and ongoing process, which enables the stochastic assessment of the performance of constructed facilities from feasibility to disposal. The WLCC assessment process takes into account the characteristics of the constructed facility, reusability, sustainability, maintainability and obsolescence as well as the capital, maintenance, operational, finance, residual and disposal costs. The result of this [risk based] assessment forms the basis for

a series of economic and non-economic performance indicators relating to the various stakeholders interests and objectives.

The key difference between LCC and WLCC being the notion that the latter is a management tool that is used throughout the building life rather than the static option appraisal tool that LCC is generally used for.[2]

This differentiation is made explicit in the most recent publication of ISO 15686-5 (2008):

'*whole-life cost (WLC) – all significant and relevant initial and future costs and benefits of an asset, throughout its life cycle, while fulfilling the performance requirements*

whole-life costing – [a] methodology for systematic economic consideration of all whole-life costs and benefits over a period of analysis, as defined in the agreed scope'

NOTE 1: The projected costs or benefits may include external costs (including, for example, finance, business costs, income from land sale, user costs).

NOTE 2: Whole-life costing can address a period of analysis that covers the entire life cycle or (a) selected stage(s) or periods of interest thereof.

NOTE 3: This definition should be contrasted with that for life-cycle costing.

So, while it is clear that the debate continues about the definition of the concept, the basic principles, which are described in this chapter, are undisputed. The key message being that best practice in cost planning now requires, where appropriate, a systematic consideration of the WLCs of the asset rather than simply the upfront capital costs.

A useful guide to the application of ISO 15686-5 can be found in PD 156865:2008:

Standardized method of life cycle costing for construction procurement. A supplement to BS ISO 15686-5. Buildings and constructed assets. Service life planning. Life cycle costing

7.4 Applications of WLCC: the public sector perspective

Within the UK public sector, WLCC should be taken into account in all business cases, which aim to justify capital investment in construction. This applies to projects financed by traditional public capital as well as through the private finance initiative (PFI) and public private partnership (PPP) procurement routes. The tangible effects of this change in procurement can be seen, for example, in the NHS ProCure 21 strategy. ProCure 21 promotes the better use of NHS assets and resources to achieve the right buildings and equipment, in the right place, in the right condition, of the right type, at the right cost (form both capital and whole life points of view), at the right time while facilitating effective response to future needs of the service with minimal impact on the environment. The Procure 21 programme incorporates WLCC models in the tendering process for its frameworks and requires specific models to be completed for each NHS scheme subsequently undertaken by the framework contractors in England. These models have helped the NHS to make significant steps forward in attaining better value for money in capital procurement.

The **Office for Government and Commerce** (OGC) had developed an established suite of guidance notes and tools, encompassing project management and sustainability, through the Achieving Excellence in Construction Successful Delivery Toolkit. The Achieving Excellence in Construction programme was launched in March 1999 to improve the performance of central government departments, their executive agencies and non-departmental public bodies (NDPBs) as clients of the construction industry. The strategy promoted a sustained improvement in construction procurement performance and in the value for money achieved by the UK government on construction projects, including those involving maintenance and refurbishment.

The Achieving Excellence initiative set out a route map with challenging targets for government performance under four headings – management, measurement, standardisation and integration. Targets included the use of **partnering** and development of long-term relationships, the reduction of financial and decision-making approval chains, improved skills development and empowerment, the adoption of performance measurement indicators and the use of tools such as value and **risk management and whole life costing**.

A central theme of Achieving Excellence is the delivery of construction products under best value for money conditions. This is not the lowest capital cost but the best balance of quality and WLC to meet the client's brief. Following the election of the new coalition government in 2010, the OGC was subsumed into the Cabinet Office and most published material on the programme can be accessed through the National Archives.

The National Procurement Strategy (NPS) sets out how local authorities can improve the delivery and cost-effectiveness of high-quality services through more effective, prudent and innovative procurement practices. The strategy illustrates the scope for potential cost savings through more efficient procurement procedures and partnership working and this is reinforced in p. 50 of the report, which examines ways to '**achieve community benefits through procurement**'.

> **Adopt whole life costs and benefits as your contract award criteria**. Procurement strategies and contract standing orders should establish "the optimum combination of whole life costs and benefits to meet the customer's requirement" as the best value contract award criteria.

The summary checklist at the back of the report also reminds local authorities of the need to ensure that whole life cycle costs have been taken into account during the various stages of the procurement process.

The Carbon Trust (CT) and the **Energy Saving Trust (EST)** have strongly advocated the use of WLCC methodologies to support a more sustainable environment, particularly in the construction sector. In January 2004, the EST published a report on the costs and benefits of community heating, which outlines the ideas and advantages behind the scheme. The guide also details the use of **WLCC with a live example of how community heating compares to other forms of heating**. The Perthshire Housing Association secured planning permission for a town-centre site to be redeveloped into a four-storey single block containing 32 units. With a grant of £2070 from the Community Energy programme helped to finance production of a brief and report into the suitability and scope of a gas-fired community heating system. The development work undertaken indicated that community heating delivered the lowest WLCC option for the Association. A subsequent application for a Community Energy capital grant was successful.

While the virtues of WLCC are now well versed, the implementation of thorough WLCC methodologies is still complex. This was recognised in a recent Low Carbon Buildings Event organised by the Government Office for London[3] and DEFRA, which examined some fundamental issues with WLCC including the following.

- What are the main barriers to making more public procurement consider whole life costing principles? What action does the Government need to take to ensure public funds are spent on developing high-quality sustainable buildings?

- What is the potential for improvements in the carbon management of public sector buildings at local and regional levels? How can improvements best be ensured? What is the role for WLCC?

The key to success lies in **clear briefing** and involvement with all stakeholders from the outset.

7.5 WLCC beyond construction

Outside of construction procurement, WLCC has been applied successfully in the procurement of assets within the University sector under the Joint Procurement Policy and Strategy Group (now known as Proc-HE), where a basic spreadsheet model has been developed to help universities appraise the procurement of large assets such as laboratory equipment. The procurement of defence systems and equipment within the Ministry of Defence feature the use of WLCC methods, particularly within the Acquisition Management System (AMS). Interestingly, 'CarCost' is a motor industry WLC programme which allows consumers to compare the relative costs of car ownership; this has been exploited by Skoda, UK, who use a basic WLCC model on their consumer website to demonstrate the costs of various models against comparables. This final example is often used as the classic metaphor for engendering WLCC thinking; many purchases we make in everyday life are intuitively based on the concept – when we buy a car, for example, we do not think just about the capital costs but also fuel consumption, maintenance and servicing costs, road tax, insurance and so on.

7.6 Private sector procurement

It is argued that developers and other speculative investors who account for a significant proportion of the construction industry output are not so readily accepting of the WLCC concept. The reasons given for this are based on the speculative investors' time horizon and profit maximisation. This is the standard neoclassical assumption that investors will seek to maximise profits by producing and then selling an output in the open market. In public sector procurement, this is often not the case as there are socio-economic, welfare and other intangibles that are seen as derivatives from the investment, that is, new hospital creates better health care, new prison reduces offending and so on. The difficulty lies then in convincing investors that the return on investment should be significantly increased by procuring buildings that are based on optimised WLCC – this element of future-proofing the building as it were adding value.

Of course, some larger private sector clients will require evidence of WLCC at the early stages of a project and will formally request it as part of a package of support options provided by the cost planner. Usually, risk and value management strategies take into account WLCC as part of a comprehensive cost planning service, particularly on multi-million pound schemes such as PPP/PFI.

7.7 Theory and methodology

It is important to understand that the fundamental theory underlying WLCC is not new, nor the mathematical constructs used to calculate costs, cash flow and other financial measures (these techniques have been described in Chapter 5). Nevertheless, the key to successful application of WLCC lies in four areas:

- Appropriateness of the methodology
- Quality of cost and performance data used
- Appropriate treatment of risk and uncertainty
- Involvement of the project stakeholders

These caveats are important since purposeful WLCC cannot be achieved through the exclusive use of an 'off-the-shelf' piece of software. Although in practice software does exist, it negates the importance of stakeholder involvement – this is essential in ensuring that the models generate accurate results and decision information that is informative and suitable. This 'briefing' stage of WLCC can, depending upon the complexity of the work, take anywhere between 1 day and 12 months to achieve. It is worth dedicating suitable resources at this point, since it reduces the possibility of re-working and model redesign later in the process.

Ferry and Brandon's '3 phases of cost planning' strategy that is described in Chapter 3 of this book, gives a useful guide to understanding the process of effective WLCC planning. In Figure 7.1, the WLCC methodology is characterised by the three phases of design detail, each level representing a decision stage (Kirkham 2004):

- Strategic (concept) level (i.e. structure, envelope, services)
- System level (i.e. steel, concrete, timer frame)
- Detailed level (i.e. concrete pre-cast or in situ, RC grade)

The strategic-level stage involves WLCC modelling in the broadest sense, looking at the building design in its entirety, and not details of specific focus. This appraisal should be used initially to assess the substantially differing design solutions that are presented to the client at the briefing stage. It is at this juncture that the design team can begin to focus the client on WLCC, helping to deliver a cost-effective solution.

The results from this analysis, and any subsequent data extrapolation, forms the basis to Stage 2, where a more detailed system level analysis can be performed on the solution(s) identified in Stage 1. Here, WLCC methods can again be used to assess the economic viability of various systems within the design such as the WLCC comparison of steel and concrete and timber frames.

The data elicited from this stage should again provide the design team with the key information necessary to develop the design to Stage 3 where component-specific WLCC analyses can be performed. At this stage, it is rare that WLCC methods are used on all design selections. A technique known as **cost significance**[4] (Saket 1986, Munns and Al-Haimus 2000) is proposed by some (in the context of traditional estimating and bills of quantity preparation), which allows the planner to identify the cost items which contribute significantly to the overall cost (this can naturally be extended to WLCC), this reduces the methodological effort by focusing on the major cost items and not, for example, on smaller insignificant items such as doors and ironmongery.

This principle is quite similar to that of **sensitivity analysis**.[5] Usually, a sensitivity analyses will be performed in Stage 2 to identify the most uncertain costs. This then allows the design team/analyst to focus on the detailed level of WLCC analyses on the cost-sensitive items. The complexity of the WLCC modelling required at Stage 3 depends to a significant extent upon the availability of cost and performance data, as well as the uncertainty attached to any assumptions.

Pareto's 80/20 law can often be applied to WLCC models in order to determine the focus. The law states that 20% of cost items are responsible for 80% of the total cost – and this focusing on those items which do not contribute significantly to cost is to be avoided.

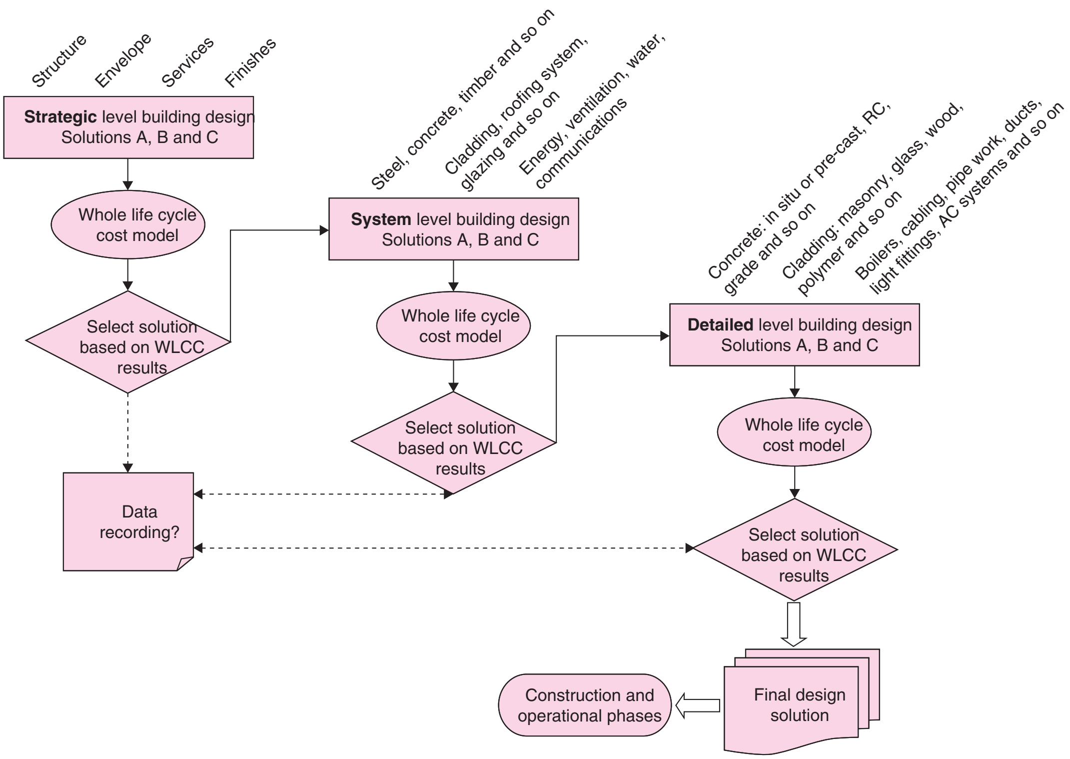

Figure 7.1 The three-phase whole life cycle cost modelling approach.

7.7.1 Calculations and numerical methods

There are a variety of numerical approaches to the evaluation of WLCC, but the underlying theory is similar in most cases. In the most simplistic format, WLCC is given by the following formula:

$$\text{WLCC} = C_c + O_c + R_c \tag{7.1}$$

where C_c is the capital cost, O_c is the operational cost and R_c is the residual cost.

The cost centres identified in Figure 7.2 can be easily grouped into the three categories described in equation (7.1), although this basic equation can tend to mask the complexity of the process overall. In complex models, the number of cost centres can be significantly high and it will be at the discretion of the cost planner to determine what should and what should not be included within each cost centre. ISO 15686-5 is attempting to standardise this although good WLCC models must be flexible enough to cope with a wide range of building types and structures. It is also worth remembering that this equation is constrained by the 'time value of money' and as such, future operational and residual costs will have to be discounted to today's value. In order to demonstrate a very basic WLCC model, we shall examine the costs of a cladding system.

Example

It is desired to compare the WLCs of two types of cladding to a factory building, whose life is intended to be 40 years. The rate of interest allowed is 3% per annum compound.

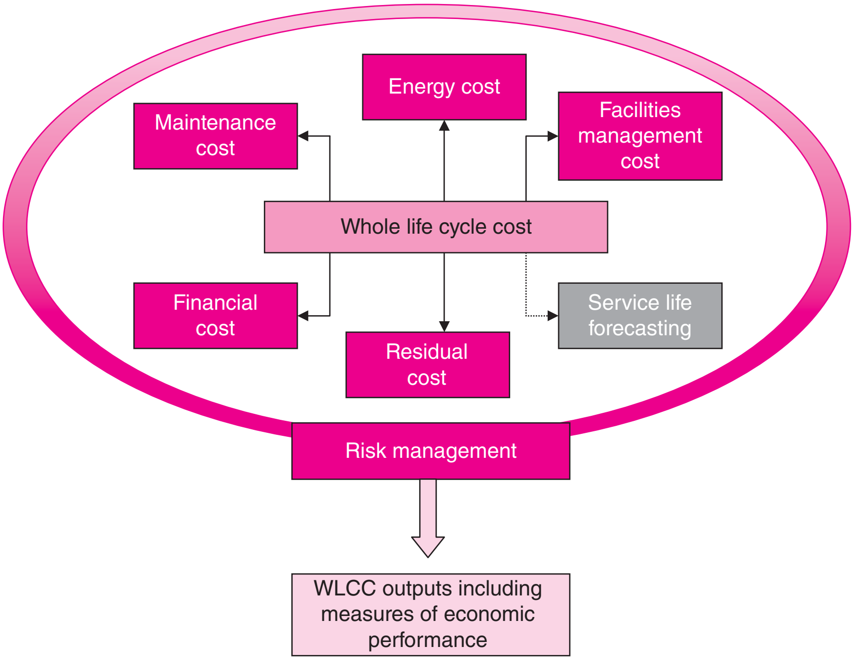

Figure 7.2 Components of a whole life cycle cost analysis (Boussabaine and Kirkham 2004) (reproduced with permission from Blackwell Publishing).

Whole life cycle costs of Cladding A

Cladding A will cost £1,000,000, will require redecorating every 4 years at a cost of £120,000 and will require renewing after 20 years at a cost of £1,400,000.

Capital cost			£1,000,000
Present value at 3% of:			
Redecoration after	4 years £120,000	at 88.8p =	£106,560
Redecoration after	8 years £120,000	at 78.9p =	£94,680
Redecoration after	12 years £120,000	at 70.1p =	£84,120
Redecoration after	16 years £120,000	at 62.3p =	£74,760
Renewal after	20 years £1,400,000	at 55.4p =	£775,600
Redecoration after	24 years £120,000	at 49.2p =	£59,040
Redecoration after	28 years £120,000	at 43.7p =	£52,440
Redecoration after	32 years £120,000	at 38.8p =	£46,560
Redecoration after	36 years £120,000	at 34.5p =	£2,941,400
			£2,335,160

Whole life costs of Cladding B

The alternative Cladding B will cost £1,800,000 and will last the life of the building without any maintenance, although a sum of £300,000 is to be allowed for general repairs after 20 years.

Capital cost			£1,800,000
Present value at 3% of:			
Repairs after	20 years £300,000	at 55.4p =	£1,166,200
			£1,966,200

Saving by using Cladding B is, therefore, £2,335,160 minus £1,966,200 = £368,960. It would therefore appear to be justifiable to use the initially more expensive Cladding B, as this will prove much the cheaper in the long run. Note that the 'present value' method of discounting has been used.

This principle can be applied to as many components as is required, although it can easily be appreciated how complex the model would be for an entire building.

7.7.2 The effect of assumptions

In order to demonstrate the effect of quite small misjudgements of the future, the example relating to Claddings A and B is now re-calculated, assuming some slight differences to the assumptions previously made. All these differences lie well within the range of error to be expected with careful estimates and exclude either inflation or any other significant anomaly.

Revised example

The rate of interest allowed is 4%, per annum compound, with an increase in 1%.

Revised WLCs of Cladding A assume that Cladding A is redecorated every 5 years instead of every 4 years, at a cost of œ100,000 and lasts for 25 years instead of 20, costing œ1,200,000 to renew.

Capital cost			£1,000,000
Present value at 4% of:			
Redecoration after	5 years £100,000	at 82.2p =	£82,200
Redecoration after	10 years £100,000	at 67.6p =	£67,600
Redecoration after	15 years £100,000	at 55.5p =	£55,500
Redecoration after	20 years £100,000	at 45.6p =	£45,600
Renewal after	25 years £1,200,000	at 37.5p =	£450,000
Redecoration after	30 years £100,000	at 30.8p =	£30,800
Redecoration after	35 years £100,000	at 25.3p =	£1,025,300
			£1,757,000

Revised WLCs of Cladding B assume that Cladding B has to be repaired after 15 years and again at 30 years, instead of only once at 20 years.

Capital cost			£1,800,000
Present value at 4% of:			
Repairs after	15 years £300,000	at 55.5p =	£166,500
Repairs after	30 years £150,000	at 30.8p =	£2,961,600
			£2,028,000

Saving by using Cladding A is, therefore, £2,028,100 minus £1,757,000 = £271,100.

This calculation gives a completely different result to the original – the initially cheaper cladding proves to be much cheaper in the long run also. It would still have some remaining life at the end of 40 years if it were decided to keep the building in commission for a longer period of time.

These simple examples demonstrate the use of WLCC techniques at the sub-element level. Typically, however, due to the magnitude that WLCC models would take if they were to assume every single element in the building – a more generalist model is used, often based on the element level BCIS SFCA structure. WLCC is determined by the NPV method in this case (i.e. the sum of all PV over the study period).

7.7.3 Uncertainty quantification in WLCC

Like almost any other type of future forecasting, WLCC has always been exposed to the criticism that decisions based upon the method are not reliable. This assessment manifests throughout earlier research (Bird 1987), and this was certainly the case in the earliest applications of the technique, particularly terotechnology, cost in use and finally LCC. The response to this has been clear and the latest generation of WLCC research demonstrates a clear metamorphosis from deterministic to probabilistic (stochastic) approaches. The benefits of a stochastic approach to WLCC lie in the treatment of uncertain parameters within the model. Where before, LCC models relied upon deterministic 'point estimates' of future costs, stochastic techniques allow the analyst to model likely uncertain cost as probability distributions. The plethora of distributions available and the techniques used to construct them allow the analyst to represent the uncertainty of the variable, and, perhaps more importantly, quantify it. A recent EPSRC project in the United Kingdom – managing risk across the whole life of a facility: a design perspective (GR/N34024/01) investigated the development a web-based risk simulation tool that can interact with whole life and risk data, with the intention of enabling designers to minimise the cost of uncertainty and achieve designs for optimum WLC and performance. One of the principle ideas behind the project was to develop a framework for effective data collection within a probabilistic environment, which could then interface directly into a WLCC model. Furthermore, the project investigated the interface between the tool and the designer to achieve a high level of acceptability. It is anticipated that the final WLCC model will assist in educating the design team of the need to manage risk more systematically across the whole life of a project.

7.7.4 Service life and performance modelling

While a strong focus upon uncertainty quantification has characterised WLCC research recently, the necessity for integrated building and building component service life prediction has been largely ignored. This is significant given the impact of ISO 15686, which focuses upon the need for standardised service life prediction models. The requirement for service life predictions technologies lays predominately in the estimation of maintenance and life cycle replacement times. It is here that service life models can provide information, either stochastically or deterministically, such as deterioration and failure of components. The importance of service life assessment, coupled with the emphasis upon whole life cycle costs during the operational life, is driving the promotion of international standards in service life prediction.

7.8 Disadvantages of whole life costs assessment

We have talked about the benefits of WLCC within cost planning – indeed the advantages of the technique for comparing costs are self-evident; it enables us to consider the long-term implications of a decision and to provide a way of showing the cost consequences of short-sighted economies.

Unfortunately there are a number of fundamental disadvantages, which explain why this technique for comparing the cost of alternative materials and constructions has been seen more often in textbooks and in the university examination room than in real life. These disadvantages may be expressed through three lines of argument.

- that initial and running costs cannot be equated;
- that the future cannot be forecast;
- that the process is heavily dependent on data and it overtly complex.

7.8.1 Initial and running costs cannot really be equated

This is because on profit developments:

- Where the building is to be sold the maintenance charges will fall upon the purchaser, and so are of little importance to the developer, who is responsible for the construction costs alone.
- Where the building is to be let, or used commercially, the repair and maintenance costs are deducted from the receipts in calculating profit for the year, and are therefore paid out of income before taxation. However, money spent at construction stage has to be raised as part of the capital cost and is eventually repayable. Repayment of, or interest on, capital expenditure is not normally deductible from receipts for the purposes of tax calculations.

In addition, on social developments:

- Even with publicly owned buildings, it is an advantage to pay maintenance out of running costs instead of incurring a heavier capital debt due to high construction costs.

- In some instances, such as schools, the bulk of the construction costs may be paid by one authority while another authority will be responsible for running costs, so that there will be little incentive to provide an unduly high standard of building with a view to subsequent saving.

On all developments:

- Money for capital development is normally more difficult to find and is subject to more constraints than money for current expenditure.
- Although a building may still be perfectly sound halfway through its planned life, it may be too old-fashioned in design and accommodation to do the job that is required of it in modern conditions.
- The same applies to expensive but durable finishes and fittings, which although still in good condition may give a very old-fashioned appearance to a building. Old joinery, shopfronts, tiling and other finishes or fittings may be ripped out long before they are life-expired, especially in the competitive world of commerce.
- In comparing figures of increased capital expenditure against future costs of repair and renewal, it must be remembered that once the money has actually been spent it is not possible to amend the decision in the light of future developments.
- As a domestic example of this, if very expensive finishes are chosen for a house to save repainting, and after a few years the owner becomes short of money, the annual interest on the expensive house still has to be met, whereas if the owner had opted for a cheaper house the redecorating could have been deferred for a year or 2. (The house could also be redecorated in the latest fashion each time, if the owner so wished.) It is questionable practice to restrict the actions of future generations by committing them to high interest and repayment costs; this is just as bad as the other extreme of committing them to inflated running costs and maintenance costs by unduly low standards of design and construction.

7.8.2 The future cannot really be forecast

- While present-day capital costs can be estimated quite accurately, the cost of maintenance and other operational costs are not quite so straightforward.
- The amount of money spent on planned preventative maintenance of a building is determined far more by the current policy of the body responsible for the maintenance than by any quality inherent in the materials. Some owners will redecorate every few years, mend or replace worn or damaged work immediately and continuously carry out a policy of minor improvements; others will spend the very minimum necessary to keep the building in operation.
- Major expenditure on repairs is usually caused by unforeseen failure of detailing, faulty material or bad workmanship, rather than by predicted overall ageing, and so is almost impossible to forecast. A well-designed and maintained piece of cheap construction might last much longer than its theoretical life, while some quite expensive work could require early renewal because of, say, entry of water at a badly designed joint.
- Interest rates, which in general tend to reflect the current minimum lending rate (MLR), cannot be forecast with any certainty, particularly over long periods of 20 years or more; remember that net interest rates are also affected by changes in taxation. Between 1988 and 1990, the MLR, although forecast by the Treasury to remain static or fall, actually increased from 8% to 15%. And that was during a period of only 2 to 3 years – would you like to guess what the Bank of England (or the European Bank) will do in the year 2025?

- During the last 40 years, there has been almost continuous economic inflation and any building or maintenance work is likely to cost several times what would have been estimated, say, 20 years ago.

7.8.3 The process is heavily dependent on data and it overtly complex

- Clearly the WLCC is most effective when good quality data are available.
- However, there are mathematical approaches that can be taken to evaluate the assumptions where no hard data exist.
- The use of probability distributions is appropriate here. For example, the BMI publishes service life data in the form of minimum, maximum and most likely values based on surveyor's experiences. It is quite straightforward to translate this information to a triangular distribution.
- The complexity of the model should be managed by the analyst. The cost significance techniques that have been discussed are appropriate for this.

7.9 Software tools for whole life cycle costing

The momentum created by the WLCC paradigm has lead to the emergence of various software solutions from the universities and professional practices. This penultimate part of the chapter will explore several systems but it is important to remain mindful of the fact that good WLC is based not simply on software but also close engagement with the client during the briefing stage – it is at this point where decisions that have a major impact on WLCC are made.

7.9.1 WLC comparator

Developed by the former Building Research Establishment (BRE) – WLC comparator is a simple tool that has been designed to calculate the whole life cycle costs of building components and elements. It provides a platform to assess the basic criteria for capital investments in an effort to ensure a reduction of future operating costs. The analytical approach enables WLCC to be performed at building component and element level. The model captures the economic analysis needed to improve capital investment decision, optimise asset selection or design and predict the best combination of interdependent systems. The model adopts HM Treasury complaint standard and accepted accountancy rules for predicting the present value of future income streams and supports ISO 15686. The tool is also recommended in OGC Achieving Excellence in Procurement Guide No. 7 – Whole Life Costing.

7.9.2 Eurolifeform

Eurolifeform (European Life Performance) – 'Probabilistic approach to life cycle costs and performance of buildings and civil infrastructure' was a research project undertaken with the financial support of the European Commission and Taylor Woodrow Construction under the EC 5th Framework Competitive and Sustainable Growth Programme (G1RD-CT-2001-00497), concluding in 2004. This work focused on service life prediction within the WLCC model and while recognising that existing models now provided the ability to quantify the risk in WLCC forecasts, other factors such as component deterioration were widely ignored. The model also responds to the problem that many WLCC approaches are used retrospectively and not as part of an iterative design process.

The Eurolifeform approach is innovative in that it utilises a stochastic whole life cycle cost (WLCC) model in conjunction with a series of deterioration analysis algorithms and a decision support application to assist in optimising the WLCC design process.

The integrated model enables the analyst to calculate WLCC results probabilistically based upon the forecasted effects of component deterioration on the maintenance and replacement intervention times. The decision support element facilitates the iterative application of the model throughout the entire design process, thus providing a repository of design decision-making information, which can be used on a micro level to optimise the WLCC design and also on a macro level to inform decisions in other similar projects.

7.9.3 WLC input tool: Glasgow Caledonian University

This research project was commissioned by the Society of Construction Quantity Surveyors (SCQS) in the mid-2004 and to date has involved the development of a framework document and WLC input tool which has been tested by local government.

Developed at Glasgow Caledonian University, the project developed a framework document and input tool for use in local government procurement to enable quantity surveyors (QSs) and others with enough knowledge to produce a WLCC analysis with the minimum of effort. The resulting model, based on MS Excel, is a user-friendly approach using a generic software input tool accompanied by a framework document designed specially to assist in the analyses.

7.9.4 4D cost model: Bucknall Austin

Bucknall Austin Cost Consultants have developed a '4 Dimensional Cost Model' which is advocated as a 'fully dynamic' WLC model where all variables within the model can be related and the impact upon each other quantified. The information is stored in a format that allows similar projects or options to be analysed using the same template of logic and pricing. There are approximately 400 variables within the model that can be changed using different scenarios. The 4DCM can also calculate capital allowances, CO_2 energy and water consumption in addition to the through life costs and a detailed through life cost breakdown is available at the inception of a project. This supports design decisions at a very early stage with essential sustainability measures in mind. Evidence from the company suggests that early collaboration during the inception and feasibility stages of a project were vindicated with the Royal Ordnance Defence division of BAE systems. The organisations saved an estimated £5 million over 25 years on a single new-build project.

7.9.5 CATO whole life cost

Part of the suite of the well-known cost planning tools, CATO WLC is a product of Causeway and is widely used by major QS and cost consultancies. The vendors claim that the software is is embedded with the capabilities to associate life cycle costs with facilities management items which is an important aspect of the BIM 'way of working'.

7.10 Key points

- WLCC is a method of appraising the long-term cost implications of design decisions.
- It considers not only capital costs but also maintenance, operation and energy costs.

- In order for the process to be most effective, it requires a significant element of client involvement at early stage, this should be facilitated through the briefing process.
- It involves forecasting sums of money into the future and is thus governed by the time value of money concept.
- In certain procurement arrangements, WLCC must be carried out as part of the cost planning process.

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Endnotes

1 Hunter, K. and Kelly, J. (2005) The development of a whole life costing tool for local government, Proceedings of the RICS COBRA Conference, QUT Brisbane, ISBN 1-74107-101-1.

2 It should be noted that on an international basis, representatives from some countries do not accept the concept of WLCC and consider the current generation of methodologies to be a natural extension of LCC. This is reflected in the current version of ISO 15686-5 that is titled 'life cycle costing'.

3 Low Carbon Buildings Event: A Climate Change Programme Review Consultation Event, London 2005 http://www.defra.gov.uk/environment/climatechange/ccprog-review/pdf/lowcarb-summary.pdf.

4 In Saket and Munns and Al-Haimus 'cost-significant models' are suggested as one way of overcoming the highly detailed and time-consuming approach to preparing such things as a traditional bill of quantities. The work of these authors presents a methodology for selecting work packages and recommends a refinement to the technique that reduces the variability in estimates produced using cost significance. Estimates are produced using both the traditional method of producing cost-significant models and a refined global cost methodology. Both techniques are tested against unpriced bills to measure the difference in results, with significant improvements being achieved with the new technique.

5 Sensitivity analysis determines how responsive the results of a model are to changes in the inputs and assumptions. It can be used to assess how robust the model is in dealing with uncertainties or assumptions about such things as cost and performance.

Chapter 8

Construction Procurement and the Relationship with Project Costs

8.1 Introduction

In the construction industry, **procurement** is the term used to describe the processes and procedures involved in the acquisition of an asset (building). Typically, the methods of contractual and organisational working are referred to as **procurement systems** or **procurement strategies**. Thus, procurement generally refers to the processes involved in designing, constructing and commissioning a new building. The concept of procurement is not unique to the built environment arena; procurement can be used to describe the purchase of anything from a small family car right through to a multi-million pound nuclear defence system. In the United Kingdom, the government has long-established agencies that deal specifically with procurement issues including **The Ministry of Defence's (MOD's) Defence Equipment and Support (DE&S)** organisation and the former **Office for Government Commerce (OGC) which more recently was subsumed into the Cabinet Office**. The latter agency has been instrumental in revolutionising public sector construction procurement in the United Kingdom through the '**Achieving Excellence in Construction**' programme. Procurement itself has become a discipline area (or indeed profession) in its own right – this is exemplified in the increasing number of 'procurement managers' who are employed specifically to govern and provide advice on purchasing protocols. In the built environment, it is rare to encounter a 'procurement manager'; usually this role is performed by various actors within the project such as clients, project managers, specialist consultants and so on. However, in some of the more modern procurement systems, there is implicit evidence that such a role exists.

Procurement generally does not necessarily deal with the purchase of tangible 'hard' items such as buildings, but it can deal with 'soft' services such as social and health care. Good procurement should always try to encompass the different types of 'clients' in what are often complex organisations. For example, the procurement of a new school must take into account the requirements of the policy makers in the Department of Education, the procurement managers, the Local Education Authority and, of course, the end-users themselves, that is the teachers and pupils. During this process, it is additionally important to ensure that the project demonstrates value for money throughout the project life cycle. The emphasis from the public sector to review and enhance construction procurement has emerged through the more informed view that buildings should now been valued not in isolation, but as a means of delivering wider social benefits, which is emphasised in Chapter 1. In summary, procurement

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

has been a key driver in the significant changes that have characterised the UK construction industry since the mid-1990s.

In this chapter, we shall explore the various methods of construction procurement that are currently in use and describe the appropriateness of each approach to the project environment. The 2011 edition of the JCT (Joints Contract Tribunal, see Section 8.3) guide to contract selection identifies three main systems: **traditional/conventional, design and build** and **integrated team/partnering**. The aim here is to give a contextual overview of procurement, rather than to explain each approach in detail. The further reading list suggests some appropriate texts to support the concepts described here.

8.2 The traditional procurement system and cost planning

Historically, the growth of the Quantity Surveying profession is inextricably linked with the **traditional procurement** system, which has at its heart the bill of quantities (BQ) (Birnie and Yates 1996). This approach to procurement is perhaps the most well known and still continues to command a significant share of all construction project work. The discipline of cost planning as a process is derived from the primary skills of measurement and cost analysis, which perhaps underpin the traditional approach. However, changes to procurement have been significant, particularly since the last edition of this text and as such, the move away from the traditional BQ-centred procurement system has gained momentum. The next 10 years may well continue to witness rapid change and we shall consider the impact of this for cost planning shortly.

In the traditional system, the contractor agrees to build to the designers' drawings and specifications, and as the designers themselves do not have a direct link with the specialists, all communication is therefore via the main contractor who does not have a contractual design liability. This can result in a 'grey area' of responsibility and liability, as information is passed from one to the other. In general, the designer (more often than not the architect) is the leader of the project and represents the client to implement the design process. The architect thus acts in *locum tenens*, as a sort of surrogate client and takes the overall responsibility to ensure the project is delivered on time and on budget. In the traditional system, the client appoints these independent consultants who produce detailed designs and issue tender documentation. The documentation is used to invite competitive bids from tendering contractors – often on lump sum basis (we shall consider lump sums later in this chapter). The successful contractor enters into a direct contract with the client and carries out the work under the supervision of the design team. Using a BQ, every aspect of the work is quantified to determine the contract price, so far as is possible. It is possible to deal with uncertainty over the quality or nature of some work; a contractor can thus price the work without a full BQ; approximate quantities, schedule of rates, activity schedules, target cost contracts and cost plus/prime cost contracts are common examples of alternative methods of pricing. The traditional approach to procurement remains popular due to the fact that most clients and contractors have experience of it. Price certainty (subject to the design been fully prepared at tender stage) is also a key benefit and gives the client a greater control of the design (through management of the design team). Acceleration is also possible with the traditional method, design and construction can run in parallel using **two-stage tendering** or may be by negotiation on partial or notional information.

Another advantage is that of having an independent professional in the role of the contract administrator monitoring the project. However, the divorce between the construction and design stages has been recognised as a potentially significant deficiency. In many other manufacturing situations (such as car production), this divorce does not exist – this can lead to disputes over variations and design changes.

Then in summary, traditional procurement is characterised by

- Separation of the design and construction functions
- Consultants are appointed for design and cost control
- Contractor is appointed to construct the works:
  - responsible for workmanship, materials, subcontractors and suppliers
  - usually no design responsibilities
  - usually appointed through competitive tendering, supposedly based on complete design information
- Contractor relies heavily on design team for information; possibility of claims if delay or disruption occurs
- By using consultants, client retains full control over design
- Client obtains considerable certainty about cost before commitment to contract/work begins
- Employer, or designers, can select specialist firms to be used – contractors require certain safeguards. Care must be taken here though, since the issue of the JCT 2005 suite of contracts, the procedures for **nominating sub-contractors** by the client team have been omitted from the Standard Building Contract (SBC). However, the procedures for the Architect or Contract Administrator to '**name**' an approved sub-contractor under the Intermediate Contract (IC) still exist.

8.3 Standard forms of building contract

Until the passing of the Housing Grants, Construction and Regeneration Act (1996), building contracts and sub-contracts were governed only by the general law of contract. Early in the twentieth century, the Royal Institute of British Architects (RIBA) had published a model form of building contract, which gained wide acceptance. Building contractors, however, felt that a contract drafted unilaterally by an organisation, however well meaning, which represented only one side of the industry was inherently unfair. An organisation called the **Joint Contracts Tribunal** (JCT)was set up to include contractors' representatives. The JCT took over administration and revision of the RIBA Form, and was gradually expanded to include representatives of all the bodies involved in procuring a building including sub-contractors and clients. It now publishes a whole range of forms to suit almost every conceivable kind of contract. The JCT forms do not have any kind of statutory authority, and there has never been anything to prevent clients or contractors from either using their own forms or altering the wording of the JCT forms to suit themselves. Although in theory a contract is mutually agreed between its parties, in practice a building contract or sub-contract is usually presented by one party to the other on a pre-printed 'take-it-or-leave-it' basis. This led to the imposition of unfair terms where either the client or the contractor was in a dominant commercial position, or had much greater experience than the other party.

The latest JCT 2011 suite of contractual documents[1] consists of 'contract families' made up of main contracts and sub-contracts, together with other documents that can be used across certain contract families. The suite is thus made up of the following:

- Minor Works Building Contract (with and without contractors design)
- Intermediate Building Contract (with and without contractors design)
- Standard Building Contract (SBC)
  - The SBC is made up of SBC/AQ (Standard Building Contract with Approximate Quantities), SBC/Q (Standard Building Contract with Quantities) and SBC/XQ (Standard Building Contract without Quantities)

- Design and Build Contract
- Major Project Construction Contract
- Construction Management Contract
- Management Building Contract
- JCT-CE Contract
- Measured Term Contract
- Prime Cost Building Contract
- Repair and Maintenance Contract
- JCT 2011 Complete Works
- JCT Tracked Change
- Home Owner Contracts

8.4 Basic forms of building contract in the traditional method of procurement

Although there are many different forms of contract (including all the JCT variations shown above), these fall broadly into three different types:

8.4.1 Measurement contracts

The contract sum is not finalised until after completion, but is assessed on re-measurement to a previously agreed basis. This method is used when the contractor undertakes work which cannot be measured accurately prior to tender. The design is usually complete and the time/quality parameters are specified. Probably the contract of this type with least risk to the client is based on drawings and approximate quantities. Measurement contracts can also be based on drawings and a schedule of rates or prices. A variant of this is the measured term contract under which individual works can be initiated by instructions as part of a programme of work, and priced according to rates related to the categories of work likely to form part of the programme (JCT 2011).

8.4.2 Cost reimbursement

These are often referred to as a 'cost-plus percentage/fixed fee' or a 'prime cost' contracts, and these are used where the contracting firm agrees that all its expenditure on labour, materials and so on will be met by the client, on top of which it will charge a fee on an agreed basis (e.g. a decorator will repaint the living room for the cost of the paint plus £10 per hour his/her time).

8.4.3 Lump sum or 'price in advance'

The contracting firm agrees to carry out its obligations for a sum of money agreed in advance (e.g. a decorator will repaint the living room for £200). Lump sum contracts with quantities are always priced on the basis of drawings and a full BQ. There are also contracts without quantities and these are priced on the basis of drawings and specifications rather than a BQ.

While these three types of contracts are illustrated with simple examples, the latter two are rarely used in their pure form on large projects for two main reasons. Firstly, the lump sum or 'price in advance' contract involves a great risk to the contractor (the building may need deeper foundations than was originally anticipated, or price inflation may substantially exaggerate labour and material prices). The cost reimbursement contract encourages waste and extravagant working by the contracting firm, which has not got to pay for anything that it uses. In fact, in the most primitive form of cost reimbursement contract where the profit is a percentage of the cost, the contractor has a positive incentive to waste as much money as possible. From the point of view of cost planning, however, there is rather an interesting paradox: the price in advance contract gives the client almost no control over the details of methods, programming or expenditure, but gives an excellent forecast of the total cost. The cost reimbursement contract, on the other hand, allows the client to give orders about the acceleration or methods of work, and to obtain detailed allocations of actual site costs, but the total cost can never be forecast with the same degree of certainty to which the former provides.

8.5 JCT contracts in detail for traditional procurement

We can now look at the various contractual methods of building, trying as far as possible to match them against the client's time and cost criteria, which were set out in Chapter 4. While this may suggest the best approach to the individual problem it must be remembered that no form of contract is proof against things going wrong, and a keen combination of design team and building team will make a good job of things whatever be the contractual arrangements. However, all other things being equal, a suitable form of contract will help. The reader is strongly urged to refer to the JCT 'Deciding on the appropriate JCT contract' document (see Further Reading), which provides a succinct and ideal reference to contract selection.

8.5.1 Measurement contracts

JCT recommend the use of measurement contracts (i.e. JCT 2011 Standard Building Contract with Approximate Quantities) for the following:

> 'larger works designed and/or detailed by or on behalf of the Employer, where detailed contract provisions are necessary and the Employer is to provide the contractor with drawings; and with **approximate bills of quantities** to define the quantity and quality of the work, which are to be subject to re-measurement, as there is insufficient time to prepare the detailed drawings necessary for accurate bills of quantities to be produced; and where a Contract Administrator and Quantity Surveyor are to administer the conditions'.

Previously, we discussed the features of measurement contracts, stating that these are best applied where the contractor is required to design separate part(s) of the works (this is referred to as the contractor's designed portion). Due to this arrangement, it means that measurement contracts are also ideal where the works are to be carried out in sections or stages.

The contract price is based on the initial tender figure submitted by the contractor – this is reassessed at practical completion where on re-measurement, the Ascertained Final Sum (AFS) is obtained by valuation of all the work. Like many other forms of contracts and in accordance with the HGC&R Act, monthly interim payments are made to the contractor (unless otherwise stated in the contracts).

Measurement contracts require the design team to provide a set of drawings and approximate quantities at tender stage, and from this the contractor will quote the tender sum. However, due to incomplete design information and the use of approximate quantities, this tender figure can only be indicative. If the final quantity varies significantly from the approximate quantity in the bills, the contractor is usually entitled to re-negotiate the rate. For example, if the bills state that 100 m^3 of concrete are required, but the re-measurement only indicates that 20 m^3 has been used, then the contractor would not have benefited from economies of scale and may be entitled to an increase in the rates for the item. Many contracts, especially in civil engineering works, state that a re-measurement of ±10% in the quantity would allow a re-negotiation of the rate.

8.5.2 Cost reimbursement contracts

Cost reimbursement contracts – where the sum is arrived at on the basis of prime (actual) costs of labour, plant and materials, to which there is an added amount to cover overheads and profit. Within cost reimbursement contracts, we shall explore three variants: **cost plus percentage, cost plus fixed fee** and a hybrid approach called **target costing**.

Cost plus percentage variants have several advantages:

- It is the most convenient contractual basis of all.
- The contractor can be selected, the contract placed and work started before the scheme has been finalised and without any estimates or quantities needing to be prepared.
- The contractor's management methods, in theory at any rate, can be used for the direct benefit of the client.
- The client also knows that the contractor will not make an exorbitant profit.

However, there are disadvantages to this approach, which are as follows:

- The drawback of poor cost forecasting facilities and low productivity arising from the fact that the project is not 'working to a price' so can afford to do things 'properly' (or slowly and extravagantly).
- There is a positive incentive towards improvidence because the contractor is rewarded with a percentage of everything that is spent.

Because of these drawbacks it is not surprising that this type of contract has a poor reputation in terms of prudent cost control. However, because of the virtues that have been mentioned previously, it is a widely used method for projects such as

- emergency first aid and repair work;
- alterations and repairs to old buildings where the extent of the works cannot be foreseen until the contract has started;
- contracts where very high-quality work is required such as restoration to listed buildings and façade retention;
- contracts where cost may be important but where the client wishes to retain control over the method of working; and
- contracts where a good long-term relationship exists between the client and the contractor.

Cost reimbursement approaches are also suitable for projects requiring an early start on site, such that the works are designed – but not to the fully detailed design level – before the works commence.

Cost plus fixed fee contracts are an attempt to overcome some of the negative aspects of cost plus percentage variants, in that by paying the contractor a fee based on the estimated cost of the project instead of a percentage of the actual cost, the propensity for profligacy is mitigated. This has the advantage (compared to cost plus percentage variant) of reducing the incentive for wastefulness. However, there are two disadvantages:

- A fairly detailed scheme and an estimate have to be prepared before work can start, so losing some of the advantage of the 'cost plus' system.
- It is likely in practice that the so-called fixed fee will have to be re-negotiated at the end of the job because of the major variations which are sure to arise in projects of the type for which such a contract would be used. This is likely to be based on the contractor's actual cost, so effectively returning to the cost plus percentage system.

In summary, cost reimbursement contracts create shared risks. The key issue though is that a contractor more used to the traditional forms of contract will have little incentive – other than repeat business from a large employer – to work efficiently and economically. Clearly, none of the standard forms of cost reimbursable contracts we have discussed here address the problem of incentivising the contractor to collaborate with the employer in forecasting the final costs so that joint action may be taken to prevent any cost over-run.

Target costing involves an attempt to get the benefits of cost reimbursement without the disadvantages described above. Usually, a BQ is prepared and priced, by negotiation, to arrive at a target cost; the contractor then carries out the work on an actual cost basis. In order to arrive at the final price, there are various methods available:

- If the actual cost is lower than the target cost, the contractor and client usually split the difference between them on a pre-arranged basis.
- If the actual cost is higher than target, the contractor has to be content with the actual costs plus a small overhead percentage.

As an aside, the philosophy of target costing is encapsulated in the pain/gain contracts that are now becoming common in many procurement scenarios. Several recent public sector projects have been procured under **Option C of the New Engineering Contract (NEC), Third Edition (Engineering and Construction Contract)**, which forms as a target cost contract with a negotiable pain/gain share. This means that both contractor and client share either the reward or the cost of deviation from the target cost. Unfortunately, many clients, or their advisers, insist on the 'pain share' being 100% to the contractor, while the 'gain share' is weighted significantly in favour of the client. This clearly is contrary to the philosophy of target cost contracting and effectively creates a Guaranteed Maximum Price (GMP) contract.

The extolled virtues of target costing are as follows:

- The contractor has an incentive to do the job as cheaply as possible and the client gets a direct benefit if this is achieved.
- The system retains many of the benefits of cost reimbursement, especially the ability of the contractor and client to work closely together in the management of the project.
- It can be used with particular success on a 'continuation' basis where the client has a succession of projects in which the same contractor can participate.

The main disadvantages of target cost are as follows:

- The target cost is subject to revision with respect to the many likely variations (so that one might as well have an ordinary lump sum or re-measurement contract).
- The fees of a quantity surveyor (QS) are likely to be high because there is dual documentation (cost reimbursement accounts to be checked and BQs to be prepared, priced, agreed and updated).

8.5.3 Lump sum and price in advance contracts

This is probably still one of the most widely used variants of the JCT forms of contract, in spite of various difficulties. One of these difficulties is of course inflation. Many large building contracts can run over several years, consequently, it is unreasonable to ask the contractor to bear all the risk of inflation during this period.

The example of Wembley Stadium given in Chapter 1 demonstrates this and also reveals the potentially devastating effects it can have on the project. Therefore, most of the contract methods set out hereafter have two versions:

- One for use on small-to-medium projects in times of economic stability where the contractor bears the inflation risk.

- One for larger projects or at times of economic instability, where the risk is borne in whole or in part by the client.

It should be noted that while the version where the contractor bears the risk gives the client a firm cost forecast, the alternative approach may well be the cheaper, even on short-term jobs. This is because contractors do not like this type of risk, and thus will tend to overprice it if they are given a choice of tendering on the two methods. There are various types of price in advance contracts, which will now be considered.

8.5.3.1 Lump sum contracts (with firm or approximate Bills of Quantities)

This is often seen as the best form of contract since drawings and detailed specifications are prepared which includes sufficient information to allow a detailed BQ to be produced, all of which is then issued to contractors for pricing.

Bills can either be **firm** or **approximate** (i.e. where the level of detail to prepare a firm bill is lacking, but there is sufficient information to proceed with the project).

8.5.3.2 Lump sum contracts with quantities

Although the relative importance of the BQ is changing in UK procurement, a good deal of major work in the United Kingdom and elsewhere is undertaken on this basis. The scheme is designed, and a number of contractors are asked to submit lump sum tenders based upon the pricing and totalling of a BQ prepared on behalf of the client. The successful contractor's tender BQ then becomes the instrument for financial administration of the project, so that the one document provides a simple means of contractor selection, price commitment and contract management. This method of contract pricing probably gives the lowest price, which is deemed best value by many clients and consultants. However, although superior to any of the previous methods in regard to cost forecasting and budgeting, it has a number of disadvantages in this respect which are discussed later in this book. It is this type of contract, with its competitive BQ rates, which provides most of the raw data for elemental cost analyses, and indeed acts as a control against which the cost of buildings erected under less competitive arrangements can be judged. In practice, the provisions of the JCT Standard Forms of Contract (which attempt to be fair to everybody) make the total price and time commitments rather less firm than they appear to be in theory.

8.5.3.3 Lump sum contracts with approximate quantities

Used as an alternative where the scheme has not been fully designed, the BQ being only a notional but weighted representation of the finished product. The work is measured as executed, and a final price is agreed using the items and rates in the BQ as far as possible. This method has the advantage of permitting an earlier start to be made, however, control, of both time and money, is much weaker than in the previous case. A contracting firm that has underestimated the cost of its commitments when tendering is sure to be able to find some way of recouping its actual costs unless supervised by experienced consultants.

8.5.3.4 Lump sum contracts without quantities

A situation where for whatever reason a BQ is not provided, drawings and specification/work schedules are provided at tender stage instead. The contractor either prices in detail the specification or the work schedules thus determining the contract sum, or states the lump sum required for carrying out the work shown on the drawings and specification. In the latter case, a contract sum analysis or a schedule of rates will normally be provided. The priced documents will be used as a basis for the valuation and control of variations.

8.5.3.5 Negotiated tendering

This is used frequently where the early involvement of a contractor's specialist skills may be recognised as essential to project success. Normally, a contractor is selected early in the design stage, and as the design develops, the BQ is prepared and priced jointly with the contractor, who will be involved in the detailed design stage as well. Advantages of this style of tendering include the following:

- The system assists cost forecasting and budgeting, as there is some contractual commitment to the cost assumptions made during design.
- An early start can also be made on site.
- Because everything is negotiated, the contract terms and the arrangement of the BQ can be tailor-made to suit the actual requirements of the parties.
- This method of contracting is very suitable for use on a 'continuation' basis, where the same client, professional advisers and contractor can establish a **good working rapport**.

Disadvantages are as follows:

- It is unlikely to produce competitive prices.
- It requires some degree of special expertise on both sides to obtain the best results.

For this last reason, the QS may well be the most influential member of the professional team and may be appointed first.

8.5.3.6 Prime contracting (serial contracting)

Prime contracting (serial contracting) is a variation on a theme of the above, the serial contracting approach that is now commonly referred to in the United Kingdom as prime contracts are a procedure where the contractor will tender for a series of similar contracts (usually related to the estate of a particular client such as the MOD or National Health Service). This method is only open to clients with a continuing work programme however. Contractors are asked to competitively price a typical BQ, on which basis they agree to carry out any similar work, which the client may require over a fixed period of possibly 2 or 3 years. Usually the contractor is asked to take the rough with the smooth, and to quote average rates, which will apply on both difficult and straightforward projects. Serial contracting provides an ideal platform for cost forecasting, as contractually binding detailed prices are available for the future schemes before they are even designed. However, there are several disadvantages to the approach, which are as follows:

- The system relies heavily on mutual trust and works only where the contractor has confidence in the integrity and fair play of the client, for which reason it has mainly been used in the public sector.
- As already stated, it does not usually produce competitive prices.

Prime contracting is unlikely to be appropriate for clients that only occasionally procure buildings. Importantly, PC approaches require a single point of responsibility (the prime contractor) between the client and the supply chain. The prime contractor needs to be an organisation with the ability to bring together all of the parties (consultants, contractors and suppliers) necessary to meet the client's requirements effectively. There is nothing to prevent a designer, facilities manager, financier or any other organisation from acting as the prime contractor. A key part of the prime contracting[2] procedure involves the development of whole life cycle cost models; these should be developed as early as possible in the design stage (see Chapter 7).

Schedule of prices or measured term contracts are used mainly for repair and maintenance work contracts. Increasingly, local authorities, housing associations and other public sector agencies 'contract-out' the repairs and maintenance of their buildings to private contractors under instruments like measured term contracts (MTCs). These have something in common with the serial contract, as the contracting firm binds itself to a 'price list' at which it will undertake work as required for a period of years, subject to an agreed discount or premium as the case may be. The most commonly used version is the National Schedule of Rates for Building Works (2013 edition) which is published by TSO. This type of contract is sometimes used as a matter of convenience for small new works.

Framework agreements are similar to that of MTC's in that these are often used for rolling maintenance work – these can be defined in contract using JCT 2011 Framework Agreement (both in binding and non-binding versions). Framework agreements are becoming increasingly popular within the public sector for driving continuous improvement under the requirements laid out in the National Procurement Strategy.

One of the most well-known framework agreements in the United Kingdom is the NHS ProCure21[3] system. NHS ProCure21 was originally developed by the then NHS Estates following consultation within the NHS and the private sector, industry and academia. ProCure21 is intended to promote more efficient capital procurement in the NHS by developing a partnering programme using pre-accredited supply chains engaged in a long-term framework agreement (framework partners).

Within the ProCure21 collaborative framework, NHS clients select a framework partner at an early stage; the partner will help the client develop the full business case (thus, expertise should be available to inform the cost planning process in theory). The ProCure21 framework agreement uses the NEC3 Option C, which stresses the importance of early warning on project issues and collaboration to solve problems and includes provisions for pain/gain sharing.

Recently, the largest ever ProCure21 scheme was completed on Merseyside – the £80 million hospital redevelopment at Broadgreen, part of the Royal Liverpool and Broadgreen University Hospitals NHS Trust.

Other major clients involved in framework agreements include the British Airports Authority (BAA); the organisation is currently involved in the procurement of the redevelopment of Heathrow Airport including the new Terminal 5 development.

8.6 Design and build procurement

> **' . . .in no other important industry is the responsibility for design so far removed from the responsibility for production.' (Emmerson 1962)**[4]

We discussed the divorce between design and construction earlier in this chapter, which is the signature of traditional procurement. This statement truly exemplifies this and perhaps acts as a catalyst to the design and build procurement route. Under this system, the contractor acts directly for the client, filling the roles of both the professional design team and builder. Typically, the process of design and build would involve the following stages:

1. Client employs designers to produce outline design

2. Contractor tenders price to complete design and perform construction
3. Tendering usually competitively selected and best 'overall submission' should win – price, design, programme and so on.
4. Winning contractor carries out design and construction through employed design consultants and sub-contractors
5. Client pays price in monthly instalments as traditional route
6. Significant shift in risk to contractor compared with the traditional route

The design and build approach has gained increasing popularity over the years – the reasons why are encapsulated in a Chartered Institute of Building report[5] which reported completion times for projects being 25% faster than those using a traditional approach. The report also identifies that up to 80% of design and build projects reported in their study were completed on time compared to that of 56% of those using a traditional approach. Finally, the report also indicated that design and build projects were 15% cheaper than equivalent traditionally procured schemes.

There are a wide range of advantages to design and build procurement, which are as follows:

- Single point responsibility
- Speed of construction
- Overlap of design and construct
- Better communication
- More timely completion
- Improved financial control
- All-in lump sum
- Simpler
- Reduced finance
- Competitive design fees
- Good relationships

Because of the lack of a competitive tender, the client usually appoints a QS to act as the Client's representative in order to control costs. The client may also ask a consultant architect to provide advice on design issues. However, the latter role is so limited and frustrating that not every architect is keen to take it on. The design and build firm may have its own in-house design team or may employ outside consultants; as these latter are responsible to the design and build firm and not to the client, this is not much more than a domestic detail.

Other possible disadvantages which the client should be aware of include the following:

- The drawbacks of production-oriented design.
- The lack of competition. Even if two or more tenders are obtained it is difficult to evaluate the 'best buy', as what is being offered by each tenderer will be different.
- Loss of control by the client over the end product if the offered price is to be maintained.

As a general rule, the design and build contractor will be dependent on a clear brief from the client, since the lack of the traditional architectural role in translating the brief into design is removed. The design and build route is also suitable for work of a standard or routine nature or where certain contractors can demonstrate technical expertise and efficiency. Complex work, or that where architectural quality is an important consideration, is not suited to the design a and build method of working; however, the reduced tendering costs continue to see the upward trend in design and build work.

Design and build procurement has also recently found itself associated with the concept of **GMP**. GMP featured as part of the Scottish Parliament enquiry (Chapter 1) where the client investigated the possibility of moving to a GMP contract for the remainder of the scheme. It is basically a self-explanatory concept, that is the cost of the project should not increase beyond the GMP but a recently published internet 'blog' by David Lewis of LawBuild solicitors provides a fascinating and informed insight into the concept of GMP – the content is reproduced here in part.[6]

> … The buzzword is "Guaranteed Maximum Price" or GMP, and it is often used in the context of a design and build contract …
>
> … There was an immediate meeting of minds between my QS friend and me, when we found that neither of us had been able to discover any difference between a GMP and the contract sum under a standard JCT design and build contract. The contract sum under a design and build contract is a guaranteed maximum price for all practical purposes.
>
> When someone talks about GMP, ask them if a client under a building contract with a GMP can require the contractor to (say) build an extra storey without an increase in the contract sum. They will obviously have to admit that a significant variation must entitle the contractor to an increase in the contract sum, GMP or not.
>
> Then try to find out what else might distinguish a GMP from an ordinary contract sum under a design and build contract. Is it that the contractor bears the risk of adverse weather conditions or other "neutral" delaying events? When they gratefully seize on this, point out that such a transfer of risk wouldn't affect the contract sum; instead it would require the contractor to pay liquidated and ascertained damages for the resultant period of delay.
>
> Is it that a GMP contract sum remains the same even if the contractor finds difficult ground conditions which cost him money to overcome? Perhaps, but under a design and build contract adverse ground conditions are normally at the contractor's risk anyway.
>
> So what is a GMP, precisely?
>
> I discovered the apparent answer to this question in Cockram's Manual of Construction Precedents, which contains a 'Price and Payment Schedule (Target Cost/Guaranteed Maximum Price) for use with JCT 2005 SBC/XQ[7].
>
> The learned author of this work, in a footnote, says that the principle behind this form is to convert the contract sum into a prime cost arrangement, under which the contract sum has three elements: the amounts payable by the contractor to subcontractors and suppliers (the "work cost"); the contractor's site overheads ("prelims cost"); and a percentage mark-up on works cost and prime cost for the contractor's head office overheads and profit ("fee"). And the form also allows for provisional sums, i.e. elements which cannot be priced before the contract is awarded.
>
> The Cockram form provides for a Target Cost, which is the estimated total of the works cost and the prelims cost and is stated in the contract. The Target Cost can be adjusted for variations or provisional sums. And then you have an incentive adjustment, so that the contract sum is reduced if the actual cost exceeds the Target Cost, or increased if the Target Cost exceeds the actual cost. So the contractor (apparently) has a monetary incentive to keep his costs down.
>
> It strikes me that a contractor who is incentivised to keep his costs down might be equally incentivised to cut corners. But be that as it may, a contractor under an unamended lump sum contract is just as incentivised to keep his costs down because (since the contract sum is fixed) he can thereby increase his profits.

It was at this point in my researches – and possibly while pondering the absence of His Imperial Majesty's new clothes – that I was reminded of Voltaire's famous remark about the Holy Roman Empire: that it was neither holy, nor Roman, nor an empire.

Could one not likewise say that a Guaranteed Maximum Price (according to Cockram) is neither guaranteed, nor maximum, nor a price?

8.7 Partnering

Partnering agreements emerged from recommendations made in the Egan report and 'Trusting the team', the Reading Construction Forum's (now Constructing Excellence) initial publication on partnering in the team. Partnering involves: ' . . . . .a management approach used by two or more organisations to achieve specific business objectives by maximising the effectiveness of each participant's resources. The approach is based on mutual objectives, an agreed method of problem resolution, and an active search for continuous measurable improvements'.

Partnering is essentially a structured methodology for organisations to set up mutually advantageous commercial arrangements, either for one-off projects or in long-term strategic relationships. The three basic components of partnering are as follows:

- Establishment of agreed and understood mutual objectives
- Methodology for quick and cooperative problem resolution
- Culture of continuous, measured improvement

The benefits of partnering relationships are cumulative, so that strategic alliances produce significantly more advantage than single project arrangements. And the benefits are increased further if partnering is applied throughout the entire **supply chain**. By definition, it is clear that the success of partnering arrangements is to some extent reliant on the premise that all parties are committed to working together for mutual benefit. Although the construction industry is good at creating relationships when things are going well, this must also apply when things are not running so well!

Partnering features 'open book' working practices and relationships, which attempt to also introduce systematic approaches to problem resolution rather than seeking parties to blame. There is also an emphasis upon customer-focused working practices and adding value through the elimination of waste and harnessing best practice.

This concept of partnering has now evolved further still and evidence from several private finance initiative (PFI) and commercial partnerships has shown that the relationships between partners has become more sophisticated – on other words, a 'second generation' of partnering. The diagram below shows the evolution of second-generation partnering from the original form reported in 'Trusting the Team'.

PPC2000 was the first standard form of **Project Partnering Contract**, again a direct result of the Sir John Egan's report; the contract provides the tangible foundation to the project partnering process. The latest version, **PPC2000/3**, can be applied to any type of partnered project in any jurisdiction, with the support of an experienced partnering advisor or with appropriate legal or other professional advice on its implementation. Other partnering based contracts include the **NEC Partnering Option** and the ICE Partnering Addendum. beCollaborate (now Constructing Excellence) produced the **Be Collaborative Contract**,[8] a new form of contract for construction projects that underpins collaborative behaviour – Be (Collaborating for the Built Environment) was an independent association for companies across the construction supply chain in the United Kingdom but merged with Constructing Excellence recently.

8.8 Public sector construction procurement and the private finance initiative

In 2003, £33 billion was spent on public sector construction in key sectors such as schools, hospitals, roads and social housing. This capital investment is set to continue expanding over the next decade.[9] The government has spearheaded procurement reform in the United Kingdom through various reports such as Egan and Latham, and more recently, through the OGC Achieving Excellence in Construction Programme.

Results of the Achieving Excellence in Construction Strategic Targets (AESTs) in 2005 demonstrated that significant improvements had been achieved since the introduction of the initiative back in 1999. In comparison with 1999 figures, the results showed that

- 65% of projects were being delivered on time compared with that of 34%;
- 61% of projects were being delivered to budget compared with that of 25%.

Moreover, the National Audit Office (NAO) report, improving public services through better construction, published in March 2005, highlighted that an £800 million overspend on construction projects had been avoided through the adoption of the AEC best practice principles. The same report estimates that further value gains of up to £2.6 billion in annual construction expenditure is possible if good practice was applied across all the public sector. Clearly, the reforms are working but a more controversial aspect of the government approach to procurement has been in the form of the PFI.

PFI is fundamentally different from all the other methods of procurement described in this chapter in that

- It is exclusively used for the delivery of public buildings; and
- The procurement involves not only the design and construction of the building, but also the provision of services within it over a pre-determined period of time known as the 'concession period'.

The PFI was introduced by the Conservative Government in 1992, by the then Chancellor of the Exchequer, Rt Hon Norman Lamont MP. The primary objective of PFI being to encourage private investment in major public building projects, such as schools, prisons, hospitals and roads. The first examples of PFI in the United Kingdom included the construction of HM Prison Parc in Bridgend, South Wales, and HM Prison Altcourse in Liverpool, Merseyside (the latter was procured under a variant of PFI known as DCMF – Design, Construct, Manage and Finance). PFI is advocated as a method of risk transfer in capital procurement – the private investment implies that the level of government borrowing falls and that risk is transferred from the public to the private sector. The concept of risk transfer is of significant debate at present, and the reader who is interested to learn more is advised to refer to the recommended further readings. The procurement procedures for PFI are long and complex and fall out of the scope of this text. However, to demonstrate simplistically how PFI works, an example is described below – in this case, a new hospital building:

- A private consortium pays for a new hospital, where the consortium usually consists of a construction company, a bank or financier, a facilities management contractor and consultants.
- The local NHS trust then pays the consortium a regular fee for the use of the hospital, which covers construction costs, the rent of the building, the cost of support services and the risks transferred to the private sector.

- Thus, in essence, most new NHS hospitals will be designed, built, owned and run by a consortium or grouping of companies.
- The NHS will employ some of the staff, mainly doctors and nurses and will rent the building and other facilities from the consortium for at least 25 years.
- The deal is constructed in such a way that the consortium is guaranteed a full return on costs including interest on the capital borrowed, plus an element of profit.

8.9 Key points

1. There are a variety of client requirements, and many contractual methods of satisfying them.
2. The method of contracting for a particular project or group of projects should be chosen with the individual client's needs in mind, not just 'on the usual basis'. It is, for instance, pointless to prepare a BQ for a client who is concerned not with money but with convenience or time.
3. We must also remember that the client organisation may not really need a building at all – perhaps it should be changing its distribution methods instead of building a new warehouse. It may therefore be important that it should not go initially to somebody who has a vested interest in putting up buildings.

Further reading

Achieving Excellence in Construction (1999) Achieving Excellence Guide 3 – Project Procurement Lifecycle, OGC, HMSO, London.

Bousabaine, A.H. (2006) Cost Planning of PFI and PPP Building Projects, Taylor & Francis, London, ISBN: 0415366224.

Hackett, M., Robinson, I. and Statham, G. (2006) The Aqua Group Guide to Procurement, Tendering and Contract Administration, Blackwell Publishing, Oxford, ISBN: 1405131985.

Joint Contracts Tribunal (2006) Deciding on the Appropriate JCT Contract, Sweet & Maxwell Limited.

Masterman, J. (2001) Introduction to Building Procurement Systems, Spon Press, London, ISBN: 0415246423.

Endnotes

1 The full electronic versions of these documents can be obtained from the JCT website at www.jctltd.co.uk or through the subscription only – Construction Information Service (CIS).

2 Client Pack, Construction Works Procurement Guidance, Scottish Executive, HMSO.

3 NHS ProCure21+ is a partnership framework where NHS construction projects costing from £1 million to £20 million can bypass OJEU procurement requirements by working with principal supply chain partners (PSCPs) and pre-accredited supply chains.

4 Emmerson, H. (1962) Survey of Problems Before the Construction Industries: A Report prepared for the Minister of Works, HMSO.

5 "How to Use the Construction Industry Successfully: A Client Guide" The Chartered Institute of Building, Ascot, UK.

6 GMP and the Holy Roman Emperor's new clothes, by David Lewis, LawBuild Solicitors on Sat 14 Oct 2006 06:18 PM BST.

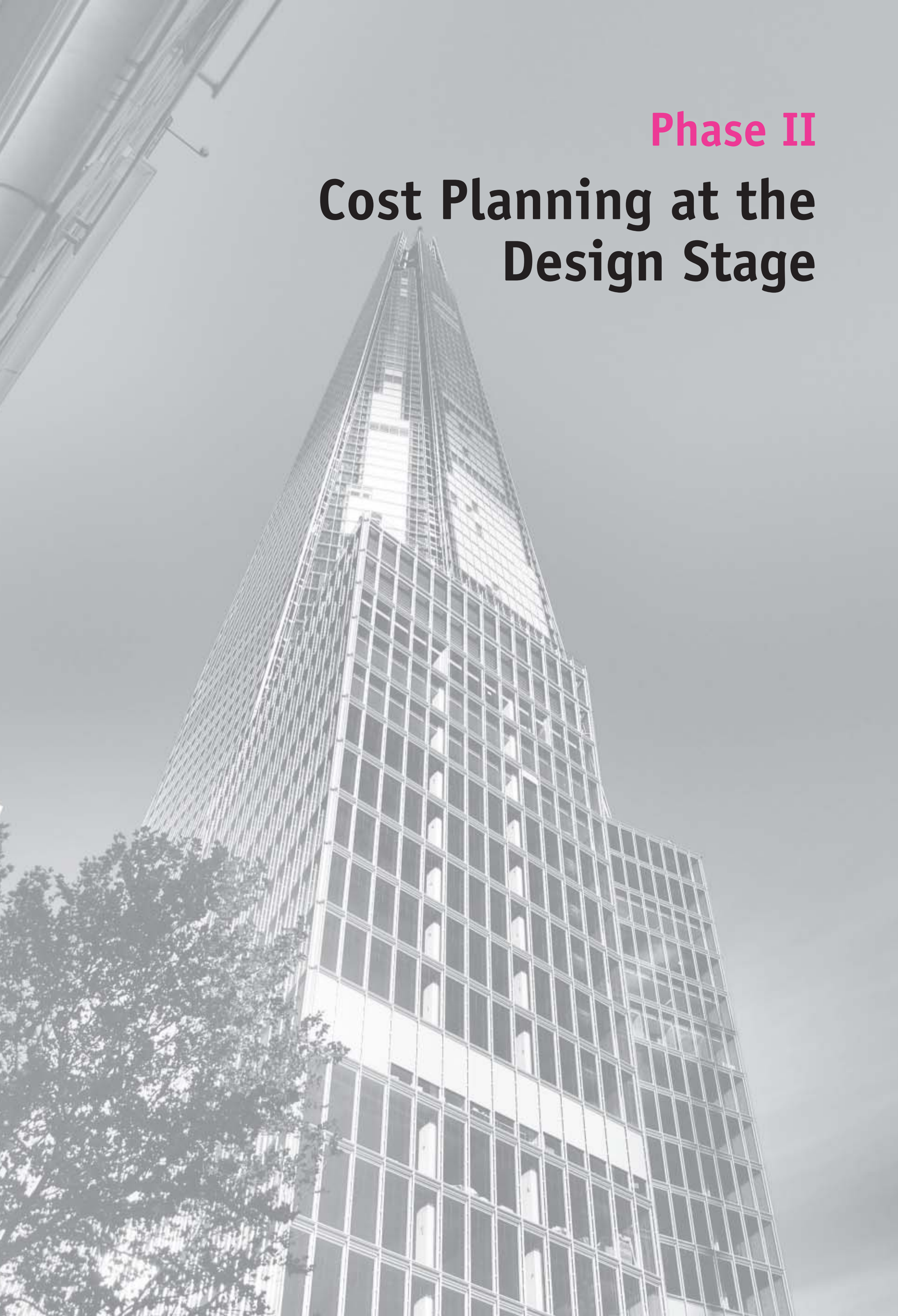
7 JCT 2005 SBC/XQ refers to the JCT2005 Standard Form of Building Contract without quantities.

8 The beCollaborate contract can be obtained via the Constructing Excellence web portal.

9 National Audit Office (2005) Improving Public Services through Better Construction, HMSO, London.

Phase II

Cost Planning at the Design Stage



Chapter 9

The Design Process and the Project Life Cycle

9.1 Introduction

The last chapters have explored the key elements and processes required in order to appropriately understand the budget and scope of the building project. Without this, it is folly to expect the design team to be adequately equipped with the necessary information to produce a robust response to the brief. In this chapter, we will explore the **building design process** and draw from this, the role the cost planner assumes. We shall also briefly touch upon the concepts of **process mapping**; this is an academic theory, which helps us to understand how good design is accomplished.

9.2 The building design process

The building design process is a complex interaction of skills, judgement, knowledge, information and time, which has as its objective the **satisfaction of the client's brief**. The optimum solution is that which is obtained within the constraints imposed by following factors:

- Statutory obligations
- Technical feasibility
- Environmental standards
- Site conditions
- Cost

Problems arise however in establishing which of the alternative options available is the 'best', as some factors such as personal comfort or aesthetics are difficult to measure (these concepts in economics are considered under the theory of utility). Neither is it easy to translate all attributes into a common unit of value, for example excessive noise levels compared with higher initial cost. In practice, compromises in the client's demands are nearly always necessary to keep within the constraints. The role of the design economist/cost planner is to provide information with regard to initial and future costs so that the design team can make decisions knowing the cost implications of those decisions. It is not usually the building economist's responsibility actually to provide 'value' as this must be the province of the team as a whole – of which, however, the building economist should be a contributing member. In

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

theory, the team will pool their combined knowledge for the benefit of the client, whose representative should, wherever possible, be a member of the team and play a part in the corporate decision-making process. As with any group activity, the composition of the team should be carefully planned to avoid vociferous members unduly influencing the final decisions.

A design economist who is to be an effective member of the team must

- understand when the major decisions of cost significance are to be made, so that information can be provided at that crucial time;
- acquire techniques, knowledge and experience to provide answers to questions of cost that will be posed as the design is refined;
- appreciate the manner in which the design team, in particular the architect, thinks and operates, commonly referred to as the **design method**.

Although each individual designer adopts a different approach, as there are many ways of solving the same problem, it is possible to identify some of the common techniques, which are very often incorporated in a typical approach to the task of achieving good design. This knowledge can be used to select the form of cost advice most appropriate to a particular problem.

9.3 The design team

It is not possible to place all the responsibility for establishing a successful cost solution solely on the shoulders of the building economist/cost planner or quantity surveyor. The architect must cooperate in, and contribute to, the cost planning process, cost being one of the several constraints that have to be faced in varying degrees, depending on the type of project and the client's financial resources. In this aspect, the architect needs to have a reasonable grasp of the factors affecting the cost of the project and the options that are available within that constraint. This knowledge will often be gained by experience, especially if the firm specialises in one particular type of contract, for example housing, factories and hospitals. Even without this experience, the architect should be aware of the very basic design and cost relationships shown below.

The advantage of illustrating this triangular set of relationships is that any two of the factors can be seen as functions of the remaining one. For example, if the size of the building is fixed, together with the form and specification, then a certain cost will be generated. Conversely, if the cost of the building is established together with its size (as is the case with some government yardsticks), then this constrains the form and specification that can be chosen. Alternatively, if the shape and quality standard of the specification is declared together with an established sum of money, then the amount of accommodation is the design variable which is limited. Since one factor must be the resultant, it is never possible to declare all three in an initial brief.

This is an oversimplistic view of the cost system, but it is a starting point in the understanding of the complex relationships, which exist between design and cost. It is the skill of the design team in achieving the right balance between these factors that makes a project a success or a failure.

9.4 The RIBA Plan of Work

Recognition for this team approach to design is included in what has come to be known as the **RIBA Plan of Work (RIBA PoW)**. This is the original 'model procedure' dealing with some basic steps in decision-making (based originally on a medium-sized project), and the stages that make up the RIBA PoW are often spoken in common parlance by members of the design team to describe the various life cycle phases that the project progresses through. The original PoW was first published in 1963 and was revised numerous times up until the 2007 version. It was comprised of five key project phases (preparation, design, pre-construction, construction and use) over key 11 stages, lettered A–L. Although the PoW 2007 has recently been replaced by the PoW 2013, it is useful to refer to this as the 'parlance of the PoW 2007' is still firmly embedded in the industry.

Preparation

Stage A: Appraisal

1. Identification of client's needs and objectives, business case and possible constraints on development.
2. Preparation of feasibility studies and assessment of options to enable the client to decide whether to proceed.

Stage B: Design brief

1. Development of initial statement of requirements into the design brief by or on behalf of the client confirming key requirements and constraints. Identification of procurement method, procedures, organisational structure and range of consultants and others to be engaged for the project.

Design

Stage C: Concept

1. Implementation of design brief and preparation of additional data.
2. Preparation of concept design including outline proposals for structural and building services systems, outline specifications and preliminary cost plan.
3. Review of procurement route.

Stage D: Design development

1. Development of concept design to include structural and building services systems, updated outline specifications and cost plan.
2. Completion of project brief.
3. Application for detailed planning permission.

Stage E: Technical design

1. Preparation of technical design(s) and specifications, sufficient to coordinate components and elements of the project and information for statutory standards and construction safety.

Pre-construction

Stage F: Production information

1. Preparation of production information in sufficient detail to enable a tender or tenders to be obtained.
2. Application for statutory approvals.
3. Preparation of further information for construction required under the building contract.

Stage G: Tender documentation

1. Preparation and/or collation of tender documentation in sufficient detail to enable a tender or tenders to be obtained for the project.

Stage H: Tender action

1. Identification and evaluation of potential contractors and/or specialists for the project. Obtaining and appraising tenders; submission of recommendations to the client.

Construction

Stage J: Mobilisation

1. Letting the building contract, appointing the contractor.

2. Issuing of information to the contractor.
3. Arranging site handover to the contractor.

Stage K: Construction to practical completion

1. Administration of the building contract to practical completion.
2. Provision to the contractor of further information as and when reasonably required.
3. Review of information provided by contractors and specialists.

Use

Stage L: Post-practical completion

1. Administration of the building contract after practical completion and making final inspections.
2. Assisting building user during initial occupation period.
3. Review of project performance in use.

The RIBA PoW was recently updated in 2013 to primarily embrace the integration of collaborative teamworking and to map and embed Building Information Modelling (BIM) processes following the UK Government's Construction Strategy desire to implement BIM Level 2 (in government projects) by 2016. Thus, the new generation RIBA PoW provides the foundation to support BIM by shifting the emphasis from the design team to the project team (a criticism of the 2007 PoW was that it will be ill-suited to modern procurement methods that promoted collaboration and open-book working and was in effect mirroring the traditional architect-led approach). This is a welcome step change as it reflects changes elsewhere, particularly the *New Engineering Contract* (Third Edition) which places effective project management at the centre.

The RIBA PoW 2013 is designed to be 'procurement neutral' and incorporates the 'green overlay' and the 'BIM overlay' that were published to support the PoW 2007 in 2011/2012. Perhaps the most notable change is that the familiar PoW stages A–L have been replaced with numbered stages 0–7:

Stage 0: Strategic definition
Stage 1: Preparation and brief
Stage 2: Concept design
Stage 3: Developed design
Stage 4: Technical design
Stage 5: Construction
Stage 6: Handover and close out
Stage 7: In use

The new PoW is organised around these eight stages and eight tasks:

- **Core objectives**
- **Procurement**
- **Programme**
- **(Town) Planning**
- **Suggested key support tasks**
- **Sustainability checkpoints**
- **Information exchanges**
- **UK Government Information Exchanges**

The reader is advised to consult the RIBA website where access to the PoW13 site can be found; this includes the functionality to produce a bespoke PoW for any given construction project.

9.5 Comparison of design method and scientific method

To understand the concept of design, it is useful to compare the design method with the traditional approach of the **scientific method**. To establish a scientific law:

- An observation is made in nature and an inference drawn, for example light passing through a prism breaks down into several colours.
- A hypothesis is set up (e.g. white light is a combination of several colours).
- Tests are applied to establish whether the hypothesis is true.
- If the results of the tests conclude that the hypothesis and original inference are correct, then a scientific law can be established based on the hypothesis.
- If not, a new solution must be set up and tested until the tests corroborate the hypothesis.

Design can be said to follow a similar pattern:

- The brief is observed and some inference obtained.
- A hypothesis is set up in the form of a model (e.g. a drawing).
- This is tested by evaluation to see whether it 'works'.
- A check is made to see whether it complies with the interpretation of the brief, and if it does then the design is accepted.

There are, however, some very important differences. The design team cannot 'loop' round the system producing new hypotheses (i.e. designs) ad infinitum. They work within the constraints of time and cost, and they must produce a final solution within the design period set by their client and within the fee structure by which they are paid. In addition, much of their creative work can only be evaluated in terms of social responses (such as aesthetic appeal), which at the present time do not have a satisfactory quantitative measure by which they can be tested.

Consequently, the team's objective tends to change from – 'What is the best solution for our client?' to 'How can we produce a design which satisfies as many of the demands of the brief as possible in the time available?'. To arrive at a satisfactory solution, some kind of strategy, very often incorporating 'rules of thumb' learned from previous experience, is used to narrow down on a particular range of alternatives. The responsibility of the design economist/cost planner in this search for a satisfactory solution should be to indicate to the team where it should look in terms of form, quality, spatial standards and so on to solve the cost problem. This will avoid wasting time on abortive designs, which will not meet the cost criteria, and will thereby increase the chance of arriving at the 'best' solution in the time available. In other words, the building economist should contribute to the overall design strategy.

9.6 A conceptual design model

A good deal of research work has been undertaken to establish a general pattern for design. The Building Performance Research Unit at Strathclyde University has put forward the following view, which is shared by several other writers. They suggest that design consists of three stages as follows:

1. **Analysis**: Where the problem is researched in order to obtain an understanding of what is required.

2. **Synthesis**: Where the information obtained in analysis is used to converge on a solution at the level being investigated.
3. **Appraisal**: Where the solution is represented in some form, which is then measured and evaluated.

Quantity surveyors have traditionally been involved almost exclusively in the latter part of the 'appraisal' process, and yet the real decision-making role is in the analysis and synthesis stages. New techniques are therefore required to enable the design economist to contribute to understanding and solving the design problem. It was assumed by the Strathclyde team that decision-making became more detailed and refined as time went on (from, say, concepts of building form and spatial arrangement through to the eventual choice of ironmongery), and that at each stage different methods of problem solving were adopted. Any cost technique must therefore follow a similar pattern, which may involve 'coarse' measurement and evaluation in the very early stages and a more reliable measurement and cost application when more information becomes available. It is with these thoughts in mind that cost models have been constructed, which can input information at each level of refinement.

One of the criticisms that can be made of traditional cost planning methods is that they do very little to contribute to the pre-sketch design dialogue, where all the major decisions of form and quality tend to be taken. Current research suggests that there is a heavy commitment of cost prior to a sketch design being formalised. This may amount to over 80% of the final potential building cost, leaving perhaps only 20% available actually to be 'controlled'. Figure 9.1 illustrates the point in a hypothetical diagrammatic form. With an improved understanding of design method, it may be possible to input information prior to sketch design, which will reduce the number of abortive design solutions needing to be produced.

9.6.1 Research into design process mapping

In the earlier chapters, we referred to the Eurolifeform project. This project investigated a **process mapping** of design in the context of whole life cycle costing (WLCC).[1] The

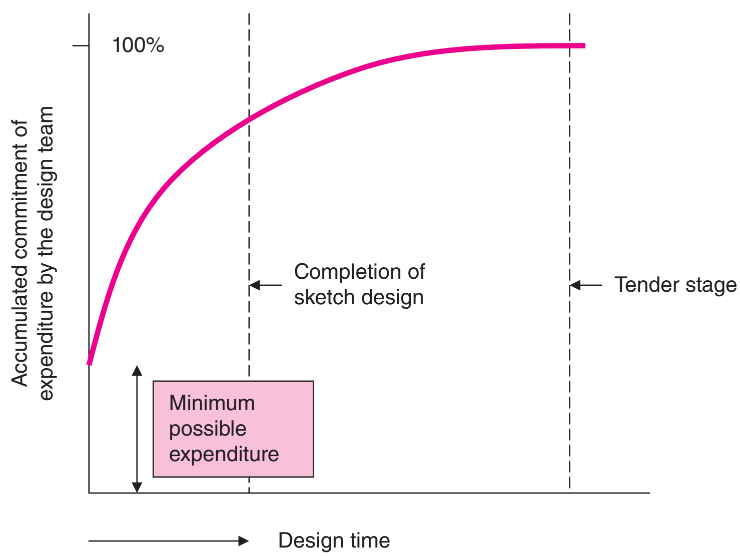


Figure 9.1 Accumulated commitment of expenditure by the design team.

rationale was based on understanding this approach to building costing as a synergy with the design process. If building design can be conceived as a systematic framework of activities comprising transformation, flow and value creation (Koskela 2000), then it is appropriate to model the design process in a logical way. Such a model, it must be remembered, is a model of the design decision-making process (when decisions are made and by whom and how they are linked but not the actual technical decisions) and the information flows relating to the decision (input data, knowledge transfer, verification, recording, monitoring). Two issues arise as a consequence: the actual model of the process and the modelling medium (e.g. data flow diagrams). When reviewing the research into these areas, particularly when related to construction design, these two issues become interrelated but with the consensus view being that the established modelling methods are applicable. The debate centres on the complexity of the models and how a generic design model can be produced from these formal modelling methods.

A number of design process models have been developed for engineering manufacture (automotive, aerospace in particular), and these are often referred to as **new product introduction process models** as they attempt to involve activities in the supply chain outside the strict design activity and also may encompass more strategic issues (the establishment of the Innovative Manufacturing Research Centres within schools of Construction Management and Quantity Surveying in the UK HEIs demonstrates this 'Egan thinking'). In addition, a number of models have been developed specifically for construction design. None of the models available extend, to any degree, beyond the start of manufacture or start of construction phase although a few make some reference to 'operations' without going into any detail. The approach in all cases is to assume that design is effectively a linear process (i.e. following the 'transformation' concept) although with some integration into the manufacturing processes. The models are all very similar but differ in detail primarily because of the original aim in identifying and defining the model. The issue of design iteration while considered is not usually a central feature of these models. Macmillan et al. (2001) produced a summary of an extensive review of design process models, which indicated, as expected, broad similarities between the different models but some significant differences at the conceptual design stage. These differences relate to whether they are engineering based (very prescriptive) or architect based (generalised descriptions of stages).

As we discussed in Section 9.4, **The RIBA PoW** is a well-known design model. It is designed to identify the main steps (from client instruction to commissioning) primarily as a contractual aid. Architects' fees can be paid against achievement of the various stages. It implies a particular procurement route (competitive tender) and, in reality, the gates between the stages are 'fuzzy'.

However, it provides an easily understood, widely used and simple model of the process, which has been implicitly used in the development of more sophisticated design models. **The British Airports Authority** guide to the construction project process (BAA 1995) is a process map but with some features that relate to the specific needs of the authority. Inception is decoupled from feasibility and there is no tendering stage. BAA operates via a partnership mechanism (see Chapter 8) and has its own internal arrangements for project definition. The 'gates' in this model are more pronounced and are used in an active way as part of the project management process. There is an attempt to cover operations and maintenance within this model, but it seems to have been added almost as an afterthought. **Network Rail** operates a similar approach called GRIP (Guide to Railway Infrastructure Projects) which is a structured project delivery model with design included. The **UK Defence Procurement Agency's CADMID** system is an asset acquisition life cycle, which is used primarily in the purchases of ordinance rather than buildings.

Perhaps the most comprehensive and ambitious attempt to model the design process is the 'process protocol' (Kagioglou et al. 1998), which is a truly generic model although again, effectively restricted to the design of the building rather than including maintenance and operational activities. The process protocol model includes gates – both 'hard' and 'soft' – to accommodate the fuzzy issues discovered by previous researchers. Current work is aimed at trying to bridge the gap between the high-level abstraction and the detailed design tasks. Since briefing and the client/design team interaction are so critical in construction design, there have been a number of studies that have concentrated on this aspect. Latham (1994) and Blyth and Worthington (2001) have modelled briefing as an iterative process including feedback from previous projects. Macmillan et al. (2001) considers a fresh approach in the search for a generic framework for conceptual design. It is instructive to note that a 'framework' rather than a 'model' is proposed. What is described as a categorical framework with five levels is demonstrated, but extensive discussion with design professionals indicated that a three-level approach was perhaps the most useful, and that a framework rather than a prescriptive model is preferable.

The Eurolifeform process map proposed in Figure 9.2 considers design (from identification of client requirement through to completed design) as a linear sequential process along the time axis and indicates the issues/stages where decisions are made (and the relevant data and information needed) in relation to WLCC performance. It is not a map designed for the purposes of project monitoring and control. Note that it is of course recognised that the design is not easily described in detail by a formal model.

Furthermore, the detailed models of the design process, which have been suggested, do not necessarily reflect design practice. Consequently this is a map of the decision stages to enable the correct WLCC data and information to be available at the appropriate point in the

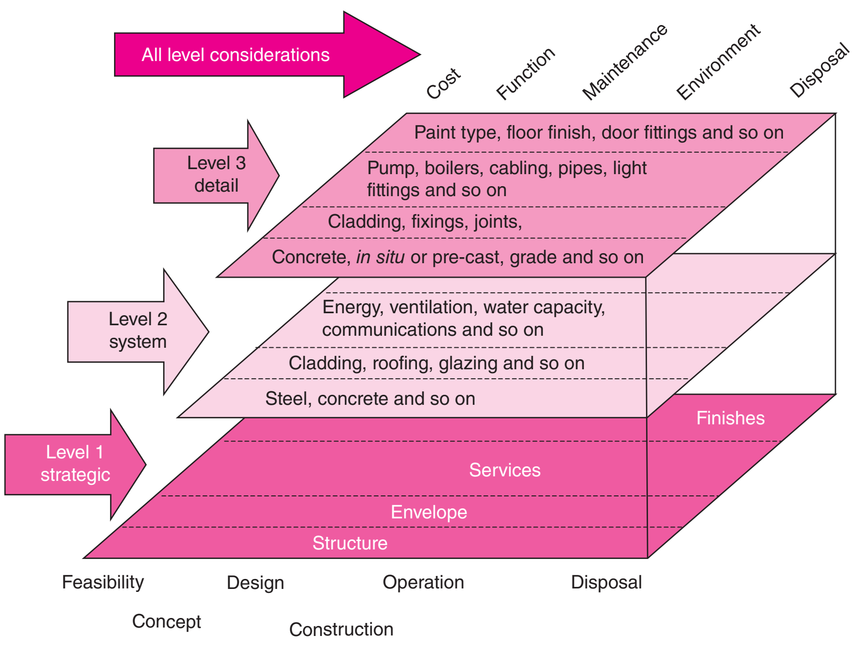


Figure 9.2 The Eurolifeform design process map.

design process. The map is designed to be at different levels (three are proposed rather than the five or six proposed in some other design models) to preserve the generic nature of the map but to allow for varying levels of design detail.

By having different levels in this way, it should be possible for performance and cost data to interact with the design map at different levels depending upon the precision and detail of the data and the level of detail decision. It is envisaged that, as design proceeds, the cost, performance and environmental data can become progressively more precise and can then be entered into the lower levels of the design map. Another advantage of this multilevel approach is that it may be able to handle the inevitable design interactions. In practice, the interaction between the three levels is likely to be at the later stages of design (after the feasibility and concept stages), so the three-dimensional map will be of this general nature.

9.7 Design techniques

It is not possible to describe fully the vast range of techniques applicable to design in a chapter or a book of this nature. Those interested in developing their understanding in this area of study should consult other publications (see the reading list at the end of this chapter). It is possible to identify some decisions, which form the basis of most design approaches. In very simple terms, these can be illustrated by some general questions relating to matters of principle affecting the design. These include the following:

9.7.1 'What are the constraints within which I have to work?'

The constraints on a project can be of three kinds:

- **Constraints imposed by physical factors**: These very often relate to the site and include the position of boundaries and easements, the method of access, the nearness to service supplies, any visual aspects and views, soil and environmental conditions and adjacent structures. In addition to the site, the physical performance of materials acts as a limitation and may exclude the use of a particular specification. Constraints imposed by physical factors are usually fixed, and therefore provide very clear boundaries to the design problem.
- **Constraints imposed by external bodies**: These, however, can often be the subject of negotiation. Planning requirements are usually the result of the policy of the local planning committee and are often open to interpretation – hence the facility for appeal when these interpretations conflict. Some building regulations can be waived if the appropriate authority can be convinced that an alternative construction form or arrangement is satisfactory. Resolving these problems can be a time-consuming business, and until they are settled the solution to the design problem has to remain flexible. However, once they are defined, they again provide a clear boundary to the design problem.
- **Constraints imposed by the client body and its advisers**: These tend to be far less stringent than the previous two categories and can sometimes be compromised more easily. Even here some may be inflexible due to a specific demand, which takes precedence over all other needs. An example may be the requirement to design a form which envelopes an expensive manufacturing process; because the plant is so expensive the form of the building must take second place. Another example is a cost limit which is subject to the financial standing of the client; this may however be imposed by an outside body such as a government department or finance company who will define the cost that it sees as being realistic. Most self-imposed constraints are able to be reconsidered in the light of experience and gradual evolution of the design solution.

Definition of the constraints is of enormous assistance in containing the design solution. They help in narrowing down the range of possible solutions, which are for practical purposes almost infinite without them. It is the responsibility of the design economist to account for these controlling factors in the budget and, therefore, set a realistic strategy of cost. Ignorance of these issues will possibly result in abortive effort and a less than satisfactory service to the client.

9.7.1.1 'What are the priorities of the scheme?'

In a sense this is the question that sets the self-imposed constraints and whose solution should provide value for money. If priorities can be ranked and given their due importance in solving the design problem, then it should be possible to spend the client's money in accordance with these requirements. This would be the ideal design and would provide the optimum solution. Unfortunately 'ranking all the priorities' is an extremely difficult task. For example, should maintenance-free windows take priority over an improved reduction in noise levels between rooms in a commercial office block? It is difficult to compare the two, and it is even more difficult to award a satisfactory weighting. However, this kind of decision is at the root of good cost budgeting and, if possible, it should be made in conjunction with the designer. The theoretical aim should be to spend money in the same order and importance as the priorities.

Whether this can ever be achieved is a debatable point, as an item which is not given a high priority by the client may yet be essential, for example easy-to-clean windows on a multistorey block. To provide this, an item may be more expensive than providing an item of greater ranked importance. This does not mean that the higher ranked item is of less value to the client, but just that because of external economic forces and the nature of buildings, the client has to pay more to achieve the desired objective. This emphasises the difference between the two concepts of 'value' put forward by the economist Adam Smith: value in exchange or value in use. In most buildings of a public or social nature it is value in use, which is being considered, whereas in a speculative housing or commercial development it is value in exchange (which is much more dependent on scarcity factors) that is the major concern. There is, of course, a link between the two because the greater the degree of user satisfaction, the more likely it is that the client will be prepared to pay more for his building. Value for money is achieved when the priorities of the client, for example profit, symbolism, welfare and religious worship have been successfully balanced with the initial and future costs allowable for the development.

9.7.2 'How much space is required?'

The purpose of building is usually to provide space for a particular activity within which the climate is modified so that the activity may function more efficiently. Other considerations such as the environmental and social impacts of the building and its activity arise out of this prime need. It is therefore usual for the client's brief to give an indication of the usable area required, but even where this is stated there is considerable flexibility allowed, for example the circulation area (corridors, waiting areas, lifts, public areas etc.) is not usually included in the list. In addition, the multiple use of space (e.g. assembly halls doubling up as dining halls in schools) may allow a more efficient use of a certain area and reduce the overall requirement. Part of the design problem is to discover the most efficient use of the spaces required to satisfy the client's brief and to arrange the areas in such a way that circulation is kept to a minimum.

As there is a strong correlation between the area of a building and its cost, the design economist should be an active participant in the discussion of areas and their spatial arrangement. Statutory requirements with regard to means of escape in cases of fire, disabled access and disability requirements, health and hygiene in conjunction with the client's requirements for efficient movement in the building will provide an indication of the minimum areas allowable for circulation and ancillary purposes. A careful study of these needs will provide the constraints for area and thereby indicate the balance between quantity and quality of building that can be achieved within a given cost limit.

9.7.3 'What arrangement of space is required?'

This question is heavily influenced by the amount of space needed. In answering it, a good designer's knowledge can be exercised to enormous advantage. Indeed, determining spatial organisation has been recognised as one of the most fundamental of the architect's range of skills.

Despite the advent of computer programming techniques, which attempt to optimise the positioning of space, the ability of the human architect to take into account a large number of factors and bring them into a suitable relationship has not yet been surpassed.

A number of techniques have been developed to assist the architect in this important task, and perhaps the most common is the association matrix. In this design aid, the relationship between spaces is identified in a table rather like a 'mileage between towns' indicator in a road atlas. The figures in the table, however, will relate to the 'cost of communication or movement' related to a unit of distance between spaces rather than measured distance. For example, the salary cost of the managing director spending time in walking 1 m may be five times that of the administrative clerk. It follows that the MD's office should be given priority in being closer to the centre of communication.

Problems arise in this technique when the subject has no direct wages cost, for example the casualty patient in a hospital who does not cost the hospital administration any salary. Without an artificial weighting factor, hospitals might be designed with the patient always taking the longest route!

The simplest form of the matrix is that in which a simple weighting system is used to define the ease of movement between spaces. To illustrate the use of such a table, let us take the example of a new administration/accommodation wing added to the existing appliance garage of a fire station. The spaces required by the fire authority are as follows:

BLANKSTOWN: EXTENSION TO EXISTING FIRE STATION

Space	**Area (m^2)**
(1) Administration area including watchroom	120
(2) Lecture room	80
(3) Firefighters' dormitory	140
(4) Television room	25
(5) Recreation room	150
(6) Mess and officers' lounge	200
(7) Visitors'/administration toilet and wash room (male and female)	25
(8) Visitors' entrance	10
(9) Firefighters' entrance	20
(10) Firefighters' ablutions area	40
(11) Appliance garage (existing)	820

The first step is to identify a suitable scale for the ease of movement required between spaces. The following may be considered reasonable:

Weighting	Degree of 'ease of movement'
5	Essential
4	Desirable
3	Tolerable
2	Undesirable
1	Intolerable

By considering the relationship of each space to the other spaces, an association matrix can be established using the above key.

It can be seen from the developed matrix (Figure 9.3) that the crucial space is the existing appliance garage. This is fairly obvious as the efficiency of the station is centred around the ability of the firefighters to reach their equipment quickly when an emergency call is received. The next step is to arrange the spaces in a diagrammatic form to show the desirable 'clusters' of accommodation. This is usually shown by means of a 'bubble' diagram identifying the

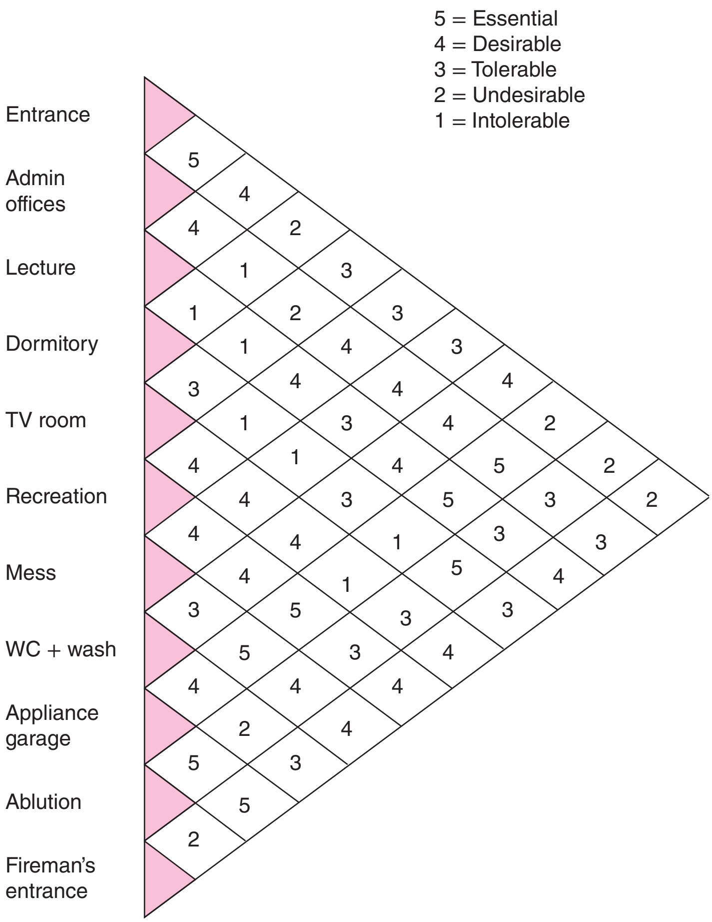


Figure 9.3 Design method association matrix – ease of movement between spaces, extension to Blankstown Fire Station.

spaces and their required links. In arranging the groups of spaces, consideration needs to be given to important constraints, such as the site, which may not allow ideal groupings to be made. For example, the parking and practice area required behind the fire station may restrict the usable site area and force a two-storey solution. The resultant bubble diagram incorporating the site constraint and association table may be as indicated in Figure 9.4.

The bubble diagrams reinforce the relationship between spaces and emphasise the view that the appliance room is the controlling factor in any arrangement. In addition, the size of the spaces is illustrated, and a visual indication of the likely room clusters is given ready for incorporation into a suitable building form. The efficiency of spatial arrangements in building

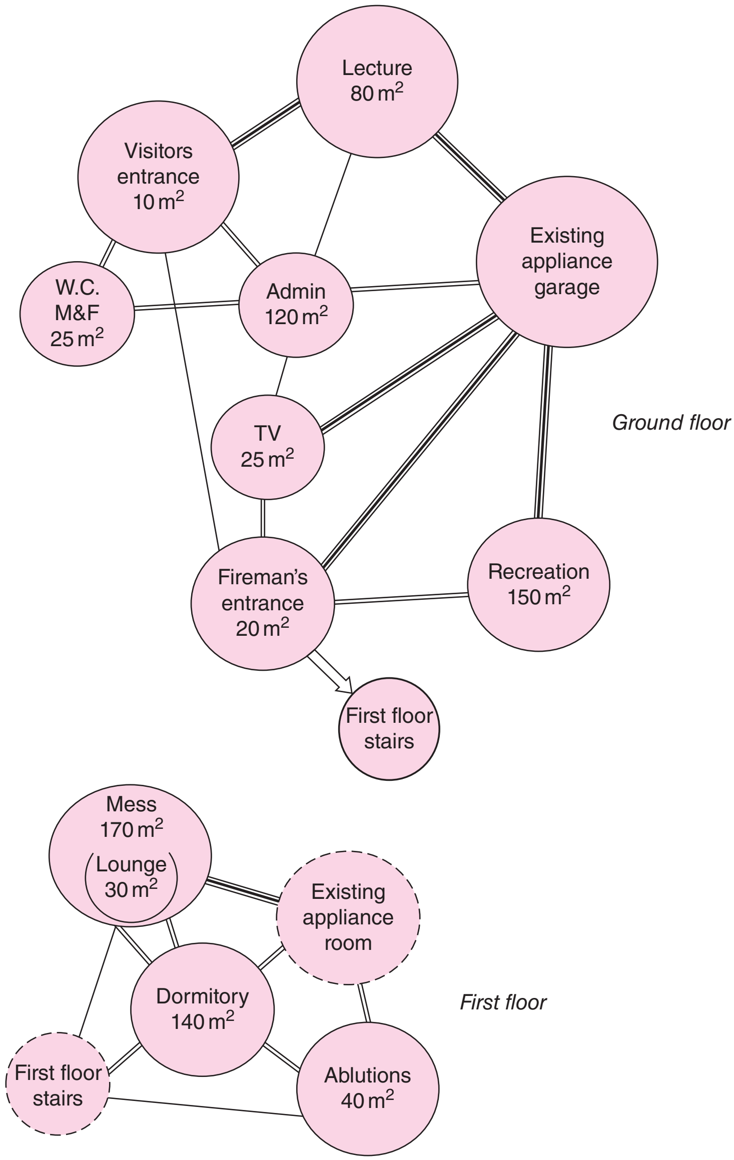


Figure 9.4 Bubble diagram.

is not a field that has involved the cost adviser to any great extent in the past, apart from commenting on the ratio of circulation space to usable floor area. In buildings in which ease of movement between spaces is a priority, such as those housing industrial processes, this area of study may prove fruitful for cost research and investigation as the layout has a major effect on the overall economy of the scheme.

9.7.4 'What form should the building take?'

Answering this question involves another person of the essential design skills of the architect, who should be able to translate the functional spatial arrangement of the bubble diagram into a building form that will reflect the relationships determined. In doing so, the architect will also be aware of the constraints that usually reduce the design options considerably, the largest constraint in many cases being the site itself. In other cases, planning requirements or cost limits may be paramount.

In the case of the Blankstown Fire Station, the available site area is considerably reduced by the need for a practice yard at the rear. The orientation is also fairly limited because of the desirability of having a frontage on to the High Street. The resultant plan is an attempt to segregate administrative areas from recreation/work areas and at the same time provide speed of access to the appliances from any part of the building or surrounding areas.

Figure 9.5 illustrates the first sketch of a design that may be suitable. Note that from force of circumstances, the architect has had to use open space in rooms for through access to the appliance garage. The visitors'/administration toilet facilities have had to be split between ground and first floor to obtain male and female facilities. In addition, an attempt has been made to isolate noisy areas from the quiet/rest rooms and the recreation block has been set back, thus providing passing motorists with a better view of the garage doors – very necessary in an emergency.

It is interesting to note that it is at this stage that the cost adviser is usually first asked for an estimate, yet it is clear that there is already a heavy commitment to space, circulation and form standards. In addition, the specification standard will probably have been indicated in the brief, and therefore the degree of cost control that can be exercised from this point on is severely limited. This reinforces the view that cost advice is most effective if given prior to the sketch design.

A request to design a more compact form once the architect has already produced a solution is likely to involve considerable effort – and also resentment. One of the aims of good cost budgeting must be to avoid abortive effort and therefore to advise where cost-acceptable solutions are likely to be found.

9.7.5 'What is the level of specification?'

This is very often the decision that has the least external constraint. It is also the design decision that suffers most when cost reduction is required at a late stage of the design process.

At the present time, there are very few numerical techniques that attempt to measure quality. It is therefore a decision that is based largely on intuitive judgement arising out of the previous experience of the design team.

The client's brief has attempted to give an indication of need, perhaps in the form of a requirement for soft or hard finish in certain rooms, maintenance-free exterior and so on. Standards of environmental comfort and the need for prestigious public areas will also have been conveyed by the client.

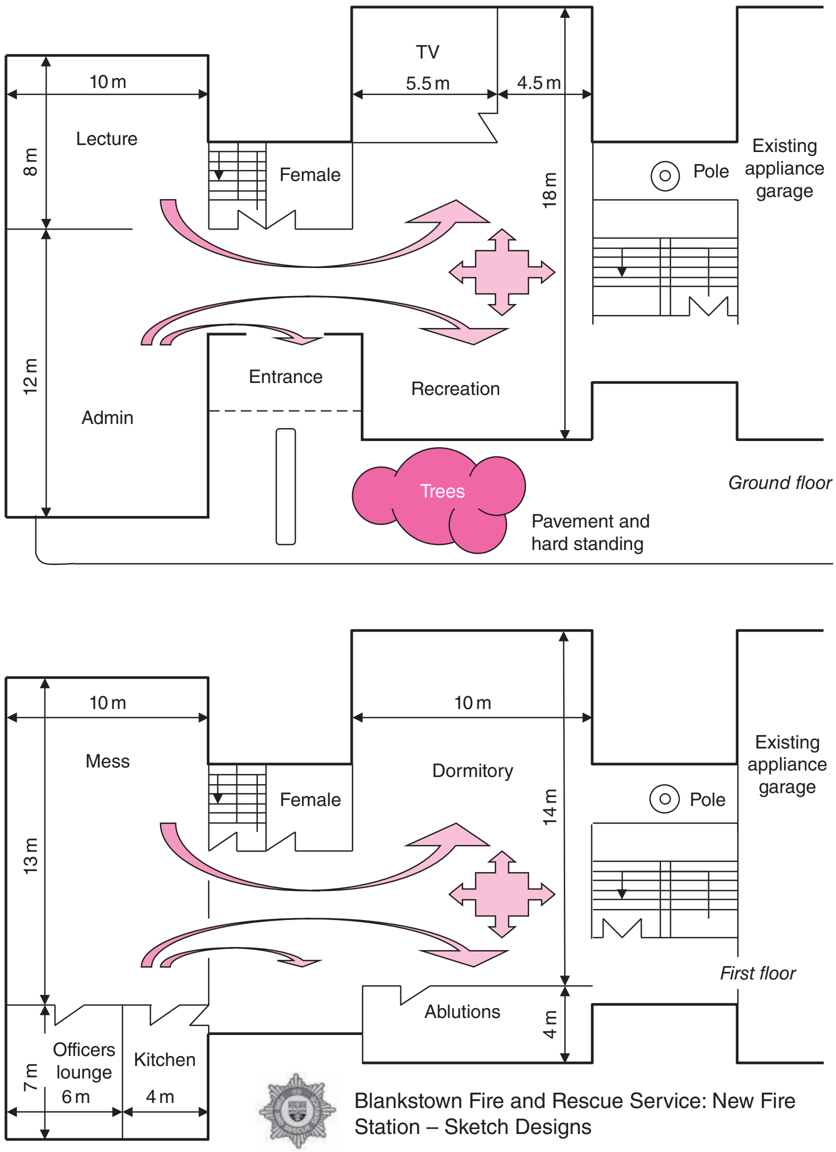


Figure 9.5 Sketch plans for Blankstown Fire Station.

In these circumstances, the selection by the designer has to be narrowed to those materials that will fulfil the function required, and a selection was done based on comparative performance. An important aspect of that performance will be the economic considerations of installation and durability that will generate capital, maintenance and operational costs.

One role of the cost adviser should be the production of alternative estimates for each major solution, in order that the cost implications of a decision can be known.

9.8 Generally

The above series of questions is a gross oversimplification of the design problem and the text has been orientated towards those factors, which have cost implications. The object has been to give the student, in disciplines other than architecture, a grasp of the early stages of the design problem and the potential for economic advice, and in particular to dispel the common misapprehension that the architect starts work by sketching a building form neatly divided up into rectangular rooms and passages.

However, it should not be assumed that a linear chronological order has necessarily been implied by the sequence of the above questions. In some cases, a linear sequence may be the method adopted for the solving of a particular problem, but in the vast majority of cases there will be a good deal of overlap. There may be simultaneous decisions covering all the points discussed and possibly reversal of the process.

The above procedure has been largely a process of designing from the 'inside-out': from internal space requirements to external form. In buildings, where external form is important or the site constraints are very tight, then it may be necessary to design from the 'outside-in'.

Each individual designer's methods and techniques have been developed to suit that particular person's approach – not every architect, for example, will use numerical methods to assist in deciding on circulation priorities.

There are, of course, a large number of design decisions still to be made on Blankstown Fire Station and these include the following:

- the working and arrangement of the building services;
- the sizing and choice of the structure;
- the fixing of components;
- the detailing of the specification.

Some of these decisions will be made in conjunction with those already outlined, and in fact may depend upon those decisions and vice versa.

Design cannot be neatly contained in water-tight compartments of sequential decisions, and this does make the input of information by other consultants more difficult.

An understanding of design method will, however, help the cost adviser to know when cost advice is likely to be most helpful in its contribution to solving the design problem. It will also assist in determining the degree of refinement in cost advice that will match the stage of detail in the design process.

9.9 Recognition of design methods in cost information systems

It is generally recognised that any cost information system must be compatible with design method. However, unless cost is of paramount importance, it should not dictate the approach the designer takes – if the financial tail wags the project dog this will not normally be conducive to satisfying all the client's requirements.

The cost adviser should also be aware that striving to achieve optimisation in cost is only a part of the total objective. While all consultants would like to achieve optimisation in their own subsystem of activity, it is the performance of all systems acting together that will determine the degree of client satisfaction.

Two examples will suffice to demonstrate recent attempts that have been made to marry cost advice to design method in the pre-sketch design stage, when the major cost-significant decisions are made. The systems are not fully developed but they give an indication of current trends.

Since these are the first of many cost control systems at different levels, it is necessary to highlight that systems such as the following represent overall strategies within which a cost control process operates. It is very rare in practice, however, for the cost adviser to have sufficient resources available to be able to carry out every single step of the strategy with respect to every aspect of the design, and it is doubtful that this would be a very economical thing to do in any case.

Just as a general commanding, an army cannot afford to attack all along a front but must concentrate its efforts at the most sensitive points, so the cost adviser's resources must be used where they will be most effective. This level of intuition and understanding is probably one of the most important and difficult parts of the cost adviser's job, and is one of the things, which makes it a truly professional task.

9.10 An evaluative system

In this system, the cost adviser attempts to evaluate the cost implications of design knowledge and decisions immediately they are postulated. Design is considered to be the arrangement of spaces into a building format. The procedure could be as follows:

Designer receives brief with floor areas given	Cost adviser evaluates cost of alternative finishes
Designer organises rooms into groups and location in a building shape and form	The form generates a type of production method and site transportation which the cost adviser evaluates
Designer looks at the structure needed to support the chosen form	Cost adviser evaluates cost of alternative forms of support
Designer selects envelope strategy	Cost adviser evaluates alternative specification of external walls and roof
Designer organises circulation and services layouts	Cost adviser evaluates alternative arrangements of lifts, service runs and corridor space

There are two problems with this method.

- **It assumes a 'linear' design method, with each event occurring after the other, although in practice these decisions are made on an iterative process. This concept is closely related to the Whole Life Cycle Cost process, which again should be iterative and conducted simultaneously with design.**
- **It depends on the generation of information by the designer before evaluation can take place, and therefore gives no indication as to where to look for a good cost solution prior to a committed decision being made on building form.**

It is, however, a significant step forward in providing an evaluation of the decision-making process prior to sketch design.

9.11 A strategic cost information system

By use of this method, the cost adviser attempts to explore a range of possible solutions available to the designer using a structured 'search' process in which the designer is involved. The object is to identify a cost 'strategy' which the designer can employ in the synthesis of building form and which will avoid abortive redesign at a later date. The procedure may take the following form:

Design team receives brief with accommodation area and quality standard given	Cost adviser explores the cost of different components of the building according to changes in the major design variables (e.g. the area and shape of a bay in a structural frame)
Design team selects the specification and parameters for each component from the explorations undertaken	Cost adviser explores the use of these components and parameters in buildings of different shape and height according to a predetermined series of building descriptions, for example, plan shape, number of storeys, density of partitions. A cost table is produced of the feasible solutions available within the identifiable constraints
Design team identifies the lowest total cost from the table and uses it as the point of reference for selecting any other alternative	Cost adviser contributes to the discussion of an alternative solution
A solution is chosen from the table by the design team	Cost adviser provides a breakdown of the major component costs, which is then adopted as the point of reference for the initial cost plan for use in traditional budgeting. The design variables incorporated in the selected solution are communicated to the designer
Designer uses the parameters and descriptions as guidelines in the preparation of the design solution	Cost adviser uses traditional budgetary procedures to maintain control

The descriptions conveyed to the architect for the design strategy should not be so rigid that a 'strait-jacket' is imposed resulting in only one possible solution. Rather, they should be 'coarse' measures which still allow reasonable scope for using the designer's skills of modelling and spatial organisation within the strategy adopted by the team as a whole. The choice of descriptors is important in making sure that the creativity of the designer is not stifled.

The advantage of this method is that it attempts to undertake a systematic search through possible solutions in order that the design team may identify the preferential options based upon cost. It identifies a 'least cost' solution, which can then form the point of reference for any alternative selection. It is, therefore, possible to obtain a gauge of value by comparing a specific choice with the lowest cost.

There are, however, quite a number of problems. The setting up of 'models' that will cope with the large number of components and design variables is an onerous task, even though the models need not be very refined at this stage of the design process. It is also extremely difficult to produce a satisfactory range of descriptors, which will be simple enough for the design team to incorporate into their thinking and also comprehensive enough to allow a reasonable evaluation of the building as a whole.

Both the evaluative system and the strategic approach depend heavily on the use of computers to provide the information sufficiently quickly for decision-making purposes.

9.12 Key points

An understanding of design method enables the cost adviser to know:

- the time when cost advice will be most effective;
- the type of advice that needs to be given;
- the objectives of the design team additional to minimisation of cost.

It would appear that the earlier the advice is given, the greater the chance of the advice being incorporated into the final design solution. The need for techniques that contribute to the analytical understanding of the problem and assist in the convergence of the best solution within the shortest possible time is the key. The development of cost models and IT-based solutions appear to offer a way forward in achieving these objectives.

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Endnote

1 The process map was published in the Final Report of EU TG4: Life Cycle Costs in Construction, 2003.

Chapter 10

Standard Methods of Cost Modelling in Design

10.1 Prototypes

When a manufacturer, say Audi, for example, produces a new motor vehicle, the process of product development they adopt will involve the construction of a prototype model. Often a number of prototypes will be developed before a final design solution is attained. Audi will do this for a number of reasons, including the following:

- To identify and solve three-dimensional problems that are not apparent in the drawings.
- To identify the tools required for production.
- To help estimate the cost of production.
- To test and evaluate its functional performance.
- To test its marketability.
- To provide a sample for a customer as evidence of the quality standard to be achieved.

By building, manipulating and testing the prototype, the manufacturer can iron out and avoid future problems when the product is actually manufactured, supplied or sold. However, it is not always feasible to build a prototype, and in the case of buildings there are particular problems.

- Buildings are very large and prototyping would be prohibitively expensive.
- They are intended to last for a very long time, and it would be difficult to simulate this in prototype testing.
- Normally, only one production model is to be constructed and the prototype costs cannot be written off over a large production run.

Therefore, because of the time needed for construction and the great expense and the individual nature of buildings, it is just not realistic to construct trial examples of a whole project to see whether or not it will work satisfactorily. This concept is interesting since 'Rethinking Construction' advocated the merits of understanding process such as manufacturing and production and applying these to the construction industry. This contention elicited some criticism from the industry, particularly given the significant variance between the manufacturing scenario and the traditional construction environment.

It may, however, be possible to build and test samples of major components, and this possibility may need to be taken into account in cost planning a building, which is to incorporate some measure of innovation or a great degree of repetition.

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

It might be interesting at this point to mention the **Sydney Opera House**, a building of great prestige and enormous innovation, where the construction and testing of prototypes and mock-ups were undertaken on an exceptional scale. The result of this was that very few problems were encountered in the use and maintenance of the building, considering the potential for trouble in a project of this nature, but of course a considerable penalty was paid in terms of construction time and cost and the political fallout that ensued (see further reading for an excellent text on this iconic building).

10.2 Other types of model

If physical prototypes are not normally possible, the design of a building must still be assessed in some way to try and ensure that the demands of the client are going to be satisfied. For the sake of expediency and cost, it is, therefore, necessary to construct models that represent the real situation in another form, or to a smaller scale, so that a realistic appraisal of performance can be made.

There are many approaches to doing this including

- physical (such as a typical architectural model);
- three-dimensional (i.e. computer-aided architectural design (CAAD) systems);
- mathematical;
- statistical (where data is used to perhaps forecast or identify trend or variance);
- simulation (e.g. using mathematical algorithms to evaluate building performance – HEVACOMP[1]);
- BIM (Building Information Modelling).

Today, CAAD is the most common approach to modelling building designs. The power of modern day CAAD systems in allowing designers to produce three-dimensional, fully rendered designs represents a significant step forward. The first generation of CAAD and the geometric modelling that is associated with it were utilised widely in the manufacturing industries. Realising the potential, designers in the construction industry readily adapted to this new technology.

Cost is one of the measures of **function and performance** of a building and should therefore be capable of being modelled in order that a design can be evaluated. In recent years, a considerable effort has been made to construct models that will help in the understanding and prediction of the cost effect of changing design variables.

Cost modelling may be defined as the symbolic representation of a system, expressing the content of that system in terms of the factors, which influence its cost. In other words, the model attempts to represent the significant cost items of a cash flow, building or component in a form, which will allow analysis and prediction of cost to be undertaken. Such a model must allow for the evaluation of changes in such factors as the design variables, construction methods, timing of events and so on.

The idea is to simulate a current or future situation in such a way that the solutions posed in the simulation will generate results, which may be analysed and used in the decision-making process of design. In terms of quantity surveying practice, this usually means estimating the cost of a building design at an early stage to establish its feasibility.

10.3 Objectives of modelling

Models for estimating and planning costs have evolved gradually. Their adoption by the profession at large has led to the establishment of what might be called 'traditional' techniques. These will be discussed and referred to in this chapter, together with some more recent developments.

At this stage it is useful to consider what a good cost model should be attempting to achieve. Traditional and future models can then be tested to see to what degree they comply with this set of requirements. The broad objectives can be listed as follows:

- To give confidence to the client with regard to the expected cost of the project, that is, economic assurance.
- To allow the quick development of a representation of the building in such a way that its cost can be tested and analysed.
- To establish a system for advising the designer on cost that is compatible with the process of building up the design. This should be usable as soon as the designer makes the first decision that can be quantified, and should be capable of refinement, to deal with the more detailed decisions that follow thereafter.
- To establish a link between the cost control of design and the manner in which costs are generated and controlled on site. This involves dealing with the cost of resources at as early a stage as possible to aid communication between the design team and those responsible for managing the construction process.

Linked to these objectives will be some guiding principles, which can be applied to the way we approach and verify the model. These may be summarised as follows:

- The degree of refinement of the model should be tailored to suit the stage of design refinement, and should call on as much design information as is available at the point in time when the model will be used. The cost data applied to this information should represent the degree of reliability that can reasonably be expected from an estimate at that stage.
- The cost data in the model should be capable of updation and evolution in the light of changes in external market and environmental conditions, without too much time being involved.
- The representation of the building or component in the model should bear an understandable relationship to the design method (e.g. the arrangement and use of space) and if possible the manner in which the costs are incurred (e.g. the production method). Ideally the model should show the relationship between the client's objectives expressed in the brief and the subsequent cost of resources used to achieve these objectives. This is, however, an extremely difficult task as many of these objectives will be of an intangible nature.
- The model should cope with constraints imposed on design and be able to test the feasibility of a proposed solution within these constraints in order that definite decisions can be made.
- The results of the model should enable this knowledge to be incorporated by the designer into the drawings, specification and quantities, so that they form part of the strategic decision-making process.

10.4 Traditional cost models

If the above definitions are understood, it becomes clear that quantity surveyors (QSs) have been using a form of modelling technique for a number of years. In their measurement for bills of quantities (BQs), they have been representing the building in a form suitable for the contractor's estimator; and when prices are applied to the measured quantities the BQ becomes a representation (or model) of the cost of the building. By altering the quantity of the measured items or changing the price according to variations in specification, it would be possible to evaluate the effect on cost of manipulating certain design variables.

However, the BQ has to be prepared at a very late stage of the design process, and any information obtained from changing the quantities or price rates would come too late to avoid abortive design effort. An estimate obtained from a BQ would also be too late to give an indication of the client's likely cost commitment at the outset of the project or allow any cost control to be exercised.

10.5 Horses for courses

There is, therefore, an obvious need to employ much simpler models at an earlier stage of design to overcome these problems. The complexity of the model will depend largely on the amount of information the designer can provide to the cost consultant because of the following reasons:

- There is little point in using a complex model that takes into account the shape and layout of the building if all that has been determined is an idea of the approximate area of accommodation.
- Conversely, it is wrong to use an oversimplified costing technique when the building form and specification is known and sufficient time is available to do a more thorough job.

As so often the case, the selection of the most appropriate technique is a case of selecting the right 'horse for the course'.

10.6 The pyramid

Figure 10.1 shows some of the more traditional models that have been developed over the years to suit various stages of the design process. The pyramid is an attempt to show that more details are required in the structure of the model as we descend the list.

10.7 Single price rate methods

The first two model types ('unit' and 'space') are basically 'single price rate' methods of estimating cost, and those of practical application have already been dealt with in Chapter 9.

10.7.1 The storey enclosure method

This single price rate system is now of historical interest only, but it was the first attempt to compensate for such factors as the height and shape of buildings. In this method, the areas of the various floors, roof and containing walls were measured, each then being weighted by a different percentage and the resultant figures totalled to give the number of storey enclosure units. The rules were as follows:

- The area of the lowest floor multiplied by 2 (or by 3 if below ground level).
- The area of the roof (measured flat).

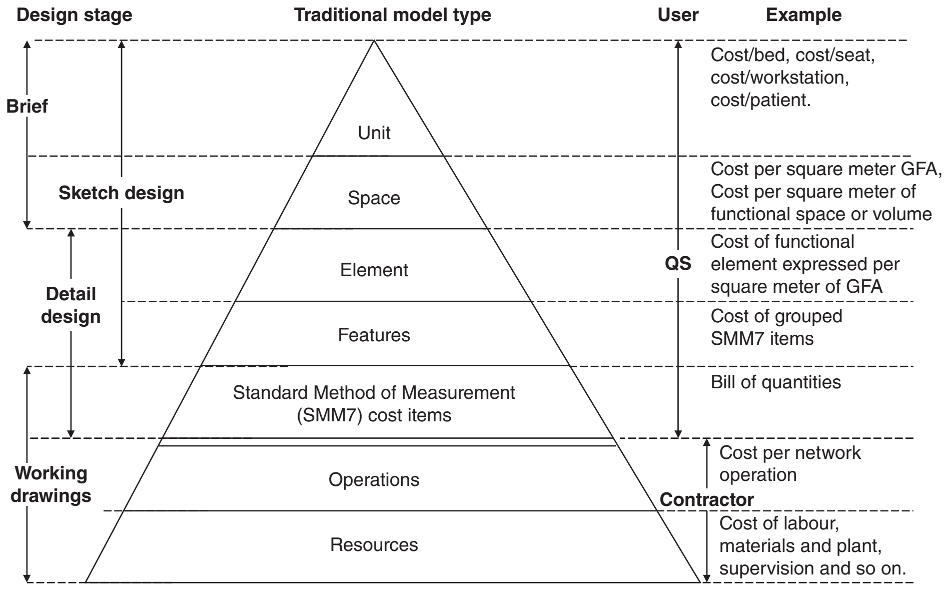


Figure 10.1 Traditional cost modelling.

- The area of the upper floors multiplied by 2 plus a factor of 0.15 for the first floor, 0.30 for the second, 0.45 for the third and so on.
- The area of the external walls, any part below floor level being multiplied by 2.

It was recommended that lifts and other engineering services should be excluded from the calculation and worked out separately. This is common practice in single price rate estimation and applies equally to the cubic and superficial methods.

The system depended heavily on the **weightings**, which were permanently built into the rules, and these were unlikely to apply equally to every building. In addition, the measured units tended to be abstract, not relating to the physical form of the building nor the client's accommodation requirements. Therefore, the technique suffered from deficiencies similar to those of the cube method. The paper presenting the method (in the early 1950s) claimed that in tests it had performed far better than the other single price approaches, but lack of use meant that it was never possible to verify this claim in practice. It never achieved wide acceptance because it was quickly superseded by the **elemental estimate**.

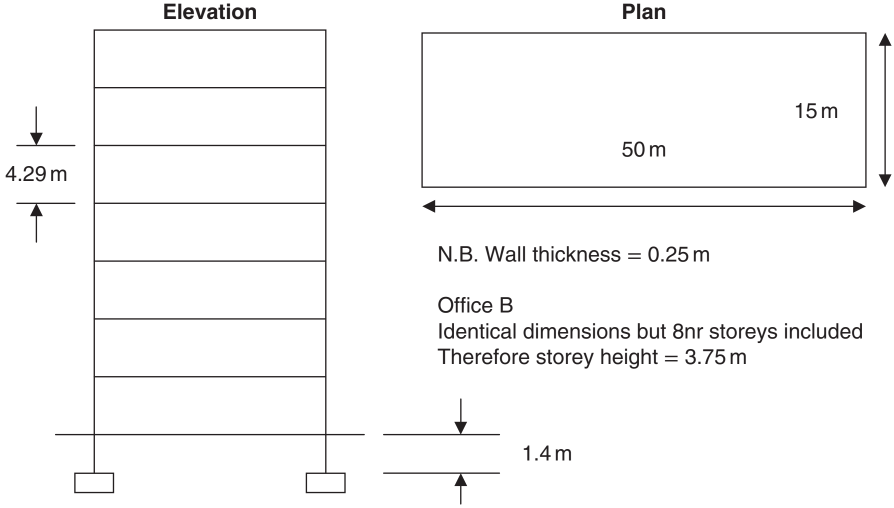
10.7.2 Comparison of single price methods

Figure 10.2 shows each of the cubes, superficial area and storey enclosure methods applied to a multi-storey office block. The actual cost of each building is known and the analysis of building A is used in each case to forecast building B. The buildings have exactly the same dimensions, except that A has seven storeys and B has eight storeys within the same envelope.

- It can be seen that the cubic method has not taken into account the extra floor, and there is, therefore, a shortfall of approximately 12% on the estimate.
- The superficial method, on the other hand, has overcompensated for the extra floor by not taking into account the fact that the envelope area remains the same. It has, however, produced a more reasonable figure.

Dimensions

Office A



N.B. Wall thickness = 0.25 m

Office B
Identical dimensions but 8nr storeys included
Therefore storey height = 3.75 m

Office A

Actual cost	= £1,758,000	Cube	= 24,000 m^3	Storey height	= 4.29 m
Area	= 5024 m^2	Nr storeys	= 7	Foundation depth	= 1.4 m

Office B

Actual cost	= £1,995,000	Cube	= 24,000 m^3	Storey height	= 3.75 m
Area	= 5742 m^2	Nr storeys	= 8	Foundation depth	= 1.4 m

Cubic metre

Office A analysis

$$\frac{£1,758,000}{24,000} = £73.25/m^3$$

Office B forecast
£73.25 × 24,000 = £1,758,000

Error
Underestimate of ≈ 12%

Square metre

Office A analysis

$$\frac{£1,758,000}{5024} = £349.29 / m^2$$

Office B forecast
£349.92 × 5742 = £2,009,000

Error
Well within acceptable range

Storey enclosure

Office A analysis

		m^2
Lowest floor	717.75 × 2	= 1435.50
First floor	717.75 × 2.15	= 1543.16
Second floor	717.75 × 2.30	= 1650.83
Third floor	717.75 × 2.45	= 1758.49
Fourth floor	717.75 × 2.60	= 1866.15
Fifth floor	717.75 × 2.75	= 1973.81
Sixth floor	717.75 × 2.90	= 2081.48
Roof	750.00 × 1	= 750.00
External walls	717.75 × 1	= 3900.00
		= 16,959.42

$$\frac{£1,758,000}{516,960} = £103,65 \text{ SEU}$$

Office B forecast

As above	16,959.42
Add	
Extra floor (seventh) 717.75 × 3.05	2189.14
Total	**19,148.56**

19,149 × £103.56 = £1,984,800

Error
Well within acceptable range

Figure 10.2 Comparison of single price estimating models using a cost analysis of Office Block A to forecast Office Block B.

- The storey enclosure method, by considering both envelope and floor, has certainly produced an even closer estimate well within acceptable limits for this kind of early exercise.

However, in each case, a change in specification, site or location would result in additional problems and call for the skill of the cost adviser's judgement to compensate for the changes. In addition, changes in plan shape and storey height would affect the cubic and superficial methods to a greater or lesser degree. These alterations, or variables, are enormously complex and difficult to assess.

Although adequate for establishing a budget, it will also be remembered that such an estimate suffers from the defect that during the development of the design it is not possible to relate the cost of the work shown on the working drawings to the estimate.

It is for these reasons that single price rate methods now tend to be rejected except for the very earliest estimates where little is known about the building form.

10.8 Elements

The model by which design cost planning has been best achieved is that of dividing the building into functional 'elements' (level 3 of our pyramid).

Elements are defined as major parts of the building which always perform the same function irrespective of their location or specification, for example,

- internal partitions always vertically divide two internal spaces;
- a roof encloses the top of a building and keeps the weather out and the heat in;
- the substructure transmits the building load to the sub-soil.

These elements have some relation to the design process, can be readily measured from sketch drawings and are easily understood by all parties including the client, thus aiding communication.

Example

Suppose an external wall element costs £80,000 and the area of the wall is 1000 m^2. The cost per square metre of wall (known as the elemental unit rate) is £80.00. If there are 1500 m^2 of the same type of wall on the proposed project, then the cost will be

$$\frac{£80,000}{1000\,\text{m}^2} \times 1500\,\text{m}^2 = £120,000$$

A cost index (see Chapter 12) is then used to update the prevailing price levels to the proposed tender date and the new estimate for that part of the building has been established. Having set out a series of estimates, one for each element (known as cost targets), it is then possible to consider each element in turn instead of trying to cope with the whole building. Costs can therefore be monitored as the design develops.

10.9 Features

Cost models based on features (groups of abbreviated quantities) rather than elements were popular for a period among some major local authorities, but this non-standard approach was never widely used and disappeared with the decline in local authority building programmes.

10.10 Standard Method of Measurement (SMM7) – the bill of quantities as a cost model

Level 5 of the model pyramid shows the position of the BQ in terms of the detailed modelling used in traditional techniques. There has been an attempt in the current revision of the rules for measuring BQs (the *Standard Method of Measurement of Building Works*, seventh edition) to orientate the measurement of the building to the way costs are incurred on site. However, the vast majority of items are still largely measured 'in place'; that is to say that they are measured as fixed in the building with no allowance for waste and no identification of the plant required during installation.

Consequently the BQ remains primarily a document for obtaining a tender in a short space of time, rather than a document for management and cost control of construction on site. It is not possible, for example, to ascertain the lengths of timber required for roof joists from this document (although this must have been known by the measurer) or the hoisting requirements for materials and components, unless the document has been annotated for the purpose.

In the case of levels 1–4 of the pyramid, the data used are actually based on an analysis of a BQ, which is somebody else's view (the estimator's) of what the firm needs to charge for the resources, plus profit and overheads. Because of the large number of assumptions upon which a BQ price is based, it is most unlikely that the real mix of resources that will be used for the project has been determined by the estimator. The factor that allows cost techniques based on the BQ to work is the knowledge that the overall cost of the job, which has been analysed to provide data for the model, is the 'going rate' for that building.

The Royal Institution of Chartered Surveyors (RICS) Quantity Surveying and Construction Professional Group has issued a new standard set of measurement rules (NRM) new rules of measurement. NRM is a suite of documents that aim to provide an understandable advice and best practice guidance for cost management of construction projects worldwide. This suite addresses all aspects of rules to provide essential guidance during the preparation of bill of quantities (BQ), schedules of works, schedules of rates and similar pricing documents, as well as cost control. The NRM suite comprises the following:

- NRM1 – contains the instructions of cost estimating and cost planning for capital building works. These instructions intend to underpin the procedures of designing buildings and budgets.
- NRM2 – contains detailed measurement for building works. This is a supporting set of rules providing detailed rules for the measurement and description of building works for both capital and maintenance projects.
- NRM3 – contains the instructions of cost estimation and cost planning for building maintenance works.

NRM2 is a simplified and modernised form of the existing Standard Method of Measurement for Building Works (SMM7) rules; it provides a detailed set of measurement rules to support the procurement of construction works and uses a protocol that should allow the QS to measure areas where most costs exist. According to Stuart Earl, chairman of the RICS Measurement Initiative NRM2 is seen as a replacement for SMM7, which was discontinued in 2013.

Consequently, the RICS Building Cost Information Service (BCIS) has updated the elemental Standard Form of Cost Analysis (SFCA) to reflect the new rules; the consequence of this should bring improvements to the accuracy of cost analysis and the generation of whole life costing data sets. We will look at the SFCA in a little more detail later in this chapter.

10.11 Operations and resources

The last two levels, 6 and 7, are indeed more closely related to construction.

A contractor's **network** outlines the activities or operations in the order that they will be undertaken on site. For example, external cavity wall brickwork, which may be one item in a BQ, will be broken down into floor levels and possibly into zones marked on the floor plan. This aids site management and the organisation of labour, plant and material.

These basic resources form the most detailed level of modelling as they are the ingredients of the production process. In fact, all the other models used for cost forecasting entail the assumption that the resource requirements of the building will just happen to work out OK (because they usually do).

10.12 Spatial costing

Some 30 years ago, a variation on the superficial and elemental methods was developed under the title of spatial costing. In this method, the basic concept was the cost of a room of a certain type, taking account of its floor area. There is a high correlation between the cost of room finishes, fittings, ceilings and walls, and the activity for which the room is designed.

If, at the brief stage of design, all that is available is the accommodation schedule (i.e. the list of required rooms), then it should be possible to forecast the cost of these items quite reliably as a function of the areas and, if possible, shapes of each room or space. The other major items of structural frame, foundations, external envelope and main services would then be considered separately.

The wall costs attaching to a room would be the cost of the finishing plus 50% of the structural partition, which is similar to that of the floor and ceiling. The extra cost of external walls over and above the 50% partition costs, and the extra cost of roof over the ceiling costs, are added on a measured basis as are the other exclusions which have been mentioned.

A major problem in using this system, or any other system that depends on BQ analysis, is the chicken-and-egg situation whereby

- no system is going to become widely used until there is a considerable body of data to support it, but
- no one is going to spend money on analysing BQs to provide data for a system which nobody is yet using.

The cost and difficulty of preparing detailed analyses have been contributory causes of the lack of data available for elemental cost planning. The room concept requires even more complex analysis and therefore would be even more expensive to use. The system also lacks the simplicity of the elemental form and the clear communication of what is meant and included.

10.13 Synthesis

Although single price rate estimates have their drawbacks, these simple models of building cost are very useful for budgeting and other very early estimates where little information is available about the configuration of the proposed building. Of these the most commonly used is the superficial floor area method, and there is a good amount of data available for it. At later stages more detailed methods, such as elemental cost planning, should be used. However, a 'cost plan' without subsequent cost control is still really nothing more than an 'approximate estimate'.

10.14 Design-based building cost models

Building cost models are basically of two kinds.

- A product-based cost model is the one that models the finished project.
- A process-based cost model is the one that models the process of the project's construction.

It is often argued that since it is the process that actually generates the costs, the second of these two models must be the more accurate. However, the construction process cannot be modelled until the form of the building has been postulated, and therefore the process-based model has little place in the scheme of things in the early design stage. In fact, an attempt to model the construction process at too early a stage can have the effect of over-riding the design process in order to arrive at a bricks-and-mortar solution before the user criteria have been properly worked out. Construction process modelling, therefore, has its place at a later stage in the cost planning process, and will be dealt with in due course. For the moment, therefore, we must be concerned with modelling the product. Such a model has to be based on data relating to finished work.

As we discussed in Chapter 8, the simplest form of such a model takes no account of the configuration, or details of design, of the building but is simply based on one of the following: the floor area of the proposed project (gross or net); the volume of the proposed project; some user parameters such as the number of pupil places for a school or the number of beds for a hospital. It is customary to exclude site works from the single price rate calculation and to estimate them separately, since their cost obviously has no relationship to the size of the building. The engineering services are also sometimes treated in the same way (with rather less justification). After the World War II and before cost planning systems became established, single price rate estimates increasingly acquired a reputation for inaccuracy, but this was because there was no follow-up process for keeping the estimate and the design in tune as the design developed. Such an estimate merely attempts to forecast that a building of a certain size can be built for a certain sum of money. It cannot analyse whether a particular design is going to meet that cost. Of course, it is possible to weight the estimate subjectively on the grounds that the proposed solution looks to be at the expensive end or at the low-cost end of the market, but here we are well into the realms of guesswork. However, although it cannot say that a particular design will achieve the required result, the single price rate approach has an important role as the first stage of a system which in the end will do that. It has the great advantage that it can be used before any design has taken place, whereas even the most simple process-based models require a tangible design as their basis.

10.15 The bill of quantities

The traditional BQ is a very good example of a product-based cost model. Because of its insistence on measuring 'finished work in place', the BQ has often been criticised by production-oriented people (although it never purported to be a production-control document), but it does have the virtue of providing a total cost model within a single document. There are two important points in favour of the product-oriented approach to this definition of the project:

- What the client will be contracting for is finished work in place, not a production process. The model is therefore couched in contractual terms.

- The design team can define and categorise the finished work, according to an industry agreed convention (The Standard Method of Measurement of Building Works: Seventh Edition or SMM7). This is not the case with the production processes, which depend as much on the methods of the particular constructor as on the details of the design, and which cannot easily be analysed or categorised outside the context of the particular project – there is no agreed basis for doing this.

Although the BQ is a useful cost model, it is not usually available until the design of the project is completed, and it is therefore of little use for cost control of that design. Its great importance, however, is as a source of cost data for subsequent projects.

Since the BQ is a major source of cost data, it is important to be quite clear about its role. It is essentially a marketing document, not a production control document, and the rates in it are prices not production costs. Although there clearly has to be a relationship between the builder's prices and the builder's costs, this really only applies at the level of the total project. The building firm cannot afford to undertake the project for less than its costs, and competition will usually ensure that it cannot charge an unreasonable profit on top of them.

This does not apply to individual pieces of work, however, because the rates in the BQ are not separately offered prices in the sense of the supermarket shelf. You can only buy the brickwork at so much a square metre if you also buy the carpentry at whatever price is charged, so these rates are nothing more than notional breakdowns of the total price, and are made with commercial rather than cost control objectives in mind. Very often the client's QS will object if the rate for a particular item is very different from that usually charged, but there is very little sanction to enforce an objection, except the rather impracticable one of advising the client not to accept the tender.

10.16 Elemental cost analysis

Elemental cost analysis is perhaps the most common product-based cost model and provides the data upon which elemental cost planning is based. This technique is currently used by the quantity surveying profession at large and, in spite of a number of failings which have become apparent over the years, has made possible a degree of control over costs which was previously unknown. It is the experience gained with this system, and the attitude of mind which it has engendered, which has led the way to more fundamental approaches to cost control. Because elemental cost analysis was developed in order to provide data for the preparation of a design cost plan, it is first necessary to look at the requirements of the latter. This is done in the context of the traditional competitive tendered type of contract, which is still popular but which at the time the system was developed was almost universally used. What are the essential features of a cost plan? The obvious requirement (common to any form of estimate prior to tendering) is that it should anticipate the tender amount as closely as possible, but there are two particular requirements that must be fulfilled before the estimate becomes a cost plan:

- It must be prepared and set out in such a way that as each drawing is produced it can be checked against the estimate without waiting until the whole design is complete. This enables any necessary adjustments to be made before the drawing is used for the preparation of quantities.
- It should be capable of comparison with other known schemes in order to see whether the amount of money allocated to each part of the building is reasonable in itself and is also a reasonable proportion of the whole. From the point of view of economical building, this second requirement is possibly even more important than the first.

It can be seen that this philosophy is especially suited to work in the public sector where, as we have seen, the only real cost criterion is comparison with what has been done before. At the time the system was developed, such work dominated the building programme – it is possible that a totally different approach might have been used had profit development then been dominant. However, once a system has become established it tends to form the basis for future development as circumstances change, and this is what has happened with elemental cost planning, still widely used today. How can the costs of one building project be compared with another? The first suggestion which would occur to a QS would be to look at the priced BQs for the two contracts. Suppose we look at the summary pages of the BQs for two different schools.

Cost Item	**Clay Green School (£)**	**Woodley Road School (£)**
Preliminaries	57,300	129,000
Excavation	24,240	28,980
Concrete work	129,915	272,925
Brickwork and blockwork	154,305	101,145
Masonry	10,950	–
Asphalt work	21,150	–
Roofing	74,655	39,045
Woodwork	228,675	290,895
Steelwork and metal work	189,660	197,850
Plumbing, engineering and electrical work	319,500	399,825
Floor, wall and ceiling finishes	136,725	133,275
Glazing	14,640	25,530
Painting and decoration	39,135	37,170
Drainage	43,260	33,495
Site works	1,109,890	1,979,470
	1,554,000	**1,768,605**
Insurances and summary items	5250	37,950
Contingencies	1,930,000	1,930,000
	1,589,250	**1,836,555**

These trade totals tell us very little. We can see that the second school is dearer than the first (it is in fact larger), but it is difficult enough to try and compare the rather varied trade breakdowns without having to make repeated mental adjustments for the difference in size between the two buildings. So a first step is to divide each trade total by the floor area of the respective schools in order to obtain comparative prices per square metre for each trade:

Cost item	**Clay Green School (2000 m^2) (£m^2)**	**Woodley Road School (2500 m^2) (£m^2)**
Preliminaries	28.65	51.60
Excavation	12.12	11.59
Concrete work	64.96	109.17
Brickwork and blockwork	77.15	40.46
Masonry	5.48	–
Asphalt work	10.57	–
Roofing	37.33	15.62
Woodwork	114.34	116.36
Steelwork and metal work	94.83	79.14
Plumbing, engineering and electrical work	159.75	159.93
Floor, wall and ceiling finishes	68.36	53.31
Glazing	7.32	10.21

	Clay Green School (2000 m²) (£m²)	Woodley Road School (2500 m²) (£m²)
Painting and decoration	19.57	14.87
Drainage	21.63	13.40
Site works	54.95	31.79
	770.00	**707.44**
Insurances and summary items	2.63	15.18
Contingencies	15.00	12.00
	794.63	**734.62**

We now have the costs on a more truly comparable basis, and it turns out that the first school is in fact the more expensive of the two. Clay Green has

- a steel frame,
- timber pitched and tiled roofs,
- mainly brick-faced external walls with 'window holes',

While Woodley Road has

- a reinforced concrete frame,
- felt flat roofs on composite decking,
- large wall areas of metal windows with concrete panel in-filling.

As we would expect, Woodley Road shows a far higher total for concrete work and a lower figure for brickwork, roofing and steelwork. At Clay Green there are some asphalt-covered concrete flat roofs and the crawl-way floor duct is tanked in asphalt, whereas at Woodley Road the floor ducts are waterproof rendered. The glazing figures allow for the larger window area at Woodley Road, while the figures of drainage and site works are consistent with Clay Green being on a larger and more rural site with a consequently greater extent of external works.

The differences in floor, wall and ceiling finishes and decoration are simply because of a higher standard of specification at Clay Green. However, while the effect of these differences in specification can be traced to some extent in the trade costs per square metre, the inclusion of parts of several elements of the building in one trade section makes it impossible to carry out comparisons very far. For instance, the figures for Woodley Road for concrete work are affected by

- the reinforced concrete frame in lieu of structural steelwork;
- some concrete walls in lieu of brickwork;
- the concrete-facing panels in lieu of faced brickwork.

We do not know how much of the difference is due to any one of these causes. Similarly, the steelwork figures are affected by the omission of the steel frame and the increased area of higher quality metal windows at Woodley Road. These are compensating differences and in fact the two figures do not reflect the scale of the variations between one school and the other in this section. Other sections are similarly affected – the rates for woodwork are almost meaningless without detailed breakdowns.

Although the figures which we have obtained are interesting, they do not enable us to make any really valid cost comparisons. We do not know whether the steel and the concrete frames are competitive in cost, and we cannot tell how much is saved by a felt roof instead of a tiled one.

In order to be able to make such comparisons we shall have to split up the BQ in a different way. We shall have to divide the work into elements. An element has been defined as 'that part of the building which always performs the same functions irrespective of building type' and (we might add) irrespective of specification. What list of elements should we use? The possibilities are nearly endless. We could use as few as six, for example

- substructure and ground floor, complete with finishes;
- external and internal walls, complete with finishes;
- upper floors including staircases, complete with finishes and proportion of frame;
- roof, complete with finishes and proportion of frame;
- engineering and electrical services;
- site works.

Alternatively, we could use any greater number within reason – some authorities have used over 40. Points to bear in mind in arriving at a decision are the following.

- The definition of an element as stated previously. Any element chosen must be capable of being defined exactly, so as to ensure uniformity between the elemental breakdowns of any number of contracts, even if the breakdowns are done by different people.
- The element must be of cost importance.
- The element must be easily separated, both in measuring from sketch drawings and in analysing BQs.
- The list of elements chosen should be capable of being reconciled with those used by others for comparison purposes.

A cost planner who does not have access to the records of a very large firm or other organisation will frequently need to make comparisons with published analyses (a popular example being those that were frequently published in *Building* by Davis Langdon (now called AECOM since 2013) and elsewhere, or with analyses obtained from the BCIS of the RICS. As an example of the need for standardisation, in most published forms of cost analysis the cost of parapet walls and copings is included under 'roof'. A cost planner might prefer to include it under 'external walls' (it would make the analysis of a traditional BQ easier), but would then be unable to compare the figures for these two elements with the published information, as the basis of measurement would be quite different.

10.17 The BCIS Standard Form of Cost Analysis

As the use of elemental cost planning increased, differing forms of cost analysis were developed by those independent authorities and firms who were building up their own cost records and by journals, which published cost information for the benefit of their readers. The weekly magazine *The Architects' Journal* was one of the pioneers in this field, and produced a detailed set of rules for their published analyses, while the RICS BCIS and others used somewhat different rules.

As previously stated, it was obviously desirable that a uniform set of rules should be established, so that users could benefit fully from cost data prepared outside their own organisations. The RICS therefore set up a working party to standardise cost analyses. This proved to be difficult because, in practice, it is not possible to define a set of totally independent functional elements, which can be related to a BQ. Any standard cost analysis therefore becomes a compromise between independent functions, on the one hand, and ease of producing the data from traditional documentation, on the other.

In December 1961, the first SFCA was published by the BCIS of the RICS. In addition to its sponsorship by the RICS, the SFCA was also supported by the chief QSs of all main government departments, which were concerned with building (and this was at a time when these bodies directly controlled a major part of the non-housing building programme).

It was this wide measure of support, which gave the SFCA such importance, as anybody using a different format would soon have become isolated from the cost experience of the rest of the quantity surveying profession. Subsequent editions of the SFCA emerged in 1969, 2003 and 2008. Some 40 plus years later, the SFCA has been revised again to reflect the new rules of measurement, and details of this can be found in the BCIS publication *Elemental Standard Form of Cost Analysis Principles, Instructions, Elements and Definitions*, fourth (NRM) edition.

Looking at the latest edition, the changes are minor; in the preface to the document, Joe Martin (BCIS Executive Director) remarks that *This new edition of the SFCA has not sought to make radical changes to the elemental list, but to take account of some practical issues that have come to light in the drafting of measurement rules for designed elements and components for NRM1 and NRM3.* Perhaps the most important change to the SFCA is the emphasis on serving the needs of BIM (see Chapter 2), Martin goes on to state that *The development of Building Information Modelling (BIM) calls for information to be supplied from the BIM model at various stages along the project timeline so that the costs can be produced or validated. At the earliest stage of a project this information will be derived from a block model which will provide basic quantities from which element unit quantities can be derived. Clear rules for measuring the building and its elements need to be included in the employer's BIM requirements and/or in the Project BIM Execution Plan to ensure that appropriate cost information is used.*

Those readers familiar with previous editions of this text will note the similarities between the 2012 and 2008 elemental cost structures, perhaps one of the more notable changes is the inclusion of Section Zero 'Facilitating Works'.

- 0 Facilitating works
- 1 Substructure
- 2 Superstructure
  - 2.1 Frame
  - 2.2 Upper floors
  - 2.3 Roof
    - 2.3.1 Roof structure
    - 2.3.2 Roof coverings
    - 2.3.3 Specialist roof systems
    - 2.3.4 Roof drainage
    - 2.3.5 Roof lights, skylights and openings
    - 2.3.6 Roof features
  - 2.4 Stairs and ramps
    - 2.4.1 Stair/ramp structure
    - 2.4.2 Stair/ramp finishes
    - 2.4.3 Stair/ramp balustrades and handrails
    - 2.4.4 Stair/ramp balustrades and handrails

- 2.5 External wall
  - 2.5.1 External enclosing walls above ground level
  - 2.5.2 External enclosing walls below ground level
  - 2.5.3 Solar/rain screening
  - 2.5.4 External soffits
  - 2.5.5 Subsidiary walls, balustrades
- 2.6 Windows and external doors
  - 2.6.1 Windows
  - 2.6.2 External doors
- 2.7 Internal walls and partitions
  - 2.7.1 Walls and partitions
  - 2.7.2 Balustrades and handrails
  - 2.7.3 Moveable room dividers
  - 2.7.4 Cubicles
- 2.8 Internal doors

3 Internal finishes
- 3.1 Wall finishes
- 3.2 Floor finishes
  - 3.2.1 Raised access floors
- 3.3 Ceiling finishes
  - 3.3.1 Finishes to ceilings
  - 3.3.2 False ceilings
  - 3.3.3 Demountable suspended ceilings

4 Fittings, furnishings and equipment
- 4.1.1 General fittings, furnishings and equipment
- 4.1.2 Domestic kitchen fittings and equipment
- 4.1.3 Special purposes of fittings, furnishings and equipment
- 4.1.4 Signs/notices
- 4.1.5 Works of art
- 4.1.6 Non-mechanical and non-electrical equipments
- 4.1.7 Internal planting
- 4.1.8 Bird and vermin control

5 Services
- 5.1 Sanitary appliances
  - 5.1.1 Sanitary appliances
  - 5.1.2 Sanitary ancillaries
- 5.2 Services equipment
- 5.3 Disposal installation
  - 5.3.1 Foul drainage above ground
  - 5.3.2 Chemical, toxic and industrial liquid waste drainage
  - 5.3.3 Refuse disposal

etc.

Most other forms of elemental analysis are basically similar, but in order to be successful they must incorporate the same sort of hierarchical principle. ***It will be seen that the SFCA can be used at different levels of generality, that is

- the element groupings substructure, superstructure, internal finishes and so on;
- the elements themselves 2.1., 2.2., 2.3. and so on
- the subelements 2.1.1, 2.1.2 and so on

Since the detail is grouped in this hierarchical way, an analysis at level 1 into six items only will be quite compatible with a fully detailed analysis at level 3 of another project. The construction of the list therefore required a careful selection of elements, each of which was significant on its own but which could form part of a larger significant group. Note, however, that the third level of detail is no longer used by the BCIS in its published analyses – a tacit admission of the unreliability of subelemental analysis referred to later in this chapter. One or two forms of analyses which have been used differ by including finishes, windows and external doors in the external walling element; and including finishes, internal doors and partitions in the internal walling element. This is more logical but means splitting finishes between external and internal walls, which is difficult to do when analysing a traditional BQ.

10.17.1 Using elemental analyses

We can see that if the costs per square metre of Clay Green and Woodley Road schools could be expressed in terms of these elements, it would enable us to find the answers to the questions which we were asking: Which is the cheaper frame? How do the two roofs compare in cost? These answers would then enable us to cost plan a third school basically similar to that of Woodley Road but with a steel frame.

10.17.2 The standard form CI/SfB, Uniclass 2

It was a source of disappointment to many people that in the BCIS SFCA, the elements themselves, their grouping and their coding were not the same as in the CI/SfB system used by the architectural profession for coding and classifying design information. It would have been very convenient for the architect to have a record of typical costs filed with his design information. However, the incompatibility of the systems was not quite such a disadvantage as might appear. We have seen that the so-called elemental costs that we obtain at present are not true costs at all, but are only a breakdown of a BQ in which money may have been allocated to the various parts of the work in a fairly capricious manner, quite apart from the overall level of pricing of the BQ itself. It would therefore be dangerous to detach these 'costs' from the analysis and index them for the use of an architect as though they were scientific data like thermal insulation values. One day it may well be possible to do this, but at present it is vital that this cost data should only be used by a qualified cost planner who has the experience and knowledge necessary to assess and manipulate it. The united classification for the construction industry (Uniclass), published in 1998 to replace CI/SfB, contains an element table much closer in form to the SFCA and which is a compromise between the needs of librarians and those of the cost planner. It has a flexible form which allows the elements to be ordered in different ways for different purposes. The advent of BIM has reinforced the requirement for a unified approach to data collection across the multi-disciplinary team, this lead to the development of Uniclass 2, which appeared in 2012 (and at the time of writing is still in the developmental phase). Led by the NBS and the Construction Project Information Committee (CPIC), a working group of representatives from all of the main Chartered Institutions, including The Royal Institute of British Architects (RIBA), the RICS, the Institution of Civil Engineers (ICE), the UK Contractors Group (UKCG), the Chartered Institute of Architectural Technologists (CIAT) and the Chartered Institution of Building Services Engineers (CIBSE), was established with the brief to encourage the wider use of Uniclass. This resulted in Uniclass 2, comprised of 11 tables:

Ac – Activities
Co – Complexes
Ee – Elements
En – Entities

EF – Entities by form
PP – Project phases
Pr – Products
Sp – Spaces
Ss – Systems
WR – Work results
Zz – CAD

The BIM 'paradigm' has created a good deal of confusion among the cost planning community regarding the relationship between classification systems, and it is perhaps important to note that there are likely to be hurdles in the use of Uniclass 2 in future BIM models as various working groups debate the implementation of COBie (mandated as a BIM deliverable by the UK Cabinet Office) through IFCs.

10.17.3 Preambles to the Standard form of Cost Analysis 2012

Previous editions of this book highlighted potential 'unreliability' in subelemental cost data collated through BCIS (insofar as the sub-element level was not reported in BCIS online cost analyses). The latest edition of the SFCA reflects a change in this; the number of sub-elements has increased substantially although the general feel and structure is relatively unchanged.

The gross internal floor area (GIFA) is measured in the normal way, that is the overall area at each floor level within the containing walls, but the basement floors (grouped together), the ground floor and the upper floors (grouped together) are each required to be shown separately and should equal the GIFA.

The definition of 'enclosed spaces' means that open entrance areas and so on are excluded from the gross floor areas, although even a light enclosing member such as a balustrade will suffice to include the area. It is possible that doubt might arise when a wall becomes so pierced by blank openings that it no longer acts as an 'enclosing wall'; obviously a mere series of columns do not meet the definition.

Although 'lift, plant, tank rooms and the like above main roof slab' are to be included in the gross floor area, we have the option of excluding these if we are prepared to allocate their costs to 'builder's work in connection'. If the plant room is only required because of the existence of a particular service, it seems quite logical to adopt the second course.

10.17.4 Roof and wall areas in the preambles to the SFCA

These are both measured gross over all openings, etc., the roof being measured on plan area. As it is 'walls of enclosed spaces' which are required, parapets, gable ends of unused roof spaces and so on would not be included in the wall area. The roof, on the other hand, is measured across overhang and would presumably include roofs over open entrance porches and other areas, which do not count as 'enclosed spaces'. If there are substantial areas of open covered way, it would probably be better to exclude them from the elemental analysis altogether and deal with them under 'site works'. The wall area is not shown on the Form, except in calculating the wall-to-floor elemental ratio, which is the wall area divided by the floor area. The lower the ratio, the more economical the design. For this purpose, the wall area is normally measured across openings.

10.17.5 Interdependence of elements

Although it is quite easy to define a cost planning element, it is more difficult actually to divide up a BQ into elements that comply with this strict definition. A major difficulty is that an indivisible building element may have several functions (some of which it shares with other elements). For example, 'external walls' may have all or some of the following functions:

- keeping out the weather;
- thermal insulation;
- sound insulation;
- supporting themselves (dead loads, wind loads);
- supporting floors and roofs;
- transmitting light and ventilation (curtain walls).

If an external wall only performs a few of these functions, then it is obviously unreasonable to compare its cost with that of a wall which performs a greater number. It is therefore usually necessary to refer to the 'frame' and 'window' elements in order to arrive at a true indication of the wall's cost performance, and similar cross-references may be required when costing other elements.

10.17.6 Preliminaries and insurances

These may be either shown as separate costs per square metre (treating them, in fact, almost as extra elements) or allocated proportionately among other elements. This is an important point and deserves some consideration: first, preliminaries and insurances. The cost of any or all of the following items (mostly at the contractor's discretion) may be included in the sections under preliminaries or insurances of a priced BQ for a new project:

- huts, temporary buildings, latrines;
- canteen, mess rooms, site catering staff, welfare;
- huts for clerk of works;
- site architect, consulting engineers and QS, and attendance of these people;
- huts for contractor's own supervisory staff and (on a large project) subcontractors' supervisory staff.
- mechanical plant, including tower cranes, excavating and concreting plant, lifts, dumpers and so on;
- scaffolding;
- non-mechanical plant and small tools;
- water for works;
- temporary electricity supply;
- consumable stores;
- temporary fencing and hoardings;
- temporary roads and standings, car parking spaces;
- health and safety requirements; cost of agent, foreman and other site supervisory staff;
- cost of timekeeper and site clerks;
- cost of security staff;
- security lighting;
- heating of building for winter working and for drying out;
- temporary weather protection;
- attendance on sub-contractors and artists;
- National Insurance payments;
- superannuation;
- guaranteed week (wet time), travelling time and expenses, subsistence and lodging;
- redundancy payments;

- training levies;
- anticipated increases in costs of labour or material;
- bonus or other supplementary payments;
- making good damage and defective work;
- fire insurances, third-party insurance and any other insurances required by the client;
- public liability or contractor's all-risk insurance;
- head office expenses (overheads);
- profit.

However, almost any of these items (and certainly any of the major ones) may be included in the rates for the building work instead of being shown separately. Some contractors do not price preliminaries at all while others do price preliminaries, but in such a way that it is impossible for the QS to find out what is or is not supposed to be included. Sometimes the contractor may have second thoughts about a tender at the last minute, and may adjust it by adding a lump sum to preliminaries or taking one off. Thus, any large differences between the amounts of money inserted against the preliminaries items on one project and on another are less likely to be caused by genuine contractual differences (site conditions, access, etc.) than by the different pricing habits of the two contractors – remember that the allocation of costs within a contract BQ is done largely for commercial purposes.

Some of the principal items such as profit, supervision, scaffolding, plant and overheads could affect the level of pricing of the work sections by 15–20%, according to whether or not they are included in preliminaries. As these pricing habits are to some extent regional, it may be possible for the department of QSs of a local authority, or for a firm of cost planners whose work is confined geographically, to consider preliminaries and insurances as separate elements with some degree of consistency. However, it would be safer on the whole to add preliminaries and insurances to each element as a percentage in order to give a common basis of comparison. If we refer back to the summaries of the two schools, Clay Green and Woodley Road, we can see that the work section prices for the latter appear low by comparison because preliminaries and insurances have been priced more fully.

This advice, of course, relates only to the analysis of BQs and to the early stage estimates for a new project based on such data. When preparing a more detailed estimate for a major new project, preliminaries and insurances have to be considered on their merits. If the new project has some abnormal feature such as a difficult site or an uneconomically short contract period, it will be necessary to give special consideration to these matters from the start.

10.17.7 Risk (client's) contingencies

We also have to consider contingencies. Unlike preliminaries, the contingency sum is an arbitrary amount decided by the client or the design team. It is not really part of the contractor's tender but is an amount the contractor is instructed to add to his tender in order that there may be a cushion to absorb unforeseen extras. It normally has no effect on the level of pricing of the BQ, and is better treated as a separate element rather than as a percentage on the remainder of the work.

10.17.8 Analysis of final accounts

Upon first consideration, it might seem a good idea to analyse the final account instead of the tender, since this will give a more accurate picture of the actual cost of the building. The objections are twofold:

- It would be much more difficult to analyse both BQ and variation account than to analyse the BQ alone.
- The analysis would not be available until perhaps 3 or 4 years after a tender analysis and so would only be of historic interest.

However, these difficulties do not seem to be insurmountable, and the convention that it is the tender that is analysed probably owes a lot to the fact that the practice of cost analysis started in the days of public sector building, when attention was focused on forecasting tenders rather than final accounts. Although the differences between the tender and final account are not usually great enough to invalidate an analysis obtained from the BQ, this is not always the case. To reflect this concern, the 2012 SFCA is explicit in this regard *BCIS will continue to collect, analyse and publish costs derived from building contracts; the expansion of the standard form will allow clients to record their additional direct costs, although BCIS will be happy to record and publish these as well.*

10.17.9 Cost analysis of management contracts

Management contracts and the like pose a difficult problem. There is little point in analysing the master estimate, since there is no contractual commitment to this – it is itself part of a cost planning system and may well have been prepared on an elemental basis. On the other hand, by the time all the costs are known, we would be effectively analysing a final account, with all the problems just mentioned. However, management contracts imply a production orientation to the project, and it is perhaps the resource-based cost information obtainable from these projects that is more useful than the product-based costs.

10.17.10 System

Whatever methods of cost breakdown and whatever methods of cost planning are chosen, they must be adhered to rigidly. Otherwise, not only are the figures futile for reference purposes but the whole idea of working to a system is lost. The technique of cost analysis depends on working in accordance with a fixed method; this is why standard forms are preferable. There is plenty of scope for rough working, but the forms must be used at all vital points, so that there is no possibility of preliminaries (for instance) being left out because the cost planner who did the previous estimate believes in showing them separately, whereas the person using this estimate for reference supposes that they are included in the rates. In most cases, the forms and instructions issued by the BCIS can be used, thus ensuring compatibility with information obtained from other sources.

10.17.11 Preparation of an elemental cost analysis

Cost analyses are ordinarily carried out today using software tools. However, many cost planners find that commonly available spreadsheet packages enable them to construct their own cost analysis system very easily. The aim of cost analysis is to provide data for use in elemental cost planning; as little time as possible should be spent on it consistent with obtaining a fair degree of accuracy. Meticulous allocation of trivial sums of money, or the identification of insignificant changes in specification, should be avoided. If there is no time to prepare a full analysis, an outline analysis will be better than nothing and may take less than an hour to prepare. For the preparation of an elemental cost analysis, we shall require a priced BQ, a drawing showing plans and elevations, and a list of elements. Each item in the BQ has to be allocated to one or more elements until every item has been dealt with and the elemental totals will equal the total of the tender. Once an office has adopted a certain form of analysis, it will be possible to prepare the BQs with subsequent analysis in mind; this will ease the task of the analyser considerably and will make it unnecessary to refer to the taking off. It is not necessary to depart radically from the usual order of billing as long as the main elements can be kept separate within each trade or section of trade. For instance, the ‘sawn softwood’ section of woodwork could be billed under headings of roof timbers, upper floors and stud partitions; and the ‘reinforced concrete’ section of the concrete work could be separated into substructure, frame, upper floors, roof and staircases. This should not involve lengthening the BQ greatly as there will be very little duplication of items between different elements; the concrete work is the only section where this should occur to a significant extent. Not only a BQ prepared in this manner will be useful for analysis, but also it will be convenient for interim valuations and for the contractor’s use in site organisation generally and in calculating performance-related payments to operatives. The so-called Northern system of taking off, where the BQ is written straight from the dimensions, lends itself to the preparation of a subdivided BQ of this sort. Any further breakdown of the tendering BQ into a completely elemental format is very unpopular with builders’ estimators, since design cost planning elements are of little significance to them and a good deal of rearrangement into trade order has to be carried out by them in sending out to subcontractors and suppliers.

10.17.12 Definition of terms

Before going any further there are a number of terms, which must be defined in order that the processes of cost analysis and cost planning may be understood (a full list of definitions can be found in pp. 13–15 of the BCIS Elemental Standard Form of Cost Analysis 2012).

- **Elemental cost** is the cost of the element expressed in terms of the superficial area of the building.
- **Elemental unit quantity** (sometimes also called quantity factor) is the actual quantity of the element, expressed in square metres for such elements as floors, roof, walls, finishes or in terms of number of elements where this is not practicable.
- **Unit cost** is the cost of the element expressed in terms of the element unit quantity, for example, 1000 m^2 of internal walling costing £20,000 gives a unit cost of £20.00/m^2
- **Elemental ratio** is the proportion, which the unit quantity of one element bears to that of another. A commonly used example of this is the ratio of external wall area to gross floor area.

When analysing a BQ, there are three different ways in which the analyser may be helped to deal with the items:

- The description of the item may indicate the element to which it belongs, in which case there is no necessity to refer to the original taking off.
- The item may be too trivial to spend time on, in which case it may be allocated as seems most obvious or as is most convenient.
- It may be necessary to refer to the taking off in order to allocate the item correctly. Since it would take far too long to do this for every item in the bill, analysers must use a good deal of discretion about this.

In cases of doubt, they would be influenced very much by the cost importance of the item.

10.17.13 Element unit quantities

Unfortunately a simple analysis of building cost into elements will not satisfy all our requirements. It will provide a monetary total for each element and we can divide each total by the floor area to get the elemental cost per square metre, but it does not give us the unit quantities or the unit costs. We need these if the analysis is to be of much use. Some commonly used element unit quantity factors are set out below as a guide; where 'none' is marked the elemental cost per square metre is the only basis of cost comparison.

Work below lowest floor finish	Area of lowest floor
Frame	Area of floors relating to frame
Upper floors	Area of upper floors
Roof	Area on plan of roof measured to external edge of eaves, but excluding area of rooflights
Rooflights	Area of structural opening measured parallel to roof surface
Staircases	Number of total vertical rise staircases or area on plan
External walls	Area of external walls excluding window and door openings (basement walls to be given separately)
Fenestration	Area of clear opening in walls
External doors	Area of clear opening in walls
Internal walls and partitions	Area of internal walls excluding openings
Internal doors	Area of clear opening in walls
Ironmongery	None
Wall finishes	Area of finishes
Floor finishes	Area of finishes
Ceiling finishes	Area of finishes
Decorations	None
Fittings	Often none, but where appropriate the total length of benches, number of tables or other details may be given
Plumbing and hot water services	Number and type of sanitary fittings, number of hot and cold water draw offs
Heating services	Heat load in kilowatts, cubic capacity of accommodation served
Gas services	Number of outlets
Electrical services	Number of points, total electrical load
Special services	Such information as will indicate the extent of each service (e.g. for lifts the number, capacity and velocity of each and number of stops should be given)
Drainage	None
External works	None

Example

Assume a building of 2400 m^2 of total floor area

Element: Upper floors

Total cost of element: £85,525
Cost per square metre of total floor area (elemental cost) £35.63

Unit quantity and cost

Element unit quantity 1000 m^2
Unit cost per square £85.00

Subdivision		
550 m of 150 mm rc slab	at £82.50	= £45,375
350 m of 225 mm rc slab	at £105	= £36,750
100 m of 25 mm softwood boarding on 175 mm× 50 mm joists	at £34	= £3400
		= **£85,525**

While these subdivisions are very useful as explanations of how the total cost is affected by specification, it must never be forgotten when using them that the greater the detail in which a priced BQ is analysed the less reliable are the results. It is more than likely that a BQ for the same job priced by another builder would give completely different figures at this level of breakdown, although quite similar in total. The overall unit costs will be found particularly useful when preparing early estimates of cost before specification details are available.

10.17.14 Obtaining unit costs from elemental analyses

In order to obtain unit costs as well as elemental costs, the analysis has to be more elaborate than if elemental costs alone are being recorded. This is especially so if we want to keep separate costs for the different forms of structure or finish within each element. There are two problems to solve

- the separation of the costs within the element;
- the recording of areas and other quantities.

Such things as areas of walls, floors and finishes can be obtained most easily from the BQ. However, sizes of window and door openings may be difficult to get from this source (particularly where there are fanlights, sidelights or windows glazed directly into frames), and it may be necessary to refer to the taking-off dimensions or the drawings. There is also the difficulty of areas which occur more than once, for instance:

- The areas of concrete in floors will be duplicated by the formwork areas and these must not be added in again.
- However, the separate areas of concrete floors and hollow pot floors will require to be added together.

Thus, either the analysis needs to be done by somebody technically qualified or else very clear procedures have to be laid down. No attempt needs to be made to separate constructions, which differ only in detail (such as 100, 125 and 150 mm floor slabs), because the aim is to obtain overall unit rates for basic constructions, not 'Bill rates' for individual items.

10.17.15 Final form of the analysis

This is one of the places where a standard form, preferably the SFCA form, should always be used. It is not necessary to fill in too much specification details if the analysis is for office use, as it should be possible to refer to the contract papers if anything more than a very broad outline is required. There should be a reference number for the analysis so that a list of analyses can be kept, and there should also be a cost index value so that allowance can be made for changes in market prices when comparing with past or future jobs. Note that elemental costs continue as a running total but unit costs cannot be carried forward, as a total of them would be meaningless.

10.17.16 BCIS online

In addition to providing printed elemental cost analyses, the BCIS offers a comprehensive database whereby analyses can be examined, and any interesting examples can be downloaded to the cost planner's own computer for use in new projects. This service also provides the facility to amend the BCIS analyses for the cost implications of a change in tender date or the UK region of construction, so enabling comparison between jobs carried out at different times or in different places.

10.18 Design cost parameters

According to the *Concise Oxford Dictionary*, a parameter is 'a quantity which is constant in a particular case considered, but which varies in different cases'. It is now necessary to look at the factors, which influence the components of the building in terms of area, number and size, as well as their quantity in terms of cost. Unfortunately insufficient research has been undertaken to date to give clear indications of the degree to which changes in the parameters of the building (or by implication its model) will affect the cost of that building. There is, however, a very great depth of knowledge gained by practitioners, which provide us with some general 'rules of thumb'. In some cases, we can be quite specific about how cost varies. For example, if we change the shape of a single-storey building so that the area of the external brick cavity wall is increased, then we can be sure that, all other things being equal, the wall cost will probably be increased in direct proportion to the increased area. Similarly, if the quality of facing bricks is increased and the shape of the building remains fixed, then the wall cost will be increased by the extra material cost of providing the better specification.

While we can probably rely on this type of simple wisdom for small brick buildings, it may not be adequate for dealing with more complex multi-storey framed and curtain-walled structures. If we change the shape or height of the building, it may not be just the extra quantity and quality that we have to pay for, but also indirect costs such as

- different lifting equipment;
- improved fixings to deal with increased exposure;
- access, and manoeuvrability and dispersal of plant on site.

A particular difficulty lies in producing rules of general application, rather than in relation to one constrained set of circumstances, and indeed there is no real agreement that such rules exist. Very often the answer seems to depend on the methods that a given builder normally uses. Using our existing knowledge, we can, however, establish some starting principles which could be the foundation for any further cost research, but which meanwhile can be drawn upon in developing a design. We can view the parameters at two levels.

- The form of the building itself (morphology), where we can study the effect of shape and height on cost.
- The major components of the building and the factors, which influence their size, quantity and cost.

10.19 Building shape

The building shape has its major impact on

- the areas and sizes of the vertical components such as walls, windows, partitions and so on;
- perimeter detailing such as ground beams, fascias and the eaves of roofs.

It would seem obvious that the building that has the smallest perimeter for a given amount of accommodation will be the cheapest as far as these items are concerned. However, the shape that has the smallest perimeter in relation to area is the circle, and this does not very often produce the cheapest solution for the following reasons:

- The building is difficult for the constructor to set out.
- Curved surfaces, particularly those incorporating timber or metalwork (e.g. in joinery or formwork), are expensive to achieve.
- Circular buildings seldom produce an efficient use of internal space, as inconvenient odd corners are generated between partitions and external walls.
- There is a tendency for circular buildings to generate non-right-angled internal arrangements. Standard joinery and fittings are based on right angles and will not fit against curved surfaces nor into acute-angled corners.
- The circle does not normally allow efficient use of site space.

In these circumstances, it would appear that the right-angled building that has the lowest perimeter will provide the best answer. This shape is of course the square. Now although a compact square form is generally recognised as the most economical solution because of its reduction in cost of external vertical elements (and the lowest area of external wall for heat loss calculations), there are some important qualifications to be made:

- Where the square plan produces a very deep building requiring artificial ventilation, air-conditioning and lighting, which would not otherwise have been needed, then the shape may become uneconomic. It is only the single-storey building with its opportunities for natural top-lighting and ventilation that may be regarded as a partial exception to this rule, although really satisfactory arrangements for top-lighting and venting are likely to be expensive in first cost and (particularly) maintenance.
- Where there is a high density of rooms, the use of the external wall as a boundary to the room helps to reduce the amount of internal partitioning required. It is therefore sometimes preferable to elongate the building so that rooms can be served from either side of a spinal corridor rather than have a deep building, resulting in a complex network of corridors to serve all rooms plus the possibility of artificial ventilation to those that are internal. A real-life case concerns a high-technology building where the internal offices with no natural lighting were so claustrophobic that no one would work in them and they were used as stores for rubbish; a small saving in cost per square metre of floor area had produced a lot of floor area that was in fact unusable and a poor bargain.
- A given amount of accommodation housed in a square multi-storey block may be much more expensive than the same accommodation housed in a less compact two-storey block, for reasons to be discussed later.
- On a sloping site involving cut-and-fill, it may be more sensible to provide a long building running with the contours rather than a square building, which would cut more extensively into the site.

These are just a few of the qualifications, which need to be made when talking about the efficiency of shape. Like a number of rules of thumb, this one was developed for traditional buildings in the United Kingdom, and two exceptions show how dangerous it is to regard such rules as universal laws:

- Modern high-technology buildings normally require large floor areas, air-conditioning and artificial lighting whatever their shape.

- Part of the reason why external walls are expensive in countries such as Britain is because they need to have a good thermal performance. In warm countries, this is not the case, and the ability to obtain natural ventilation cheaply may lead the cost planner to try to maximise the perimeter of the building.

In any case, the shape of the building is often dictated by the site boundaries, topography and orientation, and the degree of choice is therefore rather limited. If the national construction programme tends towards redevelopment rather than the exploitation of green field sites, then ideals of building shape can become fairly meaningless. There have, however, been a number of attempts to measure the cost efficiency of a building shape, and some simple examples are listed as follows:

- **Wall/floor ratio**
  This is perhaps the most familiar of all the efficiency ratios, but it can only be used to compare buildings with a similar floor area and does not have an optimum reference point such as
  $(P - P_s/P_s) \times 100\%$ (J. Cook) where P is the perimeter of building and P_s is the perimeter of the square of same area. This formula relates any shape to a square which would contain the same area, thus providing a reference point for shape efficiency.
- **Plan compactness or POP ratio** (Strathclyde University)
  $\left(2(\pi A)^{\frac{1}{2}}/P\right) \times 100\%$ where P is the perimeter of the building and A is the area of the building. In this case, the point of reference is the circle (a square would have a POP ratio of 88.6% efficiency and yet is probably the best cost solution in initial cost terms.
- **Mass compactness ratio or VOLM ratio** (Strathclyde University)
  $2\pi\left(\left[(3V/2\pi)^{\frac{1}{3}}\right]^2/S\right) \times 100\%$ where V is the volume of the hemisphere equal to the volume of the building and S is the measured surface area of the building (ground area not included). This formula chooses a hemisphere as the point of reference for considering the compactness of the building in three dimensions.
- **Length/breadth index** (D. Banks)
  $p + \sqrt{(p^2 - 16a)}/p - \sqrt{(p^2 - 16a)}$ where p is the perimeter of the building and a is the area of the building. In this index, any right-angled plan shape of building is reduced to a rectangle having the same area and perimeter as the building. Curved angles can be dealt with by a weighting system. The advantage here is that the rectangular shape allows a quick mental check for efficiency. As these formulae are only for guidance purposes only, this index is probably sufficient for early stage advice.
- **Plan/shape index** (D. Banks)
  $g + \sqrt{(g^2 - 16r)}/g - \sqrt{(g^2 - 16r)}$ where g is the sum of perimeters of each floor divided by the number of floors and r is the gross floor area divided by the number of floors. This is a development of the previous index to allow for multi-storey construction. In effect, the area and perimeters are averaged out to give a guide as to the overall plan shape efficiency.

While the above-mentioned indices are useful, they obviously have severe limitations as they consider only those elements that comprise the perimeter of the building, or in the case of VOLM the perimeter and roof. However, the repercussions of shape on many other major elements are considerable. For example, wide spans generated by a different plan shape may result in deeper beams, which in turn demand a greater storey height to give the same headroom, and thus will affect all the vertical elements. These implications need to be represented in any advanced model of building form, and an awareness of knock-on cost effects of this kind must be part of the cost planner's knowledge. Size of building is another important factor in cost efficiency. The larger the plan area for a given shape, the lower will be the wall/floor ratio.

10.20 Height

Here it is possible, and indeed desirable, to be dogmatic. Tall buildings minimise land costs in relation to floor area, but are invariably more expensive to build low-rise buildings than offering the same accommodation, and the taller the building the greater the comparative cost. The only partial exception to this rule is that the addition of a further storey or storeys to a tall building in order to make the best use of lifts or other expensive services that may slightly decrease the cost per storey, but this does not invalidate the general rule.

10.20.1 Cost problems of tall buildings

What are the reasons for the high cost of high buildings?

- The cost of the special arrangements to service the building, particularly the upper floors. Apart from the necessity of providing sufficient high-speed lifts, it is necessary to pump water up and to break the fall of sewage and other rubbish coming down. Complete service floors often have to be provided at intervals of 10 or 15 floors to deal with these problems.
- Special ventilation and lighting arrangements are needed because of the impossibility of providing adequate light wells in a tall building.
- A high standard of fire-resistant construction and practicable escape arrangements are required.
- The necessity for the lower part of the building to be able to carry the weight of the upper storeys, which obviously makes it more expensive than if it were carrying its own weight alone.
- The structure of the building and its cladding will have to be designed to resist a heavy wind loading, a factor that hardly affects a low building at all. Experience with many of the tall buildings of the last 30 years has shown how demanding is the required standard of windows, wall panels and so on at high levels, and how expensive is the failure to meet these standards. One is talking about a very different price range indeed from similar components for low-rise construction.
- The cost of working at a great height when erecting the building. There is the cost of
  - hoisting all materials and operatives to the required level;
  - the time spent by operatives going up to their work and down again at the beginning and end of each day and at break times;
  - the extra payments for working at high altitudes and all the safety requirements which this entails;
  - the bad climatic conditions for working at many times of the year.
- The increased area occupied by the service core and circulation. As the height of a building increases, it needs more lifts, larger ducts, wider staircases and so on; and these installations take up more and more of the lower floors, so cutting down on the usable area. It is possible to imagine a building so tall that the whole of the ground floor is occupied by vertical services; adding extra floors to such a building would produce no increase in usable area at all!
- The cost of dealing with the effects on neighbouring properties, such as rights of light, and the considerable costs of overcoming planning objections.

Many of the above factors will also influence the running and maintenance costs – such items as window cleaning, repainting and repairs to the face of the building will all be much more costly than the similar work to a low-rise structure. Therefore, high building should never be considered favourably on cost grounds unless the saving in land costs because of the smaller site area in relation to accommodation will pay for the considerable extra building costs. Land values must be high for this to occur, since a tall building needs a lot of space around it and the reduction in land requirement is not proportional to the reduction in plan area.

An increasing problem today is the near impossibility of dealing with the car parking needs of a tall building within the plan area of the site, except at an excessive cost.

10.20.2 Costs of single-storey buildings

Just as high building is not usually economical neither is single-storey building, but the exceptions here are much more numerous and important, for instance:

Where large floor areas free from obstruction by wall or columns are required, it is more economical to build horizontally rather than vertically, since to provide load-bearing floors over such areas would be far more difficult and expensive than a roof.

Similarly, where very heavy floor loadings are required, it is cheaper to build floors resting on the ground than high-performance suspended floors over other storeys.

Single-storey temporary or sub-standard buildings where the low-cost foundations and structure cannot be made capable of supporting a further storey can nevertheless be an economical solution.

However, both for retailing and for manufacture, there are so many user advantages in single-storey accommodation that this type of building is becoming very common. One of the problems in some areas is in finding a reasonably level site for a large building of this kind.

10.20.3 Cost advantage of low-rise buildings

The reason for the relative economy of two- or three-storey buildings compared to single-storey is that:

- One roof and one set of foundations will be serving two or three times the floor area.
- The walls or frame will be capable of carrying the extra load with little or no alteration.
- In domestic construction, it will be possible to use cheap timber-framed upper floors that will help the comparison still further.

Once the building exceeds this number of storeys, various factors make it difficult to attain the low costs possible with two-storey construction:

- It is less often possible to dispense with a separate frame.
- The frame itself must be more substantial.
- Lifts, fire-resisting construction and other expensive measures are required.

10.21 Optimum envelope area

The 'envelope' of a building, that is the walls and roof, which enclose it, forms the barrier between the inside and the outside environments. The greater the difference in these environments, the more expensive this envelope will be, but it is always at least a significant factor in the cost of constructing and running the building.

We have already seen that a square building is inherently economical in wall area, but the total envelope/floor area ratio will also depend on the number of storeys that are chosen for the accommodation. For example, imagine a large single-storey building. If we arrange the same accommodation on two floors, we should reduce the roof area by more than the consequent increase in wall area, so that the total envelope area would be reduced.

The same might happen if we arrange the same accommodation on three floors, but if we continue making the building higher and higher, while retaining the same gross floor area, the process eventually reverses and the increase in wall area becomes greater than the roof area saving. This reversal happens quite slowly, so that the envelope area changes very little over a range of several possible storey arrangements close to the optimum. It is obviously useful to know what this optimum is as a design guideline. We can use a formula to calculate this optimum for a square building, thus

$$N\sqrt{N} = \frac{x\sqrt{f}}{2s}$$

where N is the optimum number of storeys, x is the roof unit cost divided by wall unit cost, f is the total floor area (m^2) and s is the storey height (m).

If the desired width in metres (w) is known, the formula for a rectangular building is

$$N^2 = \frac{xf}{2sw}$$

More complex formulae involving several elements have been developed to optimise the shape of the whole building, but although interesting as research tools these result in over-simplification that renders them of little practical help.

10.22 Further cost modelling techniques

We have looked at the way in which simple traditional cost models have developed, noted their deficiencies and put forward a list of criteria for judging cost models. It is now intended to look at the possibilities of adopting other models, currently extensively used in other disciplines, in the search for better cost information. When we refer to better cost information what do we really mean? There are probably four major ways in which it is possible to advance. We can provide

- cost information quicker;
- more information so that a more informed decision can be made;
- more reliable cost information that will introduce more assurance into the decision-making process;
- information at an earlier stage in the design process and in a more understandable form.

By harnessing the power of modelling techniques, it is hoped that each of these objectives can be achieved, or at least a step can have been taken to improve the chances of achieving them. The traditional models evolved in the way that they did because it was expected that manual labour would be employed to do the calculations. This resulted in an oversimplification of the models, at all levels, for the sake of expediency. A new view of what is needed in terms of cost information, without reference to the constraints of manual computation, is required if the full potential of the new technology is to be tapped for the benefit of the client. However, almost by definition, all models are simplifications of the thing they seek to represent and are consequently imperfect.

10.23 Classification of models

There are a number of ways of classifying models. Classification may take place according to the function they perform, for example, evaluation, description, analysis, optimisation and so on. On the other hand, it may be according to the form of construction:

- iconic (physical representation of the item under consideration);
- analogue (where one set of properties is chosen to represent the properties of another set, for example, electricity to represent heat flow);
- symbolic (where the components of what is represented and their interrelationships are given by symbols).

Perhaps the most important knowledge concerning any model is an understanding of its limitations within the context of its use. It is dangerous to ignore the simplifications, which are inherent in the construction of cost models in particular. A considerable amount of research work has been carried out in the universities in developing models during the past 30 years. However, few if any of them have had any impact on the practice of cost planning in the real world. This is almost certain because the vast expense of developing experimental computer systems into robust, foolproof and fail-safe commercial packages has not been seen as worthwhile in the context of potential use and profitability. Potential users of computer-based cost models are therefore very limited by what is available as commercial packages.

10.24 Key points

Building cost models are basically of two kinds:

- a product-based cost model is one that models the finished project;
- a process-based cost model is one that models the process of its construction.

This chapter deals with the first of these. The simplest form of such a model takes no account of the configuration, or details of design, of the building but is simply based on one of the following:

- the floor area of the proposed project (gross or net);
- the volume of the proposed project;
- some user parameters such as the number of pupil places for a school or the number of beds for a hospital.

More complex cost models include the BQ and elemental cost analysis. An element has been defined as 'that part of a building which always performs the same functions irrespective of building type and specification'. The most commonly used list of elements is that published by the RICS as the SFCA. There are a number of useful rule-of-thumb generalities about building form and cost, which tend to favour low-rise buildings with a low wall/floor area ratio, but there are some exceptions to these.

Further reading

Ostrowski, D. (2013) Estimating and Cost Planning Using the New Rules of Measurement, Wiley-Blackwell, ISBN: 978-1-118-33265-8.

Murray, P. (2003) The Saga of Sydney Opera House: The Dramatic Story of the Design and Construction of the Icon of Modern Australia, Spon Press, ISBN: 0415325226.

RICS (2012a) Elemental Standard Form of Cost Analysis: Principles, Instructions, Elements and Definitions, 4th (NRM) edn, London.

RICS (2012b) NRM 1 RICS New Rules of Measurement: Order of Cost Estimating and Cost Planning for Capital Building Works, London.

RICS (2012c) NRM2 New Rules of Measurement: Detailed Measurement for Building Works, London.

Towey, D. (2012) Construction Quantity Surveying: A Practical Guide for the Contractor's QS, Wiley-Blackwell, ISBN: 978-0-470-65942-7.

Endnote

1 Hevacomp is a software option that is used by Building Services Engineers to simulate the effects of such phenomena as heat gain and loss in buildings.

Chapter 11

Cost and Performance Data: Sourcing and Application to the Cost Plan

11.1 Introduction

In reviewing traditional cost models, it was suggested that the techniques used are merely the structure around which the professional cost adviser's judgement is applied in order to make them work. The model itself is ill-equipped to produce a reliable answer on its own, and reliability at any stage of refinement is entirely dependent upon the costs applied to the measured quantities in their various forms. If the right cost figure is applied to any of the single price methods, then they will give better results than more sophisticated techniques with the wrong cost data applied to them.

The factor that makes detailed cost planning techniques more satisfactory than traditional methods is the control that is exercised as the design develops. Even this control, however, is based on unit rates applied to abbreviated quantities (another model) and is therefore dependent on the reliability of cost information.

At the end of the day, any estimate is dependent on the prevailing market conditions at the time of tender rather than conditions at the time of making the estimate, and this again requires information in order that market trends can be detected.

So at the root of all this forecasting and control activity, we find the need for cost data to supplement the numbers, areas, volumes and so on, which have been used to describe the building. It is this data which is critical in determining whether an estimate is reliable or not.

11.2 The ambiguous problem of software

One of the major problems with more recent models, in which software is used, is the need to ensure that the information on cost held within the database is reliable and relevant for all conditions of use of that model.

Very often, human intervention is not envisaged in the use of IT systems, and professional judgement is left until the results have been produced. This is very often too late, because the cost consultant has little chance of knowing why a particular figure has been generated without considerable investigation and interpolation. And if the consultant is to adjust a result to one that is assumed to be more reasonable, then a traditional model, using the consultant's judgement from the start, might as well have been used.

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

There is common phrase in computer parlance – GIGO ('Garbage In–Garbage Out') – this amply demonstrates this problem and reinforces the view that incorrect data used in any form of modelling will produce inaccurate results.

11.3 Types and origins of cost data

The study of '**what information should we use?**' and '**where can this be obtained?**' is essential for the correct understanding of the application and development of costing techniques. Firstly, however, we need to understand what the information is used for.

11.3.1 The applications of cost data

If we were to look at the work being undertaken in a typical quantity surveying office, we would find cost information being used for four main purposes:

- The control and monitoring of a contract, for which the contractor has already been selected, through interim and final valuation procedures.
- The estimation of the future cost of a project and the control of its design to ensure that this figure is close to the tender figure.
- The 'balancing' of costs in a cost plan to ensure that money has been spent in accordance with the client's priorities.
- The negotiation of rates with a contractor for the purposes of letting a contract quickly.

Arising out of these activities are other uses, which might well be the concern of a special section in a quantity surveying practice or in the research department of a university. These uses relate to a deeper understanding of the external political and economic trends, and the relationship between design decisions and the degree to which they affect cost. These studies usually require a more detailed level of investigation, involving the analysis of large quantities of data or the classification and structuring of the data in a particular way to assist in the development of evaluation models.

To incorporate all uses of data, we can probably classify them under four main headings:

- Forecasting of cost
- Comparison of cost
- Balancing of cost
- Analysis of cost trends

11.3.1.1 Forecasting of cost

In this section, the information that is included is as follows:

- cost per square metre for various types of building;
- elemental unit rates;
- bill of quantities (BQ) rates;
- all-in unit rates applied to abbreviated quantities.

This information would almost certainly arise from an analysis of past projects or 'historic costs'. The figures would be updated by the use of a building cost index, itself a form of cost data, and would be projected forwards to the proposed tender date by an intuitive or calculated prediction technique.

In recent years, the problems associated with historic costs (see later in the chapter) have spurred researchers and practitioners to develop techniques, which rely on current resource costs (labour, plant and material) to forecast the cost of a project. This certainly helps in the negotiation of contracts and also in the reliable modelling of the building process. Resources are where the cost is generated, and the adviser is therefore dealing with the origins of cost.

However, the problem lies in the acquisition of information on resource costs by people who are not members of a large building organisation, and in the time-consuming task of synthesising costs from detailed resource inputs.

In fact, techniques employing resource costs to forecast building costs have various ways of simplifying the problem to avoid the user being overwhelmed by too much data. These usually involve concentrating on major items and quantities at the expense of those with less cost significance. However, it should be noted that even these techniques rely heavily on 'historic' information regarding the normal time and quantity requirements for the resources required for a particular item or building.

11.3.1.2 Comparison of cost

In this use of data, the need is not so much to discover what the building or component will actually cost at the time of tender, but to make a comparison between items with similar function, or buildings of different designs, to decide which is the better choice.

The problems of the tender market are not so critical here unless there is evidence to suggest that there may be a change in the cost relationship between the alternatives by the time the decision takes effect.

The criterion in choosing data for this task should be that it is structured in such a form that if the design or specification of an item is changed, the use of the cost data will reflect the true change in the cost of the commodity.

11.3.1.3 Balancing of cost

In determining a budget for the cost control of a building, it is necessary to break down the overall cost into smaller units. These smaller units are used not only for checking purposes but also to allow a cost strategy for design to be developed. This strategy will attempt to spend money in accordance with the client's requirements, by allocating sums of money to the various major components of the building.

Data for this use is usually obtained from past projects, and it may be in the form of actual costs or as a proportion of the total cost of a similar project. At the stage that this information is used the design will not have been developed (and may not even have commenced), and therefore the categories used for this breakdown will tend to be broad and probably not exceed 40 items for any one project. The data can therefore be described as 'coarse' as opposed to 'refined'.

11.3.1.4 Analysis of cost trends

Of paramount importance in any prediction technique, which seeks to project costs into the future is information, which tells us what is happening to costs in the industry over a period of time. By looking at the way in which costs for different items are changing in relation to one another, or changing between one point in time and another, it is possible to have a better chance of selecting the specification which will suit the client's requirements over the short and long terms. It will also allow us to obtain a more reliable prediction of what the market price to the client will be when the job eventually goes out to tender.

These trends may be shown as the change in the cost of materials and labour, or there may be a detected change in the total cost of a particular type of building or component. When data is used for the detection of cost trends, the cost is very often related to a base-year cost, in which case the presentation of the information is in the form of a cost index.

It should be noted that the detection of a cost trend does not necessarily imply that it will continue into the future. Indeed, it is very unwise to extrapolate a cost movement without taking into account all the political, social and economic factors that contribute to a change in cost levels – just extending a straight line or a curve without thinking about it is a recipe for trouble.

The number of variables involved in such an evaluation is enormous, and consequently the establishment of what future costs will be is nearly always left to the professional experience of the cost adviser, who will probably take account of economic reports – which often differ widely in their predictions.

It has been said that when you get two different economists discussing a particular economic problem, you are likely to get three different opinions!

If these are the major uses of cost data, we can now look at the problems in retrieving and storing the information for these particular applications.

11.4 The reliability of cost data

Nearly all data used in cost planning techniques has been processed in some way, very often with a corresponding loss in accuracy and certainly with some loss of context.

The published information received by the quantity surveyor (QS)/cost planner usually relates to a 'typical' building in a 'typical' location with only a brief summary of the contributing factors to such a cost (i.e. the explanatory variables) included. The feedback of such cost information centres in the main around the BQ. Figure 11.1 shows a diagrammatic representation of traditional cost retrieval and planning practice.

In theory, information on wages, materials and plant is collected on site and fed to the contractor's contracts manager, who then passes this raw data to the estimator. The estimator uses it together with data from other projects to forecast the next tender price. The consultant quantity surveying firm then analyses the contract BQ from the new tender to provide it with data, which it then uses to forecast the cost of the next similar building and to control its cost during the development of design. When this new design is being built, the feedback cycle then starts all over again. The above procedures, although they purport to represent the usual practice, and sound convincing enough, are fraught with problems.

11.5 Occupation costs

In Figure 11.1, there is no feedback shown into the general system from the area of building performance cost (i.e. maintenance, repair and operational costs). Although some public authorities have attempted to obtain data on these costs and pass this information to the design team for consideration in their choice of detailing and specification, this is far from being common practice.

In the private sector, the reluctance to collect and divulge occupation costs has been contributed to by the comparatively small number of clients involved in large continuing programmes of building, and an unwillingness to spend the amount of time involved in such an exercise. However, some larger organisations have taken a lead in this area.

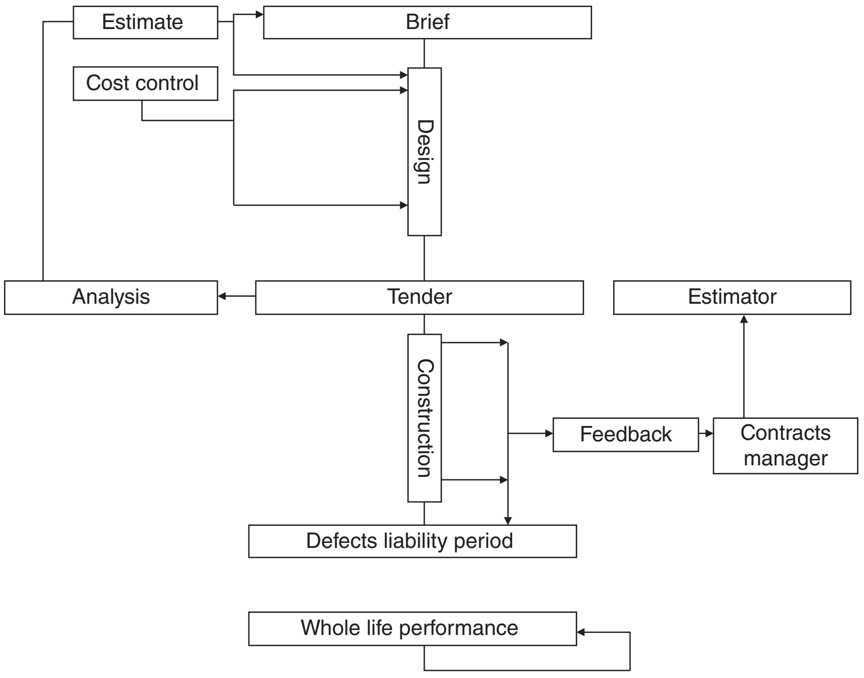


Figure 11.1 Traditional cost retrieval.

11.5.1 The UK National Health Service

Operational and maintenance statistics on the acute care NHS estate are collected annually through the ERIC (Estate Returns Information Collection), and it is the primary mechanism in use by the service to record all costs associated with running and operating an NHS trust's estate. It records cost data at two levels: trust level and site level. All costs including energy, facilities management, maintenance and financing costs are covered. ERIC enables the analysis of Estates & Facilities information from NHS trusts and primary care trusts (PCT)s in England and is a mandatory requirement that NHS trusts submit an Estates Return. This provides an indication of the status of Estates & Facilities services in the NHS for the Department of Health. The development of the Performance Management Framework agenda has led to the data now being used to inform a set of performance indicators to measure the performance of a Trusts Estates and Facilities Services. Over time, these will permit trusts to demonstrate year-on-year improvement in line with the NHS Plan. ERIC also attempts to define the framework for performance measurement and benchmarking of costs in the NHS estate. However, what ERIC does not facilitate is the framework with which to measure the performance of individual buildings within the estate.

11.5.2 IPD Occupancy Costs service (ITOCC)

ITOCC is the IPD Occupiers International Total Occupancy Cost Code which defines costs, cost ratios and space for most standard types of property such as offices, retail, industrial and warehouses. It also provides a cost framework for other types of real estate. The code comprises of four key facets, these being:

- **Transparency:** All occupancy costs are brought together, whether capital or revenue, estate or facilities expenditure.
- **Definitions:** All items are defined in detail to provide a clear and useful document.
- **Usability:** The method is logical and sensible and avoids unnecessary detail. A worked example clarifies and explains the approach.
- **Application:** The Code describes the possible uses of more accurate total cost information in terms of creating key ratios, setting targets and tracking.

IPD Occupiers produce analysis of occupancy costs, space efficiency and property management effectiveness at individual property and portfolio levels, against specific market benchmarks. This is delivered through the UK Annual Service or bespoke research projects.

11.5.3 BMI Standard Form of Property Occupancy Cost Analysis (POCA)

The aim of the BMI Standard Form of Property Occupancy Cost Analysis (POCA) is to allow standardisation of the system of collection and a single format for presentation. The system has been used for over 20 years by subscribers to the Building Maintenance Information (BMI) service. The database expresses costs per 100 m^2 per annum.

The property occupancy cost analysis presents data in a form which allows comparisons between the cost of achieving various defined functions, or maintaining defined elements, in one building with those in another. The POCA also provides a framework in which the property manager, facilities manager or surveyor may systematically collect occupancy cost data year by year.

An element for occupancy cost analysis purposes is defined as: expenditure on an item which fulfils a specific function irrespective of the use or form of the building. The list of elements is, however, a compromise between this definition and what is considered practical.

11.5.4 The Eurolifeform whole life cycle cost model

The Eurolifeform model, which is discussed in Chapter 7, comprises of a design decision support application called 'The Logbook' – this allows the building occupier to capture operational cost data during the building life. In line with recent initiatives such as the Chartered Institution of Building Services Engineers (CIBSE) Building Logbooks, the logbook application also facilitates a Post-Occupancy Analysis (POA) exercise. The idea being that the building owner will utilise the logbook to record the most up-to-date cost-in-use data on an annual basis, enabling the whole life cycle costing (WLCC) model forecasts that were produced at design stage to be matched against actual costs as these accrue.

11.5.5 Cillecta whole life cycle cost project

11.6 Problems with site feedback

Let us consider the contractor's estimating feedback cycle first of all. The difficulties are as follows (and are further considered in Chapter 16):

- Although records of labour and material costs are kept on site, the information is recorded for the payment of wages and checking of invoices, and for monitoring progress on site as an aid to contract management. These purposes dictate a format, which is not compatible with the way in which the estimator works. The grouping of items into 'operations' for reference to the contractor's programme creates difficulties in rearranging the information for the pricing of a BQ based on the Standard Method of Measurement requirement to measure items as fixed 'in place'. Consequently feedback to the estimator tends to be at the very general level of, for example 'We were a bit low on plaster rates on this contract Jack' rather than more specific data.

- Even if site data could be related back to the estimator it is unlikely to be of very great benefit, because performance of the labour force varies from day to day according to the following conditions:
  - weather
  - supervision
  - industrial and personal relations
  - obstruction by other trades
  - the skill with which the work is planned and organised
  - alternatively, lack of clear instruction
  - waiting for instructions on design changes
  - waiting for delivery of materials
  - accidents
  - replacement of defective work
  - failure by sub-contractors
  - psychological pressures.

It is unlikely that individual performance on one contract will be repeated on another. It will be explained in Chapter 18 why 'standard costing' methods used in industry do not work on a building site. The estimator can only hope to get close to the total labour content of the project and hope that good site management will avoid wastage of this resource.

- No formal record of the performance of labour will be available for work where 'labour-only' sub-contractors are used, and therefore an extremely large area of work is no longer subject to scrutiny and analysis.
- Material use and costs will also be variable between sites, and here again no firm data can be expected for the estimator to use. The amounts used will depend upon the following factors:
  - care in ordering
  - site control and supervision
  - vandalism and site damage
  - replacement of defective work
  - the competence of the workforce.
- Plant costs will be even more difficult than the other categories to relate from one site to another, and depend heavily on:
  - the quality of site management
  - the amount and type of plant available (especially where the building firm uses its own plant)
  - the extent to which the work lends itself to efficient plant use
  - the amount of disruption to efficient use caused by the work programme, and particularly by changes or delays in this.

The problems with feedback mean that very little data is kept in the contractor's office. The database for the majority of estimators still consists of a 'small black book' of labour and material constants, a list of addresses and telephone/fax numbers of suppliers and sub-contractors, and a good deal of experienced judgement!

No wonder it has been suggested that a tender represents 'the socially acceptable price' rather than a scientific appraisal of the resource needs of the project. Indeed, there is some evidence to show that estimators bid randomly within plus or minus 10% of the actual contract cost excluding profit. This is considered to be the limit of their ability to forecast reliably what the job will cost and is discussed later in this chapter.

11.7 Problems with the analysis of BQs

The estimator's problems with the retrieval of site data set the scene for the problems the cost planner will find when analysing the priced tender document, which the estimator has prepared. The vast majority of the information used by the cost planner arises from the BQ, and yet, as we are beginning to see, this document may be based upon incorrect assumptions, which just happen to work in most cases and are convenient for the estimator to use. It has been said that the only reliable figure in the BQ from the client's point of view is the total (i.e. the tender figure).

11.8 Variation in pricing methods

If we start to break down the fairly similar totals of the different contractors' tenders for the same project into smaller units, we are liable to find substantial variation in each individual sub-section when considered in isolation from other sections.

The greater the number of categories, the greater the degree of variation for the following reasons:

- We know that the rates in the BQs are not true costs, but they are not even true prices in the sense of a price on a supermarket shelf. The contractor is not offering to 'sell' brickwork at so many pounds per square metre but to construct a whole building for a total sum – the rates are simply a notional breakdown of the total price for commercial and administrative purposes. There is thus no reason why any individual rate should be justifiable in relation to either cost or competition.
- The way in which the contractor prices the 'preliminary' items of plant, scaffolding and so on, and the firm's own profit and overheads, will vary from one firm to another. Some will place these in the 'preliminaries' section while others will include them, in whole or part, in the measured work rates as they see a commercial advantage in not identifying them too explicitly. Consequently, the 'cost' of any individual trade, element or BQ item will vary according to the treatment afforded to these factors.
- It may be in the contractor's best interests to 'load' the prices of those parts of the building which are executed first, such as excavation and earthworks, to improve the project's cash flow (i.e. obtain money earlier in interim valuations to help finance the rest of the work). In a similar fashion, the contractor may anticipate variations to the contract and reduce the price of work, which is thought likely to be omitted, while increasing the unit rates of any items which are likely to increase in quantity.
- In addition to the deliberate pricing method of each contractor, there are all the variations in unit rates caused by different assumptions being made by each estimator with regard to the resource requirements. These variations tend to be highest in high-risk trades such as excavator and carpenter, and lowest in those most easily controlled such as glazing and concrete work. The assumptions made will relate to the estimator's view of the firm's expertise and economic structure.

- In an estimate for a complex product such as a building, it is inevitable that mistakes will be made. These will tend to cancel each other out, but sometimes there is an error of cost significance in a single item which may not be spotted by the QS.

If other factors such as the contractor's previous experience of the particular design team or client (e.g. factoring in a premium for a difficult architect or the QS!), knowledge (or otherwise) of the locality, experience of the type of building proposed or keenness of tendering are taken into account, it can be seen that data obtained from BQs is likely to be highly variable even for contractors who are tendering for the same job.

11.9 Variation in BQ rates for different jobs

If we now consider the BQ rates of contractors tendering for different projects, then we can expect variability due to all the above factors plus a good few more. These additional items will relate to the site and contract conditions for each particular job and will include the following factors.

11.9.1 Site conditions

There are a number of site conditions, which can affect BQ rates:

- problems of access;
- boundary conditions, especially the problems of adjoining buildings;
- soil-bearing capacity and consistency;
- topography and orientation of the building, which may affect manoeuvrability on the site and the type of resources (particularly plant) that can be used.

11.9.2 Design variations

The way the building is designed has an enormous effect on the efficient use of resources and on production method and time, for example,

- If there is a poor repetition of formwork, then it is reasonable to expect higher prices if this fact has been communicated to the estimator.
- Wet trades requiring drying and curing time will possibly create more delay than if a dry form of construction is used.

The extra costs, if any, will be represented in the rates or will result in a redistribution of prices, for example more money in preliminaries for the longer supervision required and plant not fully employed, and perhaps less money in the work sections of the BQ.

11.9.3 Contract conditions

The impact of these is very difficult to anticipate, particularly with regard to their effect on unit rates. In general, it can be assumed that the more onerous the terms as far as the contractor is concerned, the more likely it is that a higher tender will be put forward. However, when a contractor is short of work or particularly wants a certain job (say for prestige purposes), then the effect of 'tough' clauses may be less than that would normally be expected.

Any contract, which requires more working capital for the project, or additional risk, is almost certain to incur a cost penalty that will be passed on to the client. In addition, conditions relating to both the length of the construction period, particularly a shortening of time, and the phasing of the works may result in uneconomic working and will influence the estimator's rates and particularly the 'preliminary' items.

11.9.4 Size of contract

For each contracting firm, there is an optimum size of contract that will suit its particular structure and resources. Large firms very often create 'small works' divisions of the main company to deal with those projects, which are small or of a specialist nature, such as restoration or fitting-out work, and which cannot carry the overheads of a giant corporation.

Smaller firms, on the other hand, find it difficult to gear themselves up to a multi-million pound project with its specialist plant, complex labour relations and sophisticated supervision and control requirements. The size of the firm in relation to the contract for which it is bidding will therefore affect its approach to the estimate.

The unit rates for a large project should make allowance for the economies of scale that could be expected. However, the following factors do not always allow these economies to be made:

- the problems of site working,
- the lack of advanced mechanical production plant and
- the nature of the industry

11.9.5 Location

This factor will obviously affect the problems of accessibility to the production resources. The transport of materials, workpeople and plant to site, with perhaps accommodation of the workforce on remote sites, makes this an important consideration.

On top of these problems are those of local climate, which, even in the United Kingdom, may affect the starting on the site, the degree of protection required and the interruption of the work programme.

Despite these problems, it should be noted that of all the old principal government cost limits, only the housing cost yardstick identified location as a cost variable and divided the country into regions. The other yardsticks made no allowance for regional variations, but did take the problems of a particular site into account by the use of an 'abnormals' allowance.

A contractor's estimator is likely to pass on the problems of a particular area as an extra cost to the client if the firm has had experience of that location. This again will create variation in the rates because of different allowances being made.

11.10 Research into variability

All the problems listed contribute to the wide variability in BQ rates. Derek Beeston of the former Property Services Agency looked at the major items in each work section (or trade) in a large sample of BQs from different government projects and compared the unit rates for each individual item. He found that the variability tended to be different for each trade and expressed the degree of variability in the form of the 'coefficient of variation', which enables a comparison to be made between the variability of items of different value and is given by the formula:

$$\text{Coefficient of variation} = \text{standard deviation}/\text{arithmetic mean} \times 100\%$$

So in concrete work, for example, the cost per cubic metre may be £33.00 and the standard deviation may be £5.00:

$$\text{Coefficient of variation} = (5/33) \times 100\% = 15.15\% \text{ say } 15\%$$

This can now be compared with plaster work with a cost of £3.00 per square metre and a standard deviation of £0.30:

$$\text{Coefficient of variation} = (30/300) \times 100\% = 10.00\%$$

The standard deviation on its own would not allow the degree of variability in each trade to be compared. The results of Beeston's investigations showed the following:

Excavator	45%	Joiner	28%
Drainlayer	29%	Roofer	24%
Concretor	15%	Plumber	23%
Steelworker	19%	Painter	22%
Bricklayer	26%	Glazier	13%
Carpenter	31%	All trades	22%

It is no surprise that excavator, with its high-risk problems due to weather, soil conditions, accessibility and so on, should have the highest variability. The ranking of some of the others is perhaps unexpected and a detailed investigation would need to be undertaken to discover the reasons for their particular performance. However, the table does illustrate very clearly the problems of using BQ data. Once again, success depends upon the skill of the user in determining what rate to use against a particular measured quantity. A computer cannot make this judgement.

11.11 The contractor's bid

If we accept the problems associated with obtaining reliable feedback from site and the rather arbitrary value given to unit rates in the BQ, then we might wonder how the contractor arrives at a 'bid' for a particular contract when he is in competition with others. The theory is that the estimator:

- knows how long it will take a team of craft operatives and labourers to execute a job;
- knows the precise amount of material required including wastage;
- can define the exact output of each item of plant to be used and the time it will be on site;
- can add on the measured cost of supervision and overheads;

to arrive at the net cost of the job excluding profit. The process is essentially deterministic; it assumes that the estimator (if clever enough) can determine the exact amount of resources and their cost. However, every contractor knows that this is not possible.

11.11.1 The notion of non-deterministic pricing

Research has suggested that while the above process is theoretically adopted, it is in fact very often used to justify a total that the contractor has in mind from the very beginning. Brian Fine, who used to work for one of the largest UK building companies and later became a management consultant, has suggested that contractors may bid at what they consider to be a 'socially acceptable price'. This is not well defined, but is considered to be the price that society is known to be prepared to pay for a particular type of building. For commercial projects, this would probably be related to the income of the office block or output of the industrial plant. For social projects, it may be related to the known funds available. In the case of government-funded projects, it may be a defined cost yardstick.

It is considered that this value of the building is relatively easily calculated and that generally the building is buildable at around the socially acceptable price. By bidding at this value, the estimator overcomes the problem of being unable to predict resource requirements for the project. As the client's anticipated cost is probably based on what has been successfully built before, it is therefore likely that the estimator will have put forward a reasonable estimate, and the labour and material 'constants' are used to justify this.

It is unlikely that many contractors consciously go through the above process, and indeed they often react strongly to the suggestion that they do. However, despite the wide variation in individual BQ rates, the final tender figures are often considerably closer than one would expect. A coefficient of variation for the spread of tenders on a project tends to be in the range of 5–8% and this can be applied to a wide variety of projects.

11.11.2 Support for the notion of non-deterministic pricing

Contractors will occasionally admit that they can write down the cost of the job before they start pricing it, assisted by

- working out the yardstick amount before pricing a government job;
- the client naming the approximate value of the contract when enquiring if the contractor is willing to tender;
- the building grapevine of sub-contractors and suppliers, who probably quote several times for the same job but for different contractors, and ensure that the anticipated contract sum is well circulated.

The case is further strengthened by the following:

- **The name of the project appears to influence the cost**: A good example of this phenomenon was the decision by a number of hospital boards some years ago to let nurses' accommodation blocks as a separate contract to the main hospital development. The reason for this decision was that the nurses' accommodation was costing appreciably more than comparable students' accommodation in the education sector. Tenderers had apparently applied the same criteria of complexity, difficulty and high cost associated with hospital projects to the far simpler problem of the nurses' accommodation blocks. Hence, of course the high prices, and the suggestion that the real cost was not being estimated.
- **Constants are not reliable:** As stated earlier in this chapter, it is not possible to establish accurate constants of labour, plant and material to apply to the job that is being estimated.
- **Chance of contracts being won:** In a competitive market, it appears that contractors take their place in the bidding order by chance. As would be expected with chance, in the long run they appear to win contracts in direct proportion to the number of other contractors they are bidding against.
- **Estimates are tailored to suit the market:** If the estimation of cost really was a deterministic exercise, then the constants used in the estimate would be absolute and unchanging unless, of course, they were amended as the result of ascertained cost feedback. However, what happens when an estimator or firm loses a number of bids in succession? The estimator is

told to 'sharpen your pencil' and the firm reduces their rates! In order to survive they must get work.

This practice suggests that the estimate does not mean very much in terms of an accurate prediction. If the firm does get the job and they think it will be 'tight', they put their best management team on the project and very often get a better return than on a job where they foresaw a large profit and did not maintain such tight control! The lower price that they are bidding could be the socially acceptable price.

It would not be fair to suggest that the concept of socially acceptable price has been thoroughly substantiated on the basis of the few arguments considered. However, doubt has been cast on the deterministic estimating process, and this in turn should influence the way in which we look at and use cost data.

Obviously, the factors of supply and demand related to the capacity of the industry, and its workload will influence the level of the contractor's bid, and the relationship between these factors and the socially acceptable price has not yet been well defined.

However, it is important to realise that market conditions reflect the economic standing of the country and this aspect may well have more impact on 'historic' cost data, and the price society is prepared to pay for its buildings, than any other.

11.12 The structuring of cost data

In addition to the difficulty of acquiring reliable cost data, there is the problem of what to do with it once acquired. The need for a system of cost planning to have access to cost data at a number of different levels of complexity postulates a hierarchy of cost groupings, or even a series of interlocking hierarchies, because some of the criteria to which cost data will be applied are of different types and not merely different scales. One such hierarchy, which we encountered in Chapter 10, is based upon the concept of design cost elements. This is a highly pragmatic breakdown of a project for cost planning purposes which, apart from its inherent faults, suffers from the disadvantage that it does not meet the requirements of any other functions in the design/build process. Another hierarchy is the Standard Method of Measurement format used for BQs, which is only of limited use for other purposes. However, because the information provided in the BQ is generally of a high quality, tied back into the contract, available to the builder without further cost or trouble and structured in accordance with the 'Common Arrangement of Work Sections for Building Works' produced by the Co-ordinating Committee for Project Information (CPI), its format does tend to pervade documentation produced for process purposes rather more than might be expected.

Operational cost centres, which are useful for actual control on site, are difficult to relate to the estimating and commercial systems of the industry, except at the highest levels of generality. Because of the obstruction to communication between builder and designer which is caused by the price mechanism and the associated contractual standpoints, there has been little attempt to link site operation costs to design criteria.

11.13 An integrated system of groupings?

A number of efforts have been made, over the last 30 years in particular, to devise an integrated system of groupings of building work which would meet the needs of all participants in the project, from the point of view of design process, costing, communication, organisation and feedback. It is argued that such a system would reduce duplication of effort (it is alleged that the same piece of building work may be physically measured up to 15 times for various purposes), improve communication between the parties and permit a far higher quality of costing and cost feedback. The CI/SfB system whose use was encouraged by the Royal Institute of British Architects (RIBA) was one such effort, but was too oriented towards its original purpose of filing design information to have found much favour elsewhere (it is now incorporated in the wider Uniclass system). A much more complex version of the same basic system, CBC, was developed in Scandinavia and relied heavily on computer use at a time (the 1970s) when this imposed considerable constraints on a system. In Britain, the then Department of the Environment set up a data coordination study with substantial resources and a large measure of contribution from industry and the professions, it being their very reasonable view that this was the only way of obtaining results which would be useful, and acceptable, to all. Unfortunately the work ceased, for party political reasons, without producing much more than a number of very interesting reports and the Construction Industry Thesaurus, which is used mainly for library, information and reference purposes. Little further work has been undertaken in this field in more recent years and little progress has been made, but there is plenty of (rather dated) background reading available.

11.14 Sources of data

So far in this chapter, we have dealt with some of the more general problems of cost information associated with its use, retrieval and structure. Although these problems should be identified, it has to be recognised that the quantity surveying profession has been using data obtained from BQs for many years with reasonable success. Contractors, too, have been able to prepare realistic estimates from the very generalised feedback that they get from site. The problems associated with data should not therefore be allowed to obscure the fact that present data sources available to the industry have allowed the development of a simple and reasonably effective system of cost forecasting and control that the various parties are familiar with.

From the point of view of the client's cost adviser, information can be obtained from two main sources:

- data passing through the cost adviser's office;
- published material found in the technical press, price books and information systems.

There is no doubt that most cost advisers would normally prefer to use their own data, for the following reasons: the data will be from a project whose background they know. They will therefore be aware of all the problems associated with the project:

- its location
- the market conditions and
- complexity

which influenced its price, and they will also know about the project's outcome. We have already said that traditional cost modelling requires sound professional judgement. This is better served by using information that is known to the cost planning organisation through involvement in the project rather than received second-hand from a published source, in an abbreviated form and with little background information.

The further detailed breakdown of any structured information is available should it be required. To take the example of an elemental cost analysis, the firm will have available:

- the full-priced BQs
- the original measurements
- the working drawings
- the contract

should they wish to find further information on why an element cost a certain amount or what were the prevailing market conditions at the time and whether the overall price was considered high or low. It is very unlikely that this level of detail would be available in any published data, however well prepared. To take another example, many QS/cost planners prepare their own cost indices because they know the weightings and costs included, and these can be manipulated with greater confidence in assessing the needs of a particular project.

- The data will refer to the geographical area in which the firm carries out most of its work.
- Compared to published data, there is a shorter time lag between receiving raw data, processing it and being able to use the structured information in the office. This is particularly relevant to cost indices, where the published information may be anything up to 6 months behind the times.
- The choice of classification and structure of the processed data is under the control of the firm. It is therefore possible to ensure that the details which are most relevant to that particular practice are emphasised and identified rather than having to accept a standardised published format. If errors and ambiguities occur, it is also easier to spot them in your own system rather than somebody else's.

Having established the preference of most cost planners for their own information, it would be unrealistic to suppose that any but the largest firms or organisations could exist solely upon the data passing through their office. The range of projects undertaken by most practices is considerable, varying from government and local authority buildings to commercial and leisure buildings for individuals and corporate clients. The variety of specification, location, size and shape of this range is also large, and it is therefore most unlikely that the office will have up-to-date information which it can apply to all its new projects.

11.15 Published cost data

The common unit rates, which each QS will gather from handling project information, will help in preparing an approximate estimate of quantities, but at the coarser level of elements, and single-price estimates, a wide enough variety of data is unlikely to be readily available. While the cost planner can probably make intuitive assessments, particularly of cost per square metre, it is reassuring to have a check available in the form of published information. Indeed, it is probably the primary role of published information to provide data that enables practitioners to check on their own knowledge and to provide a context for their own decision-making. The following are the major sources of this kind of data, which apply almost entirely to the conditions in the United Kingdom. Such information as exists overseas is often of a more condensed statistical nature and makes the cost planner's task in most other countries more difficult.

11.15.1 The technical press

There has been a steady improvement in the quantity and quality of cost information appearing in the journals and magazines concerned with design and building management. Until some 30 years ago, almost no information was disseminated in the press regarding costs of buildings. This was always jealously guarded as confidential until *The Architects' Journal* took the lead in refusing to publish accounts of new buildings unless cost information was included. Since then, however, largely due to demand from clients for better cost control, editors have found it necessary to devote more space to cost analyses and forecasts. The type of information that can now be found in such journals as *The Architects' Journal* and (particularly) *Building* magazine includes elemental analyses; resource costs and measured rates; cost indices with future cost projections; analysis of the economic performance of the industry and cost studies of different types of buildings. Indeed, with the rapid changes in the level of resource costs and measured rates over very short time spans, the technical journals, published at weekly intervals, have largely replaced the traditional annual standard price books as a source for quick reference material.

11.15.2 Builders' price books

A traditional source of useful information has been the price books, which are normally published annually by several long-established organisations. These too have expanded the scope of their contents to keep pace with current demands and to try and maintain an edge over the technical journals. However, in periods of rapid inflation or market changes, they have suffered the drawback of having to prepare their information well in advance of the year of publication. This time lag of several months, and the 12-month period for which the information is meant to be current, means that the rates have tended to be forecasts of what is likely to happen at some unknown point of time in the year ahead. This problem has more recently been overcome by the publishers offering online computer access to updated information. Despite the above problems, it is usual to find an assortment of *Spon's Architects' and Builders' Price Book*, *Laxton's Price Book* and *Wessex Price Book* on the shelves of all the building professions. Their popularity stems from the very comprehensive nature of the data now included, and sub-sections normally cover

- professional fees for building work;
- wage rates in the industry;
- market prices of materials;
- constants of labour and materials for unit rates;
- unit prices for measured work in accordance with the Standard Method of Measurement;
- elemental rates for a variety of work;
- building cost index;
- approximate estimate rates and comparisons;
- cost limits and allowances for public sector buildings;
- European prices and information.

Spon also publish separately a very comprehensive *Mechanical and Electrical Services Price Book*. They also publish a *European Construction Costs Handbook* and an *Asia-Pacific Costs Handbook* for overseas work. As with data from any source, considerable care needs to be exercised in the use of the information in all these books. They assume that a reasonable quantity of work for all items is required. The subletting of all work which is normally sublet (a builder's price for this type of work is likely to be higher than normal market rates) is also assumed. No allowance is included for overhead charges and profit, nor for preliminary items or VAT. The prices are based upon a tender price index of 325 in relation to a base of 100 in

1976 (which may not be the same as the index normally used by the cost planner). The user is expected to make all allowances for changes in the location, size of contract, small quantities of particular items and market changes. It will be seen from this how dangerous it is to start picking out prices at random from various publications, all of whose rules may be different, without reading the detailed conditions in each case. However, price books have a very useful role to play in enabling practitioners to check on their own knowledge and assumptions.

11.15.3 Information services

With the advent of cost planning techniques and the need for a wide range of information on different types of project, it was realised that most offices would require information additional to that normally found in one particular practice. It was suggested that if firms could be persuaded to supply their own elemental cost analyses to a central body, then a large pool of information could be gathered which could then be disseminated to the subscribing members. If these analyses could be supplemented with other more general information on trends and economic indicators, then a useful service would be provided to the profession. Therefore, in 1962, the Royal Institution of Chartered Surveyors (RICS) set up the **Building Cost Information Service (BCIS**) to undertake this task. For its first 10 years, the service was only available to QS members of the RICS, but since 1972 it has been available outside the quantity surveying profession. Today there are other cost information services, but the breadth of information and independence of the BCIS, and its sister service BMI, makes these RICS services the leaders in their respective fields. They are dealt with here in more detail.

11.15.4 Building Cost Information Service (BCIS)

The BCIS is a subscriber-based service, which collates and analyses data submitted by its subscribers and incorporates material from other sources. The information is interpreted by the BCIS professional staff of chartered surveyors and is presented in two formats: BCIS Bulletin Service (a hard copy service) and BCIS Online (an electronic data service). Naturally, all information provided by subscribers is treated in confidence. Approval to publish project-specific data, such as elemental analyses, is sought from subscribers and any other parties for the information. A summary of the BCIS Bulletin Service, which principally deals with capital cost data, is given below.

The **indices and forecasts** report is published quarterly, this is a bound report including:

- the complete series of BCIS Indices;
- a 24-month forecast of the main tender and cost index series;
- an executive summary;
- a thoroughly researched commentary on market conditions with trends projected over the coming 24-month period;
- a range of individual indices for tender prices, regional prices, input costs and output prices.

A quarterly bound publication, **surveys of tender prices**, includes a range of current pricing studies incorporating updates of

- the BCIS Tender Price Index;
- the BCIS Building Cost Index

This publication provides

- information on average building prices for different building types, new and refurbishment, expressed in £/m^2 of gross internal floor area and adjusted to current prices using the BCIS Indices;

- functional prices, such as œ/pupil place for schools, for around 200 building types;
- studies of price differentials by size of contract, location and type of work;
- results of a survey of the percentage added for preliminaries, dayworks and sub-contract work.

It should be noted that the BCIS Indices are based on an index of 100 in 1985, and so are quite different to those used by Spon's, for example. Previous warnings about care when combining information from different sources should be remembered.

The *Five Year Forecast* (published in the summer of each year) provides information on economic factors affecting the construction industry. The forecast includes the following features:

- Building cost trends and summary of forecasts
- Executive summary
- Latest trends
- Economic background – covering inflation, growth and interest rates
- Materials
- Labour
- Earnings, wages and rates
- Market conditions
- Output
- Housing
- Output forecasts
- Tender levels
- Tender price forecast
- Assumptions for inflation, demand, labour and materials

Elemental analyses are a key source of price information from accepted tenders and are published quarterly as loose-leaf data sheets classified for filing by building type. This was covered in the previous chapter.

The guide to *Daywork Rates and Updating Service* is an annual guide that covers the daywork rates for 54 grades of operative, giving both current and historical rates. Each rate is calculated in accordance with the BCIS/RICS interpretation of the appropriate 'Definition of the Prime Cost of Dayworks'. Daywork rates can change at any time in the year, so BCIS offers an updating service which informs subscribers of changes in rates as and when they occur.

The information in the *BCIS Quarterly Review* is a selection of BCIS data which gives guidelines on the general level of building prices. It contains average £/m^2 building prices, the BCIS tender price index, the BCIS building cost index and location factors. There is also a brief commentary on market conditions and tender prices.

Each year BCIS also publishes the *Annual Guide to Daywork Rates*, and an *Updating Service* to provide information on the latest changes to the daywork rates. The guide contains all current and historic daywork rates calculated by BCIS, for the wage awards for the major trades in England, Scotland and Wales, including

- Builders – 10 grades
- Plumbers – main grades – 7 grades
- Plumbers – apprentices – 8 grades
- Heating and ventilating – 22 grades
- Electricians – main grades – 12 grades
- Electrician's apprentices (Scotland only) – 4 grades

Normally published at the end of each calendar year, each rate is calculated in accordance with BCIS's interpretation of the appropriate '**Definition of Prime Cost of Daywork**' carried out under a Building Contract agreed between RICS and the contracting organisations. The example calculations show where differential payments, merit money and so on should be included.

The **RIBA/BCIS Cost Calculator** provides a range of costs from the BCIS building project database. These costs reflect the tender costs of actual building projects in the United Kingdom and are aimed at architects who require more accurate guidance on what typical projects cost to build.

The RICS also provide comprehensive information on occupancy and maintenance costs through the **BMI** service. The subscription service includes the following data sources.

The *BMI Bulletin* is a regular update for subscribers with the comprehensive BMI Occupancy Cost Information Service data. These paper reports are published throughout the year and compiled in folder format.

The *BMI Quarterly Cost Briefing* is available separately on subscription as well as forming a part of the BMI Bulletin Service. The briefing provides guidance on changes in prices and costs. Each Briefing, published every 3 months, provides information on current and forecast trends in maintenance and occupancy costs. Maintenance price indices monitor the movement of contractors' pricing on actual contract providing useful information on the market. The price indices contained within the briefing monitor market trends in private housing; public housing; and private, industrial, commercial and public non-housing. The briefing also contains information on cost indices, tracking the general movement of costs through different industry sectors.

The latest edition of the *BMI Building Maintenance Price Book* has been thoroughly revised and updated, containing information and data on:

- Budgeting
- Estimating
- Cost control
- Schedules of rates
- Letting maintenance work
- Measured term contracts

The book is separated into three sections covering:

- Basic costs – labour rates, scaffolding, and plant and materials
- Labour constants
- Measured rates

Finally, the service also provides access to the **BMI Special Reports**[1] which cover reviews of occupancy, maintenance and rehabilitation costs.

11.15.5 BCIS Online

Since 1984, the BCIS has been operating a computer-based service which gives subscribers unlimited access to the entire BCIS databank from their own PC. It can be accessed from anywhere in the world. With a link to the BCIS host computer a simple menu-driven structure (which was summarised in Chapter 2) enables the user to select the type of data and the specific information required in the shortest time. The system is straightforward to use. Simple but powerful selection tools cut out time-consuming browsing to locate, for example, the cost analyses needed for a project. This ensures that users have access to the widest possible range of examples as well as the most up-to-date information – particularly important when the market is volatile. Once the required information has been located, users can copy it to their own machine for further use. The system allows analyses to be updated to current or projected pricing levels and adjusted for location. Data can then be printed; displayed on screen; used in conjunction with approximate estimating and other software such as spreadsheets.

11.15.6 Government literature

The Department of Trade and Industry (DTI) publish the *Quarterly Building Price and Cost Indices* and these can be accessed via the UK government statistics portal **National Statistics**. Used primarily for those involved in estimating, cost checking and fee negotiation within public sector construction projects – it includes data on tender and output price indices, resource cost indices and location and function studies. This information is produced by the DTI Construction Statistics and Economics Unit, which has responsibility for the collection, analysis and publication of statistics for the construction sector. The Division provides regular statistical analysis of building materials; overseas trade, overseas construction by British firms, price and cost indices and key performance indicators of construction activity. In addition to the statistical advice, the Division provides economic analysis and advice to assist in the assessment of the construction market and in the formulation of efficient policies. The unit also produces the *Construction Statistics Annual*. This publication gives a broad perspective of statistical trends in the construction industry in Great Britain throughout the last decade together with some international comparisons and features on leading initiatives that may influence the future. Finally, the National Statistics portal also provides information on **Price Adjustment Formulae for Construction Contracts** through the monthly bulletin of indices. Used in conjunction with the formulae, price adjustment method of adjusting building and civil and specialist engineering contracts to allow for changes in the cost of labour, plant and materials. These are familiarly known as NEDO Indices, Baxter Indices or Osborne Indices and are widely used primarily on variation of price contracts.

11.15.7 Technical information systems

Most construction professionals will have access to services such as the **Construction Information Service (CIS**) and **Specify-IT**, both providing a wealth of information on product specifications. Prior to the widespread use of these electronic resources, office library systems contained a collection of current trade literature relating to building products. Their major purpose is to provide a ready reference for the practitioner on specification and performance of a wide variety of building products. At one time, it was not uncommon to find current price lists included, but prices change more frequently than specifications, and the problem of updating this secondary information has been solved by leaving it out. The use of these services for cost planning purposes is however negligible.

11.15.8 Other sources of cost data

While the two main sources of data for the cost planner are the firm's own data and published data, there is a further source available for some types of work, which in some ways is a combination of the two. This is the obtaining of information from specialist sub-contractors and specialist consultants, and with an ever larger proportion of building cost represented by specialist firms undertaking:

- roofing
- flooring
- fenestration
- doors
- cladding
- finishes
- structural systems
- landscaping and engineering services.

Like published information it suffers from remoteness, but because there is usually an element of personal contact involved, it is often possible to explain and discuss exactly what the circumstances and requirements are. Personal knowledge and contact are also helpful because there is little other guarantee of the soundness of such advice. If prices are obtained from specialist sub-contractors, the cost planner must remember to allow

- the builder's profit;
- the builder's contractual discount allowance if the sub-contractor's price is net;
- facilities which the builder must provide;
- scaffolding;
- unloading and moving materials;
- storage;
- office accommodation;
- use of builder's plant and equipment;
- incidental builder's work in cutting holes;
- assistance with site fixing. Some firms send only a specialist fixer who does little more than supervise the builder's own site workers.

It is important to find out exactly what the sub-contractor requires in these matters – some such firms are almost entirely self-sufficient, others lean upon the builder as much as possible.

11.16 Future development

Reliable cost data continues to be a vital primary need of the cost planner, and this has become even more apparent as the profession moves towards providing clients with whole life cost advice. A great deal of research has been carried on the use of advanced analytical tools such as data mining and artificial intelligence in order to best utilise the data that is available. The prediction of trends in construction cost indices is also a rich vein of activity and many larger consultancies will employ economists with the expertise to help advise cost planners on likely changes in materials and labour constants. As these developments filter through to the industry, it should be expected that change will be rapid and fundamental.

11.17 Key points

- An attempt has been made in this chapter to outline the sources of cost data available to the cost planner and their use and problems.

- The primary source of such data is still the priced BQ, but the reliability of this data is rather questionable and the extent to which it even tries to represent actual costs is open to doubt.
- Price data contained within the BQs is usually confidential and the contractor's permission must be sought if any analysis is to be published. Builders' own cost systems are not usually as suitable for design cost planning purposes as might be expected. Published cost data of various kinds is a useful back-up. BCIS and other information services are also very useful.

Endnote

1 BCIS Special Report Serial 355 Occupancy Costs of Industrial Buildings, ISBN 1904829473 (2006) October 2006 provides a useful example of occupancy cost plans for this type of building.

Chapter 12

Construction Cost Indices

12.1 The cost index

Cost indices are a 'weapon of choice' in the armoury of the cost planner since they provide a valuable insight into changes in the cost of an item or group of items from one point in time to another (time series). The Consumer Price Index (CPI) is perhaps a well-known example; it represents the ratio of exchange between money and a 'basket of consumer goods'. In compiling an index, a base date is chosen and the cost at that date is usually given the value of 100 (index number), all future increases or decreases being related to this figure. An index number of 100 is ordinarily used since it avoids the confusion of negative numbers where values fall below the base index number.

Example

Suppose the cost of employing a labourer on site at base date was £160.00 per week and the current figure is £240.00 per week. £160.00 would be given the value 100 and £240.00 would be represented by the figure 150, derived in the following manner:

$$\{(240 - 160) \times 100\}/160 + 100 = \text{cost index in relation to base}$$

As the base is 100, the number of points of any subsequent index above 100 (in this case 50) also represents the percentage increase since the base date.

However, if we are comparing costs over time in which the data we wish to update is not at base year cost, but has an index of say 120, then to arrive at the percentage increase in cost where the current index is 150 the following calculation is used.

$$(150 - 120)/120 \times 100 = 25\%$$

Notice that the answer is not the difference in the number of points on the index scale, that is, 30.

12.2 Use of index numbers

There are a number of uses to which index numbers can be put in the construction industry.

12.2.1 Updating elemental cost analyses

This is perhaps the most common use for the quantity surveyor and is an essential part of the elemental cost planning process. Tender information of past projects can be brought up to

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

current costs for budgeting purposes. However, great care is required when updating information beyond a period of, say, 2 years.

12.2.2 Updating for research

It is extremely difficult to obtain large quantities of cost data relating to the same point in time in order to analyse trends and patterns for cost research. By bringing cost information, obtained at a number of different points in time, to a common date by the use of an index, a much larger sample of data can be examined.

12.2.3 Extrapolation of existing trends

By plotting the pattern of costs measured by an index, it may be possible to extrapolate a trend into the future. However, there are very great dangers in extrapolation. For example, during the 1960s, there was a steady increase in cost of about 5% per year. Extrapolations were undertaken using this figure for projects 1 or 2 years ahead. This worked quite well for a number of years until 1970, when the cost of building to the client suddenly rose by about 10%. Many quantity surveyors (and other professions) had not foreseen this rise and were heavily under-valued in their budgets. It may be thought that inflation is fairly constant in the United Kingdom at present – but then that is what people thought in the 1960s. Extrapolation based purely on present-day trends can be fraught with risk.

12.2.4 Calculation of price fluctuations

During periods of rapid inflation, it was the custom for building contracts to be entered into on a basis whereby the contract amount was adjusted during the progress of the work to take account of inflation since the date of tender. By applying an index to the cost of work undertaken during a specified period, it was possible to evaluate the increase in costs of resources to the contractor more speedily and with less ambiguity than by using the previous laborious method of comparing every invoice price with the base date cost of the same item. The New Energy and Industrial Technology Development Organisation (NEDO) index (see later) was most often used for this purpose.

12.2.5 Identification of changes in cost relationships

If a cost index is prepared for the different components of a building, or for alternative possible solutions to a design problem (e.g. steel versus reinforced concrete frame), then it is possible to see the changes in the relationship between one component and another over time. It may then be possible to identify when one solution appears to be a better proposition than another.

12.2.6 Assessment of market conditions

Quantity surveyors are particularly interested in the price their clients have to pay for a building. If the index will measure the market price, as opposed to the change in the cost of resources, then a measure of current market conditions can be obtained which is of enormous benefit in updating and forecasting cost.

12.3 Approaches to constructing an index

Over the last two or three decades, there have been a number of attempts at providing a reliable cost index. They include the following.

12.3.1 The use of a notional bill

In this method, a typical (or synthesised) bill of quantities (BQ) is chosen and repriced at regular intervals by a competent quantity surveyor based on the experience of current rates. Unfortunately, rates vary so much that it is extremely difficult to assess the current tender situation in such a way that a reliable index can be obtained from the resultant totals. This method is now to all intents and purposes obsolete.

12.3.2 Semi-intuitive assessment

This method is based on trends in resource costs combined with tender reports by quantity surveyors. By receiving reports on current tenders from each of the project quantity surveyors in their organisations, experienced practitioners can adjust their knowledge of the changes in material and labour costs to prepare an index for the current market situation.

This works quite well where the market is stable or steadily changing, but these judgements are extremely difficult to make at a time when the economy is subject to 'stop–go' conditions.

This method has been superseded by the tender-based index described later.

12.3.3 Analysis of unit price for buildings of similar function

If data could be found giving, say, the cost per square metre of all schools of a certain type being built in the country at one point in time, then the average of these costs could be used to provide the basis of an index. If the exercise were repeated at regular intervals for that type of building, then a regular index could be established.

Problems arise, however, due to such large design variables as specification and shape. Such an index would also be only applicable to buildings, which are homogeneous in function and standard and for which there is a regular building programme to provide the data.

12.3.4 Factor cost index

If a typical building is analysed into its constituent resources and the cost of each resource is monitored over time, then a combined average index can be prepared which measures the change in the total cost of the building over the same period. Each resource (labour, plant and material) would need to be given due importance in the index according to its value in the total building. The construction of and problems associated with this type of index are described in more detail later.

12.3.5 Tender-based index

There is a great need for quantity surveyors to have a measure of the market price their clients have to pay for their buildings. The accepted tender figure based on the pricing of a BQ is a record of the market price for a particular building at a specific point in time. If the measured items in the BQ are repriced using a standard schedule of base year prices (to give a base year 'tender'), then an index can be constructed by comparing the current tender figure with the new derived base year total. Efficient methods are available to avoid repricing the whole BQ. Details of this method are provided later in the chapter. The last two of these approaches now need to be considered in more detail.

12.4 The factor cost index

It has already been explained that this uses changes in the cost of resources to build up a composite index. To illustrate the method, let us look at the construction of a simple index for the cost of a brick wall. We will assume that the following table represents the cost of the constituents at base year level in the first column, and then at today's date in the second column. The final column represents the index resulting from these figures (calculated as described previously).

	Base year (£)	Current (£)	Index (£)
Bricks	20	28	140
Mortar	2	3	150
Labour	8	10	125
			415

Average index = 415/3 = 138.34

However, in the earlier example, no account has been taken of the fact that bricks as a proportion of total costs are 10 times more important than mortar, all the resources having been given equal status. Consequently, a very rapid rise in the cost of mortar would have a disproportionate effect on the composite index, and this would not be representative of the increase in the cost of a brick wall as experienced by the contractor. To overcome this problem, the resources need to be 'weighted' in accordance with their importance as follows:

	Index	Base year weighting	Extension
Bricks	140	20	2800
Mortar	150	2	300
Labour	125	8	1000
		30	**4100**

Average weighted index = 4100/30 = 136.67

The effect of the weighting is to reduce the index value in this example because mortar (which has increased most in price) does not now share equal status with bricks and labour. A further problem arises at this point. Suppose for some reason the labour force becomes more productive over the time period, by say 25%. Then at base year, costs of the value of the labour would have been £6.00 instead of £8.00. This will affect the amount of labour involved in building a brick wall and consequently its cost. This change, although affecting the cost to the contractor and possibly the client, will not be represented in the index unless the weightings are changed.

	Index	Current year weighting	Extension
Bricks	140	20	2800
Mortar	150	2	300
Labour	125	6	750
		28	**3850**

This is a very real difficulty with the factor cost index because it is not easy to judge productivity over time, particularly with regard to the construction of whole buildings. In fact in the majority of cases, weightings in building factor cost indices are assumed to remain constant until a revision of the index is undertaken and a further analysis of the importance of each resource is made.

When an index uses the base year weightings for each calculation, then it is known as a **Laspeyres index**. When the index uses weightings obtained from the current year or point in time that is under consideration, then it is known as a **Paasche index**. Both names derive from their original authors.

Another factor not considered in the above examples is the contractor's profit and overheads. Profit, particularly, can be a function of market conditions, and it would be difficult to devise a reliable quantitative measure for this variable. This is why a number of factor cost indices have incorporated an additional component, called a 'market conditions' allowance, very often based on the professional judgement of its author.

12.4.1 Constructing a factor cost index for a complete building

The brick wall was chosen to illustrate the essential ingredients and problems of an index of this type. When constructing an index for a complete building, the task becomes more complex although the same principles apply. A typical procedure can be summarised as follows:

- A typical building (or group of buildings) is selected for analysis into its constituent proportions of labour, plant and material.
- Analysis takes place and the building resources are allocated under various headings to suit the representative cost factors for which information is available. For example, if use was being made of published information for material indices (such as those prepared, The Department for Business, Innovation and Skills), then the different materials in the building would be analysed according to the structure of that published data.
- The different types of labour (corresponding to different wage-fixing bodies) are identified and the basis for evaluation of a unit of labour cost identified. Usually this would include the following:
  - Changes in the hourly or weekly wage rate as determined by agreement of the parties to the wage-fixing body.
  - Changes in employer's 'on costs' and contributions such as holidays with pay, National Insurance contributions and so on.
  - Changes in the agreed standard working week.
  - Changes in the average hours worked per week, as recorded in government statistics. This item and the preceding one will affect the degree to which overtime rates are paid for each unit of labour output.
  - Changes in productivity. One method of obtaining a gauge of productivity is to take the total quantity of materials used by the industry, priced at 'standard rates' (i.e. constant figures) and divide by the total building labour force. If the output per operative increases over a particular time period, then it is assumed that this is the result of productivity and the labour weighting should be reduced accordingly.
  - Change of location. It may be necessary to assume a particular geographical position for the typical building in order that regional differentials can be ignored. The labour unit cost for each type of craftsman and labourer would be computed and then weighted according to the importance of each in the total labour force. The resultant weighted average for labour would be carried forward for weighting with other resources.
- Material rates for comparison with base year prices are selected. Although it is possible to identify a long list of cost significant materials and calculate a separate index for each, it is more usual to rely on published statistics for this type of information. The Department of Trade and Industry (DTI) regularly produces indices of materials for a range of material classifications. It is then merely a question of analysing the typical building according to the published material types to obtain the weighting to be applied to each material index.
- Plant types, together with their weighting, are identified and a standard method of evaluation adopted. This may be based on an average of hire rates for the particular item or it may be calculated by considering purchase price, depreciation, maintenance, standing time and so on to establish a standard resource unit cost which can form the basis of the index. In many published factor cost indices, the change in the cost of plant is ignored.

When the weighted index for each of the three basic resource types is calculated, they are then brought together and weighted again, this time in accordance with the importance of each within the total building cost. Typical values for weighting are (say):

Labour	35–45%
Material	50–60%
Plant	5–10%

The final weighted index represents the change in cost between one point in time and another for the typical building chosen. Any subjective judgement to take into account market conditions, productivity and so on can then be made if it is considered necessary.

12.4.2 Limitations and uses of factor cost indices

It is important to realise that the factor cost index is actually measuring the change in the cost of resources to a contractor for a 'typical' building. Its main shortcoming from the quantity surveyor's/cost adviser's point of view is that it takes little or no account of the tendering market. It does not directly measure the change in the price the client must pay, and although the 'market conditions' allowance attempts to rectify this situation, the source may not necessarily be reliable, having usually been made on a subjective basis as suggested above. Neither does it measure the change in cost of a specific building under consideration by a quantity surveyor.

It is unlikely that the 'typical building' will have the same mix of resources as the client's project; however, on many occasions the difference will not be cost significant. To try and minimise this difference, the 'typical' building may be more of an economic model than a likely real-life building, having, say, a mixture of light concrete block and clay block partitions so that a change in the cost of only one of the alternatives will not unduly distort the index, on the one hand, nor be ignored, on the other.

In spite of these drawbacks, the method is very suitable for identifying trends in resource costs and relationships. It was particularly useful for evaluating cost fluctuations in contracts which allowed for reimbursement of any changes in cost to the contractor that occurred during the contract period, as was common practice at times of high inflation.

12.5 The tender-based index

A much more attractive proposition than the factor cost index from the private quantity surveyor's point of view appears to be an index which takes as its source of information the tender document itself. This should record what is happening in the market place and therefore should be much more useful in updating prices for a design budget.

In essence, the tender figure is compared with a figure produced by pricing the same tender document using standard rates at the base year prices. From the two resultant figures, an index can be calculated showing the increase or decrease in cost to the client within the current tendering market.

12.5.1 Limitations of the tender-based index

There are drawbacks with the method, including

- the questionable validity of BQ rates;
- the difficulty of obtaining priced BQ for jobs which are comparable except for date of tender.

If, however, a large enough sample of projects is taken, then the difficulties can be dealt with by 'trampling the problem to death'. If an appreciable quantity of projects is analysed, it is hoped that all other differences except current levels of cost will cancel themselves out.

An obvious difficulty is the work involved in analysing all the rates in scores of BQs. Fortunately it has been found that much time can be saved by taking only the few largest items in each work section and this results in a negligible degree of error.

12.5.2 Constructing a tender-based index

The procedure for preparing and using a typical tender-based index can be summarised as follows:

- Prepare a priced list of typical BQ items at the prevailing base year pricing levels (possibly with an allowance for preliminaries included). This is of course a time-consuming task, and the current published forms of this index tend to use the PSA Schedule of Rates for Building Works,[1] which is available from the Stationary Office. This schedule is very comprehensive and is more than adequate for the majority of buildings.
- Take the priced document for the lowest tender received and note the format (e.g. work section, elemental).
- For each section of the format (e.g. excavator, concrete work), pick up the largest value item in the section, then the second, and so on, until a total of 25% of the section value is achieved. (It is of course the value of the item as extended in the cash column, and not its unit price, with which we are concerned.) This procedure is repeated for all sections with the exception of preliminary items, PC and provisional sums, profit and attendance on PC items, and daywork percentage additions.
- For each of the items selected, find the corresponding unit price in the base schedule of prices. The difference as an addition or subtraction from the base year rate is then obtained by comparing the BQ unit price of each sample item with its equivalent base year price.
- The extended base year value is calculated for each item (i.e. weighted by its quantity). The total of all the extended items at base year prices is then compared with the total of all the extended items for each section to obtain an index.
- The index obtained for each section is then weighted according to the value of that section as a proportion of the whole tender BQ for the project being considered (less preliminaries, PC and provisional sums, contingencies and so on) and a combined index for all sections obtained.
- The preliminaries are usually dealt with by considering them as a percentage addition to the other items in the BQ, excluding dayworks and contingencies. If the rates in the base schedule include an allowance for the preliminary items, then the index figure arrived at so far is not a true one, since net BQ rates have been compared with gross base rates. So, if the 'false' index of BQ items is 130 and the value of the preliminaries in the current tender is 10% (as a percentage of the remainder of the BQ), then the final index would be

$$130 + (130 \times 10/100) = 143$$

- To obtain an average index for publication rather than for one particular job, the index numbers for all the tenders which have been sampled in a specified time period are averaged by taking either the geometric or arithmetic mean. The difference between the mean of the current and preceding quarters is used to gauge the movement in tender prices. The geometric mean is usually taken when relative changes in some variable quantity are averaged, because the arithmetic mean has a tendency to exaggerate the 'average' annual rate of increase.

A number of simplifications have been made in the above procedures for the purpose of clarity. For example, in practice, problems arise with items that cannot be matched (these are generally overlooked in the item selection process), and where a sample amounting to 25% of a section's total cannot be obtained. The rules governing the index being used should always be carefully consulted in such situations to discover the method to adopt.

12.5.3 Uses of the tender-based index

The tender-based index has several advantages over a simple factor cost index from the point of view of the client's quantity surveyor.

- It measures the change in the cost to the client of a particular project over time, taking full account of market conditions in addition to the change in cost to the contractor.
- It is relatively simple to operate once a base schedule of prices has been obtained.
- It allows comparison of the price obtained by tender for a specific project with the national or regional building price trend. This could assist in deciding whether to call for fresh tenders from another group of contractors, or not.
- It allows the relationship between the market for buildings of different function and locality to be plotted.
- It is not based on other indices and therefore any inherent inaccuracies are not compounded.

There are, however, one or two problems, which have to be acknowledged:

- To overcome the problems because of the variability of price rates in BQs, a large number of projects are required for each index. It has been suggested that at least 80 projects are required for a suitable sample, but this condition is seldom met. Unless access to this number of BQs is available, the trend being plotted may be erratic and not typical. Very few organisations have access to this number of projects and therefore most firms cannot prepare their own index by this method.
- The index relies heavily on the base year schedule which will have to be regularly revised to take into account new products and new methods of measurement. This is a time-consuming and costly task.
- Because of a lack of suitable projects at any one point in time, the average index may have to rely on an unbalanced sample containing more jobs of one particular function and location than is considered desirable. This may lead to errors in the trend plotted.

12.6 Published forms

A number of published forms of costs indices exist, these tend to be classified under the two major index types, factor cost and tender based.

12.6.1 Factor cost indices

Of these perhaps the following are the most familiar.

12.6.1.1 The BIS Price Adjustment Formulae for Construction Contracts (formely known as NEDO)

The quarterly Department for Business, Innovation and Skills (BIS) construction price and cost indices (PCIs) and these are currently published through the Building Cost Information Service (BCIS Online) under contract to BIS and is comprised of the following indices:

- tender price index of public sector building non-housing, social housing, building and road construction
- resource cost indices for buildings, roads, infrastructure and building maintenance
- output price indices for construction sectors
- output price indices for direct labour
- location and function studies

The indices are based on market prices, nationally agreed wages and so on, and therefore do not take into account the problems of a contractor on a particular site. Although primarily provided for the assessment of price fluctuations on contracts where there is a fluctuation clause, they can be adapted for use in a composite building cost index, as dealt with in the following BCIS index.

12.6.1.2 BCIS building cost indices

These measure the change in basic input costs – labour, materials and plant – and are based on cost models of average buildings. There are nine indices:

- BCIS General Building Cost (excluding M&E) Index
- BCIS General Building Cost Index
- BCIS Steel Framed Construction Cost Index
- BCIS Concrete Framed Construction Cost Index
- BCIS Brick Construction Cost Index
- BCIS Mechanical and Electrical Engineering Cost Index
- BCIS Basic Labour Cost Index
- BCIS Basic Materials Cost Index
- BCIS Plant Cost Index

The model for each BCIS index is based on the Price Adjustment Formulae for Construction Contracts. The BCIS indices are calculated by applying the work category indices to the models. Each work category index is a compound of resources of

- labour,
- materials and
- plant

and changes in the cost of each of these components are reflected in the work category indices.

Generally, the labour indices are based on the national labour agreements and the materials indices are based on the Producer Price indices prepared by the Office for National Statistics. The models were prepared by analysing 54 new work BQs into the building work and specialist engineering work categories.

The BCIS General Building Cost Index is a weighted combination of the **Steel Framed Construction Cost Index, the Concrete Framed Construction Cost Index and the Brick Construction Cost Index**.

The BCIS General Building Cost (excluding M&E) Index is a similar index to the BCIS General Building Cost Index, but excludes the following installations.

- electrical;
- heating, ventilating and air conditioning;
- sprinkler;
- lift;

- catering equipment;
- other specialised M&E items such as fire alarms.

The cost indices for steel framed construction, concrete framed construction and brick construction are all based on cost models containing buildings with each particular form of construction only.

12.6.1.3 The Building housing cost index

The BCIS do not compile a separate housing cost model as part of the BCIS General Building Cost Index. However, they have published Housing Cost Index in *Building* magazine. The base to this index is 1970. This index is based on fixed weightings of specified labour, materials and overheads found in typical house building.

It is perhaps useful to look back at recent trends in indices, the Scottish Executive 'analysis of historical construction cost movements in social housing report', study (published in 2004) illustrated the following trends in the various indices.

Index	Total % change 1985 – 2002	Average annual % change 1985–2002	Average annual % change 1985–1992	Average annual % change 1992–1997	Average annual % change 1997–2002
BCIS General Building Cost Index	6.1	0.3	–0.5	0.9	1.0
BCIS Steel Framed Construction	5.0	0.3	–0.4	0.9	0.5
BCIS Concrete Framed Construction	3.6	0.2	–0.6	0.8	0.8
BCIS Brick Construction	7.4	0.4	–0.4	0.8	1.3
BCIS General Building Cost Index (Excl M&E)	5.4	0.3	–0.7	0.8	1.2
BCIS M&E Cost Index	7.7	0.4	0.2	1.1	0.0
BCIS Labour Cost Index	28.0	1.5	0.7	0.3	3.8
BCIS Materials Cost Index	–10.3	–0.6	–1.4	1.3	–1.5
BCIS Plant Cost Index	4.4	0.3	–1.1	0.5	1.9
'Building' Housing Cost Index	12.8	0.7	–0.3	0.6	2.3

12.6.2 Tender-based indices

As tender-based indices are a comparatively recent innovation, there is not the long history of results that could be found with factor cost indices. However, the number of institutions and practices producing an index of this type is steadily growing.

12.6.2.1 DTI's Construction Statistics and Economics Unit building tender price index

The construction of the index is similar to that already described in this chapter, where a sample of items is taken for each work section up to 25% of the value of the particular trade. This index was the original tender price index and has formed the basis for the others, which have followed.

12.6.2.2 BCIS tender-based index

The method of construction is similar to that of the DTI form just described. Two indices are prepared, one relating to fluctuating contracts and the other to fixed price. This goes some way towards overcoming the problem of the different allowances made in tender figures for future variations in price. The sample of jobs from which the index is derived is not restricted to government projects, and therefore it can be expected to cover a wider range of building types than the preceding index.

12.6.2.3 AECOM (formerly Davis Langdon) tender price index

This has developed from being once based solely on schemes in London to full coverage throughout the United Kingdom. They generally produce a minimum and maximum forecast and this is usually published as part of the Cost Model series in *Building* magazine.

12.6.2.4 Other indices

Other indices are in general use but do not strictly fall under the previous three headings. One example is the Halifax House Price Index. Since 1984, the Halifax House Price Index has been used extensively by government departments, the media and businesses as an indicator of house price movements in the United Kingdom. Similar approach is taken by the nationwide, the methodology involves tracking a representative house price over time rather than the simple average price approach (this is used by HM Land Registry). Both are based on a large sample of housing data, and the latter provides the longest unbroken series of any similar UK index.

The DTI compiles the **Tender Price Index of Social Housing** (TPISH).The Index is calculated from analyses of accepted tenders, forwarded by housing associations and local authorities. TPISH is an indicator of trends in accepted tender prices for building public sector housing contracts in England and Wales. It is a smoothed quarterly index and includes adjustment factors for location.

12.7 Problems in constructing and using cost indices

It has already been stated that there are a number of problems associated with the construction of cost indices. Such problems can also create difficulties in the use of the index and these, together with some more general points, are summarised as follows:

- The index will usually be measuring a trend for a typical or model building type, and may not necessarily be measuring the change over time for the particular project that is being developed.
- When the base date is several years old, then the question should be asked whether the index is being based on outdated criteria. This particularly applies to a factor cost index using base year weightings. It may be that the balance of resources has changed considerably in the intervening period and that this is not represented in the index. Over quite a short period, the 'mix' of resources on a typical building may alter as a result of the very changes in cost that the index is trying to record; for instance, a rise in metal prices may cause a substitution of plastic for lead and copper in plumbing and roofing work.
- In the longer term, changes in technology may not only make the base 'mix' untypical but may also distort its prices – as new techniques and materials come into greater use their

price tends to decrease proportionately, while the cost of obsolescent technology tends to rise faster than the general rate of increase. However, every index must have some history in order that trends can be identified.

- Regular publication of the index at monthly or quarterly intervals is required. Otherwise, the user is put in the position of having to forecast the immediate past (i.e. the time between the last publication and the present) as well as the future.
- The basis of construction of the index must be known in order for it to be used intelligently. The choice of a tender-based or factor cost index will be dependent on what the user wishes to measure, but in addition the weightings of any index are important in judging whether the results can be applied to the project under consideration.
- Short-term changes in an index must be treated with caution since the inherent errors in the system of compiling the index may well be the equivalent of several points on the scale.
- In the tender-based indices, a good sample of BQs must be used if bias due to regional variation and building function is not to distort the results.
- When plotting a trend in an index, it is sometimes advisable to use a logarithmic scale for the index against a natural scale for time. The advantage of this method is that if costs are rising at a regular percentage every year, then the index values will be shown as a straight line. Any deviation above or below this line will show immediately as a change in this regular pattern and will assist in detecting a new trend.

Cost planners obviously have a duty to keep themselves aware of past, current and future economic trends, and should use this awareness in coming to a conclusion on any extrapolated index value which they wish to use in estimating for future projects. Of course no one has yet proved that they can accurately forecast the future, and this particularly applies to future index numbers. Anybody who could actually do this would be in the city earning a multi-million pound salary, not cost planning the average building project.

Providing reasonable care has been exercised, cost planners should not be blamed if their forecasts turn out to be wrong because of changed economic or political factors that were unforeseen at the time of making the estimate. For this reason, many cost planners tend to use a reputable index such as the BCIS 'All-in' Tender Price Index, on which any responsibility for 'getting it wrong' can be placed. This might be more difficult if an in-house or a less well-known index was used.

In recent years, it has become a common practice and far more sensible to give a range of anticipated future costs based on the possibility of certain events occurring. In any case, it is most important that everything should be made explicit when the original estimate is given. The details should include the following:

- the index which has been used;
- the point or range that has been chosen together with the reasons for this choice;
- the timescale for the project which has been assumed when making the forecast.

12.8 Which type of index to use

By their very existence it is obvious that all cost indices have a role to play in assisting the cost adviser to determine the market forces affecting a project. The choice of index will, however, be determined by the use to which the index is put:

- For short-term forecasting, allowances for fluctuations and so on, the factor cost index can be used.

- For general estimating and cost planning purposes, a tender-based index will more reliably measure the change in the cost to the client. It also has the advantage of being able to measure the performance of a tender, region or building type against the national average.
- For very long-term forecasting and budgeting, the use of a unit price index based on cost per square metre or unit accommodation may be more applicable.

12.9 Key points

The object of a cost index is to measure changes in the cost of an item or group of items from one point in time to another. The CPI produced by the government every month is a well-known example. In compiling an index, a base date is chosen and the cost at that date is usually given the value of 100, all future increases or decreases being related to this figure. Published cost indices are available for

- building in general;
- various types of building;
- various components of building cost.

Building cost indices may index either

- construction costs based on the cost of resources or
- tenders.

These differ because tenders are more affected by market conditions. The use of a reputable published index gives the cost planner some protection if unforeseen events occur.

Endnote

1 The PSA Schedule of Rates (Carillion) is one of the most common rate guides in the construction industry and is the standard document for public sector construction work. It contains over 20,000 rates spanning a range of building works and materials and the Electrical and Mechanical Services schedules over 10,000 each. It is used for Measured Term Contracts (see Chapter 8) following the Co-ordinated Project Information Initiative.

Chapter 13

Cost Planning the Brief

13.1 The brief

After the initial budget has been prepared and accepted (Chapters 5–7), the cost planning process can begin in earnest, with the brief being agreed and outline drawings being prepared.

13.2 An iterative process

It might be thought that the title of this chapter is misleading – since the cost plan itself is not going to be prepared at this stage a better title would surely be 'Costing the Brief'?

This might be so if that was all that the cost planner was going to do – passively estimate the cost of carrying out the client's ideas.

But this will not be good enough. We have seen that this is the stage where the big cost decisions are made, consciously or unconsciously, and design work should not start until the brief itself is right. There is little point in spending large sums of money meticulously – and successfully – cost planning and controlling a design which is not in fact a very good answer to the client's needs.

In the case of profit projects, it is often possible to charge higher rents or get a higher price for leases if a better standard of amenity and finish is provided, so that the budget is flexible to a limited extent. In such circumstances, the cost disadvantages of larger and more luxurious public spaces, more and faster lifts, better fittings and so on will have to be evaluated in relation to income. The acceptable final cost may be quite different to the original rough estimate because of such decisions.

Clients for private residences often become more ambitious as the drawings progress, and again provided that they are kept informed of the consequences of their decisions they may prefer to have the house they now want rather than the cost they first thought of.

It is obviously preferable that these matters should be decided at brief stage rather than during design development or, even worse, during construction.

Many authorities consider that the traditional practices of the British building industry make it too easy for the client to make changes during the construction stage and that this is partly, or even largely, to blame for the comparatively high cost of building in the United Kingdom compared to that of some other countries. The cost planner therefore must be helping to develop the brief and examine its cost implications critically (unless specific instructions to the contrary have been given – but clients rarely do that these days!).

Nevertheless, the first task is indeed to cost the brief as presented. With sketchy information and without any sort of design, it will be impossible to use any kind of resource-based cost

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

model, so even where it is proposed that the final cost plan will be based on resources, there is little alternative to a product-based estimate at this first stage.

13.3 Preliminary estimate based on floor area

This will be a very approximate estimate; it could hardly be otherwise in view of the lack of information at the cost planner's disposal. There are exceptions to this, for instance:

- Where the project is one of a series (such as a chain of service stations or superstores) and information has been accumulated on a number of almost identical buildings.
- Where the first estimate has to be calculated according to a government formula and the building will be tailored to fit the estimate.

In the preparation of the preliminary estimate based on floor area, previous experience of the designer is most valuable as there are some whose designs always come out above average costs just as there are those who can be relied upon to achieve an economical design.

At an early stage, the cost planner is quite likely to be told 'This will be an economy job' and only a knowledge of the people or practices concerned will indicate how far this statement can be relied on in framing the estimate.

The cost planner should never allow the amount of the estimate to be influenced by opinions expressed by interested parties, or worse still by the figure that the client would like the job to cost, unless these also coincide with the cost planner's own judgement.

When an estimate based on early designs has worked out at £3,500,000, it is all too easy to remember that the budget is £2,250,000. The danger then is that the cost planner may assume that the estimate is too high and reduce it a little in order to make the difference less breath-taking.

Cost planners may also find themselves in front of a committee or a board, one of whose members 'knows a job just like this one which was built for much less than the cost planner's figure'.

Remember that it is the person who has prepared and possibly signed the estimate who will be held responsible for it, not the designer, client or the assertive committee member. This is as it should be. Cost planners are paid for their skilled evaluation of real probabilities, not for telling people what they want to hear.

The initial estimate, like all others, must make quite clear what is and is not included. It is quite good practice to use a form for preparing the estimate, with a definite section to show inclusions and exclusions. A computer spreadsheet program should similarly present a menu of possible inclusions and exclusions to jog the cost planner's memory, and to print them out when preparing the estimate for the client. Such items as

- site preparation,
- such as demolition or dealing with contaminated land,
- archaeology,
- complete internal decoration,
- joinery fittings,
- venetian blinds and curtaining,
- furnishings,
- office partitioning,
- lighting fittings,
- carpeting in offices and flats,

- site works,
- specialist plant and services,
- shopfitting and security systems

should be specifically dealt with, not just forgotten about or covered by some vague overall clause.

In fact it is even more important to define these things properly in a preliminary estimate than it is later on, when the detail of the estimate itself may be sufficient to answer many of the questions.

Make sure that professional fees, value-added tax (VAT) and project manager's and construction manager's fees (where appropriate) are clearly excluded or included – clients quite rightly think that the estimate shows their total commitment unless they are told otherwise. It is especially important to make the position about VAT clear – it is the usual current practice for cost planners and estimators to ignore this, but the client must not be left in any doubt.

If fees are shown, it is important to get them right. Until the mid-1980s this was comparatively easy, as everybody charged according to the fee scales of their various professional bodies. Today, when fees are subject to negotiation or competition, this is more difficult, but unless something has already been agreed to the contrary it will probably be best to assume fees according to scale at this preliminary stage. Reductions can always be made later, if necessary.

Professional fees should be estimated to project completion, not just design completion, and should include the various specialists as well as expenses and document reproduction. Despite the supposed advent of the 'paperless office', this last can be a considerable sum.

The estimate must also be specific about inflation. If it is based on current building costs it should say so, and also make clear that it is subject to revision in the event of increases or decreases in those costs. There have only been one or two periods when building costs have been fairly static in the last 40 years. The longest such period has been in very recent times so that there is a tendency not to get too worried about this, particularly among students and trainees who have never experienced major escalation in building costs. However, even if things seem to be set fair at the time when the estimate is being prepared, it is still wise to mention that it is based on current costs and may need adjustment for inflation.

If, on the other hand, the estimate is based on anticipated cost levels in the future, the basis of calculation should be set out in the estimate so that revision can be made if the prediction proves to be false. But in both cases, there are advantages in tying the estimate to a well-known and reputable cost index such as the Building Cost Information Service (BCIS) index, so that the cost planner's personal judgement cannot be blamed if things suddenly change.

As has already been pointed out, the person who could accurately forecast economic conditions 2 or more years ahead would be in demand in other and more lucrative fields than in construction cost planning!

A final problem relates to whether the tender or the final cost is being forecast. Clearly the latter is the preferable alternative, since it is this sum of money which the client is going to have to find in the end, and in any case there is little alternative in the case of projects which are to be built under a contractual arrangement that does not involve a lump sum tender as such.

However, in the public sector in particular, the custom is often to estimate the tender amount, and it is important in both public and private sectors to be specific about which alternative has been used. At times of high inflation, there can be a considerable difference between the two figures, especially if the cost planner makes some allowance for the claims which often arise during the course of the work and which will be reflected in the final cost but not in the tender amount.

As the preliminary estimate cannot be related to the subsequent cost plan (except in total), it is not worth preparing it in any greater detail than is necessary for its primary purpose, that is to give an approximate estimate of cost. Also, although cost planning is very much more than the preparation of an estimate, it gets off to a bad start if the first estimate is badly wrong. This stage is therefore extremely important.

Finding the right rate at which to price floor area is not easy, and the most reliable starting point is a recent similar job from office experience. Failing this, or as a check on it, a wide selection of costs from a published source such as the BCIS system should be used, resisting the temptation to choose only from the lower part of the cost range. The BCIS online system is a particularly good source, not least because of the way in which it facilitates the adjustments, which are about to be described.

To adapt the floor area rate from one project to another when shape is not known requires consideration of seven factors, as follows:

- market conditions;
- size;
- number of storeys and so on;
- specification level;
- inclusions and exclusions;
- services;
- site and foundation conditions;
- other factors.

A most important point is to check what is actually meant by floor area. This might be:

The total area at each floor level measured over the external walls including all staircases, lift wells and similar voids, and including all internal and external walls. The gross internal floor area (GIFA) measured according to Standard Form of Cost Analysis (SFCA)/BCIS rules. This is the same as the previous example, but excludes the thickness of external walls.

Something rather less than the last, perhaps excluding voids, circulation spaces or plant rooms.

The net commercially lettable floor area (often still given in square feet to complicate the issue).

Obviously for the same building these would each yield quite different cost factors, and it is important to check that the same option is used for all the data source examples and the new estimate or that conversion factors are duly applied.

Further points for care include factors which may not be properly reflected in traditional floor area formulae, and which may occur either in the project being estimated or in the cost data examples. The most troublesome of these is the atrium, which was not a common design feature when these floor area formulae were devised, and which if large cannot be treated as an ordinary void if comparison is being made with non-atrium buildings. A somewhat similar problem arises with buildings which have an unenclosed ground floor used as part of an open car parking area.

13.4 An example of a preliminary estimate

We can now proceed to work through an example in which the above factors are taken into account where applicable.

The proposed project is a new 2400 m^2 six-storey office block in a provincial city, with shops on the ground floor and offices on the other five, with a budget of £2,000,000. The previous project on which the estimate will be based is a project of similar quality in outer London, but of four storeys only and also with shops on the ground floor. The total floor area was 1235 m^2 and the tender price 12 months previously was £680/m^2.

The differences between the two schemes in this textbook example are rather more than one would ideally like to see when choosing a suitable cost plan to adjust, but will enable all the issues to be considered and demonstrated.

13.4.1 Market conditions

This adjustment deals with the changes in building prices and in tendering conditions between the time when the previous job was priced (or built) and the anticipated date of tender (or of building) for the new project. Two quite different issues are being considered together here:

- official changes in the cost of resources;
- changes in the market itself, taking into account the capability of the industry and the amount of work available to it, in the regions and at the periods in question.

In doing this, it is most important to compare like with like. It may be, for instance, that the project being used as a basis for comparison was tendered for conventionally, so that the prices are those ruling before construction started, whereas the new job might be built using construction management where prices ruling at the time of carrying out the works are what matters.

One of the published cost indices previously described would probably be used, but where the estimates which are being compared are not too far apart in time (up to a year or so), it is quite possible to make the adjustment for resource costs by simply adding a percentage based on known labour and material fluctuations. It may indeed be necessary to do this for short-term estimates because of the time lag in publishing historical indices.

For this purpose, the proportions of labour, material and plant content given in Chapter 12 could be used, with a heavier bias towards materials if the contract is for an expensive building with good finishes and high-class materials. In making this calculation, the figures should be taken as fractions of the gross contract amount without deducting overheads and profit, since these should rise more or less in proportion to increases in prime cost.

Where 'do-it-yourself' indexing of this type is being used, or where a published index is being used which only reflects changes in the prices of resources, it is most important to remember to make the adjustment for changes in market conditions as well. This can be done intuitively if both projects are local, but if one or both of them is in an area which is unknown to the cost planner it may be necessary to make discreet enquiries.

Local changes in the market often tend to be relatively short term (because an overheated local construction sector just has to cool down somehow), and thus are not always easy to pick up from published building cost indices. Local enquiry may be worthwhile in a case such as the present one if the new project is in an unfamiliar region.

In this particular example, allowance would have to be made for the difference between outer London and the provincial city, remembering whether or not differences in resource costs (e.g. labour rates) have already been adjusted.

Let us assume an overall upward adjustment of 10% for inflation and region on this contract. This can either be shown at the beginning of the estimate, thus

$$\text{£}680/\text{m}^2 \text{plus } 10\% = \text{£}748/\text{m}^2$$

or added on at the end.

The first method is preferable, as all the adjustments that follow can then be done at current prices, which is usually easier.

13.4.2 Size, number of storeys and so on

At this stage no actual drawings or dimensions are likely to be available, so that adjustments have to be done by proportioning, that is the use of ratios in comparing the project used as an example and the new project.

In the early days of cost planning, it was fashionable to use proportioning methods extensively to show that the new approach was different to old-fashioned approximate estimating. But this point no longer has to be demonstrated, and proportioning has two disadvantages:

- It is not the quantity surveyor's usual method of working and thus mistakes are more easily made.
- Sooner or later approximate quantities have got to be used, and these are difficult to reconcile with proportioning.

It is therefore recommended that proportioning only be used when there is no alternative.

The new provincial block will have a larger plan area than the London example; this will tend to reduce the proportion of external wall area to floor area (assuming a similar plan shape) and hence should reduce the cost per square metre of floor area a little.

However, the new block will have six storeys instead of four, and this will have the effect of increasing the cost as it is a general rule that building higher costs money. But the difference between four and six storeys is not critical, and the likelihood is that this and the previous factor will cancel each other out.

The less that is known about the new building, the less point is in adjusting for hypothetical trifles. We are working with a broad brush at this stage, trying to get a 'ball-park' figure as a starting point for the cost planning process. However, a more important point to consider is that on the outer London block one-quarter of the floor area was set aside for shops, whereas on the six-storey building the figure will be one-sixth.

As shop areas are normally left in an unfinished state for the shopkeepers to fit out according to their needs and tastes (**shell and core**), this part of the building will be relatively inexpensive. By reducing the proportion of the building allocated to shops, we shall be increasing the overall price per square metre.

Assuming that the saving in floor, ceiling and wall finishes, and services between offices and shops will be £72 per square metre of total floor area:

Outer London block		
Shops (25%)		
£748/m^2 minus 3/4 of £72	= £694/m^2	
	309 m^2 at £694/m^2	= £214,446
£748/m^2 plus 1/4 of £72	= £766/m^2	
	926m^2 at £766/m^2	= £709,316
		£923,762
Check – total 1235 m^2 at £748/m^2		£923,780

Provincial block			
Shops	16.67%	400 m^2 at £694/m^2	= £277,600
Remainder	83.33%	2000 m^2 at £766/m^2	= £1,532,000
			£1,809,600
£1,809,600/2400 m^2			= £754/m^2

Similar adjustments may be required wherever the buildings are divided into areas with different cost profiles and where the proportions are different on the two buildings. Car parking areas within office buildings frequently lead to adjustments of this sort.

13.4.3 Specification level

So far the changes have been dealt with by adjusting the elemental rate, as there has not really been any alternative and this was in any case the preferred approach in 'classical' elemental cost planning. But from now on, it is possible to think in terms of lump sum changes and adjust the elemental rate at the end, and many cost planners prefer to do this. We will show both methods.

Whichever method is used, it is important to remember whether or not the building cost has already been adjusted for inflation. If it has been (as is recommended), then any specification adjustments must be done at prices ruling at the date of the new scheme, and not those ruling when the previous or example project was carried out. Alternatively, of course, all specification adjustments could be made at the earlier pricing level and the inflation adjustment for the total scheme could be done at the end.

It is assumed that the specifications of the two buildings will be of the same general standard, but:

- The designer has decided that the cheap floor covering used in the offices in outer London was a mistake, and wants to allow an extra £12 m^2 for this.
- The client wants natural stone dressings in lieu of the cast stone used on the previous project.

The adjustment for the flooring is easy. Allow an extra £12/m^2 over the area of the offices, say two-thirds of the total floor area.

$$1600\,\text{m}^2 \text{ at } £12/\text{m}^2 = £19,200$$

This is equal to £8/m^2 of gross floor area when divided by 2400.

Calculations like this can be done by simple proportion if preferred (1600/2400 of £12.00 is £8.00), but it is quite easy to make a mistake doing this – inverting the ratio for example! – and the longer calculation is more easily checked.

The stone will be a little more difficult to allow for (in the absence of any drawings, remember). The area of external walling in a medium-rise office building of this sort should be about 10% more than the floor area (again, check this with several analyses if possible). Not much of the wall area will actually be stone – most of it will probably be windows. We will assume that 25% of the area is stone and that natural stone facing will cost £130/m^2 more than cast stone. So the extra allowance for natural stone is

$$(110/100)\,2400 \times 1/4 \times £130.00 = £85,800$$

which is £35.75/m^2 of gross floor area.

Note that a number of assumptions have been made about the London example which could have been avoided if a full SFCA/BCIS type of cost analysis had been available, even though it is not intended to produce this first estimate for the new building in elemental form.

13.4.4 Inclusions and exclusions

The client has found that office tenants prefer to do their own partitioning and decoration, whereas on the outer London project these were provided by the developer. This adjustment will most easily be carried out by extracting the relevant lump-sum figures from the BQ for the London project, if these are available.

	£
PC sum for office partitioning	26,250
Add for profit and attendance	1313
Decoration in offices	4300
	31,863

As it comes from the original scheme this figure must be adjusted for inflation, also for five-sixths of the building being offices in lieu of three-quarters.

£31,863 plus 10% inflation allowance (from above) = £35,049
Division by floor area of offices on London building (926 m^2) gives a cost of £37.85/m^2 of office floor area
The saving on the provincial block by omitting these items is therefore £37.85 × 2000 m^2 = £75,700 in total
£75,700/2400 m^2 gross floor area = £31.54/m^2

By the (alternative) proportion method, the calculation is

£31,863 divided by 1235 m^2 = £25.80
£25.80 plus 10% inflation allowance (from above) = £28.38/m^2

The omission of partitions in the new building per square metre of gross floor area is therefore £28.38 × 4/3 × 5/6 = £31.53/m^2. These all assumed that the cost of partitions was available from the BQ or cost analysis for the outer London block. If this was not the case, then a telephone call to a firm of partition installers might be the only way of finding out a cost per square metre. There is no need to tell them that you want to know this so that the partitions can be omitted! This would be a current cost of course, so does not need to be adjusted for inflation or market changes.

13.4.5 Services

Services form a major part of the cost of any modern building. On a project of any size, there will be consulting engineers for the heating, air-conditioning, plumbing and electrical work, and any specialist service installations. The terms of their appointment should include for providing an estimate of the cost of the services for which they are going to be responsible.

The building cost estimate would be adjusted as follows:

Provincial office block
Estimated figures received from consultants:

	£
Air-conditioning and space heating	165,000
Plumbing	52,000
Electrical installation	108,000
Lifts	118,000
	443,000
Builder's work, attendance, profit 7.5%	33,225
	476,225

£476,225/2400 m^2 = £198.42/m^2

Outer London block

	£
Comparable figures extracted from cost analysis or BQ	186,000
Add 10% for inflation as main estimate	18,600
	204,600

£204,600 divided by 1235 m^2 = £165.66/m^2
Increase in cost of services compared to outer London block
£198.42/m^2 − £165.66/m^2 = £32.76/m^2

In view of the early stage at which this estimate is being prepared, the engineering consultants may not feel able to give an estimate for services, but it is important that they should do so. This will avoid the situation, which might arise if the cost planner were to assess the cost independently, and the amount required by the engineering consultants when they prepared their detailed scheme proved to be very different. The resulting arguments would do little to improve either the harmony within the professional team or the client's confidence in the team as a whole.

Nevertheless, it is quite possible that the consultants, having been asked to establish a preliminary cost target before they have fully established what is required, will play safe and allow themselves a sum of money sufficient to cover almost any eventuality. (It is, after all, in the nature of engineering design to allow for the likely 'worst case'.)

The situation where engineering services appear to be taking rather too large a slice of the whole cake is common enough to be met by most cost planners from time to time, and how it is dealt with depends very much on the cost planner's terms of appointment. If these include a measure of executive authority, then the cost planner might well call a meeting to thrash matters out; otherwise it may be only a matter of pointing out the problem to the architect, project manager or whoever is directing the project.

The cost planner should bear in mind, however, that prices per square metre for services are extremely difficult to estimate (there is still a lack of cost data in this important area) and should try to cooperate with the various consultants rather than raise difficulties. It may, for instance, be very reasonable for the engineer to insist on client requirements being defined with more precision before even a rough estimate can be given.

If there are no consultants appointed, or if at this stage they are not prepared to commit themselves, the cost planner would be better not making any adjustment to the estimate for the services, unless there are glaring differences between the outline requirements for the two buildings.

It is, however, becoming increasingly common for professional cost planners, particularly in the largest firms, to be closely involved in the cost planning of the engineering services which, after all, represent a considerable (and increasing) proportion of the budget for which they are responsible.

Special services, especially transportation services such as lifts, should always be adjusted, as their cost bears little relation to the area of the building and they are much more easily priced on a 'per unit' or 'per installation' basis. The adjustment should be done as a comparison of lump sums, as shown above.

13.4.6 Site and foundation conditions

These are best adjusted on the basis of the so-called 'footprint area' or site area of the building. On most buildings, this should be more or less the same as the roof area.

A major factor today is the possibility of having to take measures to deal with a contaminated site. The cost planner must make enquiries of the client, the structural engineer or the local authority to find out if there are any such requirements. This is assumed not to be the case with both the sites under consideration in our example, which are in developed urban areas, but the new provincial project will require piled foundations which were able to be avoided in outer London. Either the cost of piling per square metre of footprint area can be obtained from a suitable analysis or a certain number of piles can be allowed for, as follows:

Say 90Nr piles average 4m long at £75 m	= £40,500
£40,500 divided by 2400 m^2	= £16.87/m^2

Note that the complex of pile caps and ground beams in connection with the piles will cost little less than conventional foundations, so there is no saving to be set against the cost of the piles.

13.4.7 Other factors

The client is anxious to have the building erected as quickly as possible and the contract period will consequently be very short. This will tend to increase the cost, both because the site labour force will need to be larger than is economical and because the number of local contractors and sub-contractors who can be relied upon to work to such a tight timetable is restricted and competition will therefore be limited. The contract price may therefore have to include a great deal of overtime. This is expected to add about 5% to the cost.

Figure 13.1 shows how the estimate would be set out in an appropriate format, showing the changes in elemental rates. Figure 13.2 shows the same estimate using the usually preferred method of working out the elemental rate at the end. The estimated cost of £1,997,500 is slightly below the budget of £2,000,000 so is likely to be acceptable.

It is assumed that the question of professional fees is set out in a covering letter.

13.5 An example using BCIS data

The following example is worked out manually, although in practice the whole thing could be done using the BCIS online service.

Example

A budget or early brief figure is required for a steel-framed factory of 2100 m^2 gross floor area located in Leicestershire. The tender date is expected to be in the fourth quarter of 2013.

Mean cost per square metre GIFA of a steel-framed factory adjusted to United Kingdom mean location at first quarter 2012 prices	341/m^2
Adjust for location Leicestershire × 0.915	312/m^2
Mean building price of factory in Leicestershire 2100 m^2 at £312/m^2	£655,231
Allow for local pricing adjustment based on QS's knowledge of local market (say) × 0.95	£622,469
Allowance for inflation to fourth quarter 2006	£673,168
BCIS All-in Tender Price Index	
First quarter 2012 = 221	
Fourth quarter 2013 = 239 (forecast)	
Adjustment (£622,469 × 239)/221	
Approximate estimate at fourth quarter 2013	£675,000
Excludes external works, professional fees and VAT	

Project	Office Block, Midtown		
Date of estimate	Feb-13		
Assumed date of tender	Sep-13		
Gross internal floor area	2400 m^2		
Basis of estimate			**£/m^2**
Office Block, outer London (Sept 2012)			680
Adjustment			
1 **Market conditions**			
BCIS Index. Add 10%		+	68
			749
2 **Size, number of storeys and so on**			
6 storeys in lieu of 4 – see notes		+	6
			754
3 **Specification level**			
See notes. Wood block flooring £8		+	43.75
Portland stone £35.75			**797.75**
4 **Inclusions and exclusions**			
See notes. Office partitions and decorations excluded		–	31.53
			766.22
5 **Services**			
See consultants notes		+	32.76
			798.98
6 **Site and foundation conditions**			
Piling (90nr 4 m long)		+	16.87
			815.85
7 **Other factors**			
Tendering (see notes) add 2%		+	16.32
			832.17
Professional fees			excluded
			832.17
Total estimated cost	2400 m^2 at £832.17/m^2 say 1,997,500		

Included (and as above)	**Excluded (and as above)**
	Floor, ceiling and wall finishes
	All furnishings
	Electric light fittings
	VAT
	Professional fees

Figure 13.1 Preliminary estimate of cost, showing the changes in elemental rates.

Project	Office Block, Midtown		
Date of estimate	Feb-13		
Assumed date of tender	Sep-13		
Gross internal floor area	2400 m^2		
			£
New estimate: 2400 m^2 at £680			
Adjustment			
1 Market conditions			
BCIS index. Add 10%		+	163,200
			1,795,200
2 Size, number of storeys and so on			
Six storeys in lieu of 4 – see notes (2400 m^2 at £6)		+	14,400
			1,809,600
3 Specification level			
See notes. Wood block flooring £19,200 Portland stone £85,800		+	105,000
			1,914,600
4 Inclusions and exclusions			
See notes. Office partitions and decorations excluded		–	75,700
			1,838,900
5 Services			
See consultants notes		+	78,624
			1,917,524
6 Site and foundation conditions			
Piling (90nr 4 m long)		+	40,500
			1,958,024
7 Other factors			
Tendering (see notes) add 2%		+	39,160
			1,997,184
Professional fees			excluded
Total estimated cost	say 1,997,500 = £832.29/m^2		

Included (and as above)	**Excluded (and as above)**
	Floor, ceiling and wall finishes
	All furnishings
	Electric light fittings
	VAT
	Professional fees

Figure 13.2 Preliminary estimate of cost, calculation of elemental rate at the end.

13.6 Cost reductions

It may be that the estimated cost is higher than the client can afford, or more than the client wants to pay. It would be very dangerous to reduce the amount of the estimate for this reason, or on some vague grounds such as a general reduction in standard, although of course adjustments could be made for specific items such as (on the basis of the first example) cheaper lifts or a return to the cheaper floor finish.

However, if the total of the estimate is much too high it is best to face facts, and either reduce the size of the building or get the brief or the budget substantially modified. It is the easiest thing in the world to cut an estimate by 10% (or by any other percentage) under the influence of the client's pleadings and the designer's optimism.

It must be emphasised that an overall 10% cut in costs means much more than a 10% cut in standards as much of the structural work, for example, cannot be reduced in cost. It must also be remembered, as stated earlier, that the estimate will carry the cost planner's signature, not those of the people who want to modify it. It can be assumed therefore that if the cost planner amends the estimate from its original figure there must be some tangible reason or reasons. These reasons need to be spelt out if a modified figure is presented.

Finally, mention must be made of the threat 'the job won't go ahead on this figure, do you want it to go ahead or not?'. This may be the response of a profit-oriented client, or an architect who does not want to lose a commission. Alternatively, it may be the attitude of a public body which knows that a major project will never get the go-ahead if its true cost is known beforehand, but will be very difficult to stop at a later stage when the enormity of its cost becomes apparent. Nobody ever seriously believed, for example, that the Sydney Opera House would only cost the figure of one or two million dollars which was first given. And closer to home, the British Library would have been unlikely to have received the go-ahead if an honest estimate had been given!

We are now well into the realms of professional ethics, about which people must make up their own minds in the light of the case before them, but whatever the ethical position the responsibility of the cost planner for whatever figure goes forward must be remembered.

To repeat what has been said twice already, the other parties will adopt a very low profile if things go wrong!

13.7 Data sources

The example of the two office blocks assumed that there was data available on a comparable scheme. In the later stages of estimating, when a cost plan is prepared on an elemental basis, an exact similarity of use between data source and proposed project is not vitally important – costs/m^2 of external walls, windows, doors, floors and so on need not vary much between a library and an office block. The costs per square metre of floor area of the buildings themselves, however, will vary considerably because of the differing proportion of these items in them.

If there are no truly comparable schemes in the office, it may be possible to get information from a professional colleague or from the BCIS, or as a last resort to use published information. When working from one's own information it is best to use one building as an example because the variables in design and tendering are known, but it is often helpful to supplement this with published information for similar buildings. As many examples as possible should be obtained to try and average out all the variable factors. Published information is always useful for checking and comparing an estimate prepared from one's own sources.

13.8 Mode of working

It may be objected that the above methods of working are far too crude. For instance, instead of guessing a percentage for an accelerated programme for the office block, it would surely be better to compare the consequences of a normal programme and an accelerated one by preparing network diagrams and costing out the two sets of resources.

Well, of course, it would except that no detailed design exists for the building at this stage; although it might be possible to study the effects in detail for a known building of fairly similar characteristics, the answer would not be sufficiently valid to justify the amount of work involved (and in any case there was a 'market forces' component to the figure based on restricted tendering which such an exercise would not disclose). Also the workload to achieve this would be quite heavy; even if computer simulations are used they require a fairly considerable data input.

To repeat what was said at the beginning, what is being looked for is simply a 'ball-park' figure for a hypothetical development – ('How many noughts?') – and often there may not be enough firm information even to carry out the very modest range of adjustments set out above.

There will be plenty of opportunity to use more sophisticated techniques as soon as there are some tangible proposals to examine, and this process begins with the preparation of tentative sketch designs.

13.9 Key points

- This is the stage where the big cost decisions are made, and design work should not start until the brief itself is right. There is little point in spending a large sum of money meticulously – and successfully – cost planning and controlling a design which is not in fact a very good answer to the client's needs.
- The preliminary estimates will almost certainly be based on the cost per square metre of floor area, preferably using a computer spreadsheet to jog the memory and make sure that nothing has been accidentally left out. It is usual practice to exclude VAT from the figures. The reports to the client must make clear what is included and what is excluded. Cost planners must be prepared to back their judgement if their estimates come out to a higher figure than the client is expecting.

Chapter 14

Cost Planning at the Scheme Design Stage

14.1 Elemental estimates

Once the initial sketch drawings are available, an outline elemental estimate should be prepared in order to assess the architect's initial solution against the cost parameters of the project. This will be particularly important if the shape or design is rather unusual, or appears inherently expensive.

Not unlike the preliminary estimate, this is sometimes called a **preliminary cost plan**, but this is still misleading, as it is really only an approximate estimate, and it is probably the elemental format that leads to this terminology. The real cost plan will be prepared when this elemental estimate has been finalised, and it will be in a fresh format.

There are some advantages in using a 'short list' of consolidated elements for preparing the preliminary plan, as the only measurable items will be the main floor and wall areas and there is unlikely to be a specification as yet. For the purpose of this example a short list is assumed, and four main areas need to be measured, as follows:

- Ground floor area;
- Total floor area;
- Area of external walls, including windows and doors;
- Area of internal walls, including windows and doors.

Let us look at an example, based on the architect's first sketch design for the six-storey office block developed from the brief and estimate, which was considered in **Chapter 13**. This is shown in **Figure** 14.1.

Example

Gross internal floor area			
Ground floor area	30.00 × 7.50 = 225.00		
	22.50 × 7.50 = 168.75		
	393.75	× 6 floors	2362.50 m²
Tank room	8.00 × 6.00		48.00
			2410.50 m²
External floor area			
Main walls	4 × 30.00 × 27.00		3240
Tank room	28.00 × 2.50		70
			3310 m²
Internal wall area (say)			**1200 m²**

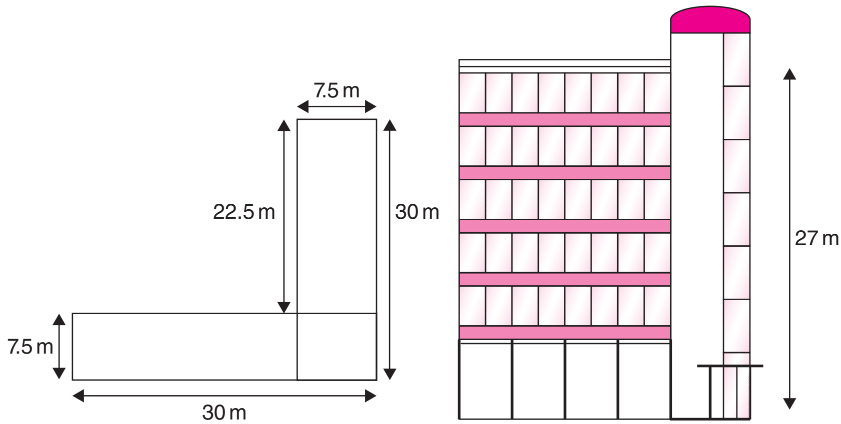


Figure 14.1 Architect's first sketch design for provincial office block (not to scale).

Already we can see that the ratio of external wall area to total internal floor area looks rather high (3310:2410 = 1.37 to 1), and we may feel that this is going to prove an expensive building. However, the elemental estimate will confirm or reject this theory better than any amount of conjecture. The best rates for pricing would be those obtained from an analysis of the outer London block, as we based the first estimate on the same project.

We must remember to add the 10% price increase and the 2% tendering differential which were included in the approximate estimate in Chapter 15, so as to keep the two estimates on the same basis, unless circumstances have changed in the interim. In which case, of course, the total of the estimate will have to be revised. Again, a standard form should be used. The form shown in Figure 14.2 is an example of the sort of thing required. Some of its features would vary according to the preferences of the individual office – for instance, some people might prefer to show the preliminaries as a separate item, or to make a separate element of the frame. On the other hand, it would be possible to combine the finishes with the relevant structural items. However, the selected arrangement should be standard within the office so that the recorded information can be kept in a suitable manner.

The overall rates for elemental estimates can be obtained when doing the ordinary analysis and filed separately, and being large omnibus items there is perhaps less risk than usual in poaching prices from more than one job. With the rise of integrated computer systems, this information can be stored and manipulated with far greater ease than was previously the case. While the original practitioners of elemental cost planning believed in showing the elemental costs for each element (as in **Figure** 14.2), it is more usual today to omit them, and just show the total costs for each.

Let us return to the particular example. The establishment of rates for the various elements will have been complicated in this instance by the different proportion of unfinished shops compared to the outer London job.

14.2 A typical elemental rate calculation

The rate for floor finishes, for example, will have been obtained as follows:

Project used for comparison (outer London)	
Elemental rate for floor finishes on outer London project	27.90/m^2
Add 10% increased costs and 2% tendering	3.35/m^2
	£31.25/m^2

Elemental estimate no. 1					
Project	Office Block, Midtown				
Date of estimate	March 2013			**Total cost (£)**	**Cost (£/m²) of floor area (2411 m²)**
Assumed date of tender	September 2013				
Ground floor area	(A)	394 m²			
Total floor area	(B)	2411 m²			
External wall area	(C)	3310 m²			
Internal wall area	(D)	1200 m²			
Work below lowest floor finish	(A)	394 × 321.00		126,474	52.45
Upper floors including frame and stairs	(B–A)	2017 × 123.50		249,100	103.32
Roof including frame	(A)	394 × 164.50		64,813	26.88
External walls	(C)	3310 × 212.00		701,720	291.04
Internal walls	(D)	1200 × 50.00		60,000	24.89
Floor finish	(B)	2411 × 44.00		106,084	44.00
Ceiling finish	(B)	2411 × 27.50		66,303	27.50
Wall finish	(C+2D)	5710 × 13.00		74,230	30.79
Decoration	(B)	2411 × 4.50		10,850	4.50
Fittings				2750	1.14
Services				476,225	197,52
Drainage				19,000	7.88
Site works				27,500	11.41
Contingencies				30,000	12.44
				2,015,049	**835.76**
Professional fees				–	–
				2,015,049	**835.76**
(Inclusions and exclusion as approximate estimate unless otherwise stated, VAT not included)					

Figure 14.2 Elemental cost estimate.

Calculation of floor finish elemental rate for areas excluding 'shell and core' shops.

1235 m² at £31.25 m²	38,594/m²
Shops 25% = 309 m² at say £10.00	3090/m²
Balance 926 m²	35,504/m²

which divided by 926 gives £38.34/m² of gross internal floor area.

New provincial block – 2410 m²	
16.67% shops = 402 m² at £10.00	4020/m²
83.33% remainder = 2008 m² at £38.34	76,987/m²
Total 2410 m²	**£81,007/m²**
which divided by 2410 gives £33.61/m² of gross internal floor area	**£33.61/m²**

Add say 5/6 of £12.00 for more expensive floor finish in offices (as approximate estimate)	**10.00/m²**
	£43.61/m²
Say	**£44.00/m²**

This complicated calculation would have been much easier if the unit costs for the floor finishes had been available for the outer London job, and it would not have been necessary to use the risky proportion method.

Alternative calculation using unit costs

Unit rates taken from detailed analysis of outer London project, plus 10% inflation allowance and 2% tendering allowance.

Quantities measured from architect's drawing of provincial job.

Office areas	1688 m² at 34.25/m²	=	57,814
Shops	338 m² at 8.95/m²	=	3025
Tank room	48 m² at 8.05/m²	=	386
Entrance, staircase, WCs and so on	337 m² at 45.20/m²	=	15,232
			76,457
Add 10% increased costs and 2% tendering			9175
			85,632
Add extra cost of better floor finish in offices 1688 m² at 12.00/m²		=	20,256
Total cost			**£105,888**
Elemental cost (divide by 2411)			£43.92/**m²**
Say			**£44.00/m²**

14.3 Examination of alternatives

From an examination of the elemental estimate shown in **Figure** 14.2, we can see that the scheme at £2,015,049 is likely to prove more expensive than the amount of the first approximate estimate (£1,997,500). Much of this increase is due to the slightly increased size of the building as designed (2410 m² instead of 2400 m²), but the cost per square metre of the floor area is also increased from £832.17 to £835.76, and the estimated cost is now slightly over, instead of under, the budget of £2,000,000. While the increase is not very large (it could be got rid of by a small reduction in the level of specification), it does make us wonder whether this is the most economical solution to the design problem. At this point, the figures in the right-hand column (cost per square metre of floor area) come in useful in enabling us to make comparisons with other contracts.

It certainly seems as though the external walls are costing a lot, which confirms our first thoughts on looking at the plan, but we now have figures to prove the matter. Although it would be practicable to build this scheme within the budget, it would be worth the architect's while to see whether an alternative shape would be possible.

The rather unsatisfactory appearance of the first elemental estimate should lead to the consideration of alternative schemes. It may not always be possible to improve wall/floor ratios very much, because of site restrictions or other unalterable factors. But let us suppose that in the case of the provincial office block the architect has been able to produce an acceptable alternative design (Figure 14.3):

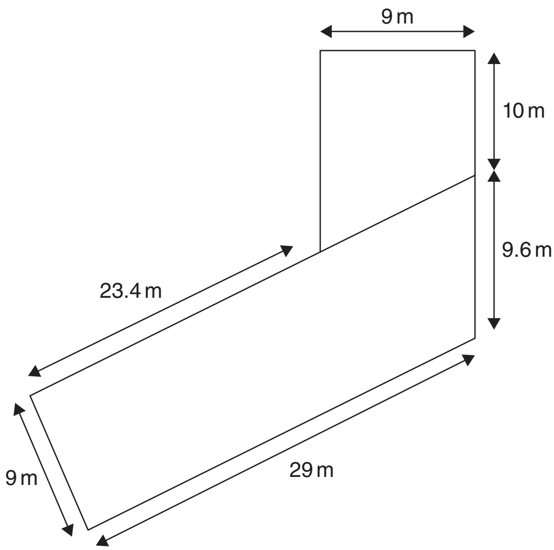


Figure 14.3 Revised sketch plan for provincial office block.

Mean length of building = (33 m + 29 m)/2 + (14 m + 10 m)/2 = 43 m	
Ground floor area = 43 m × 9 m	= 387 m^2
Total floor area 6 × 387 m^2	= 2322 m^2
plus tank room	= 48
	= 2370 m^2

Length of external walls = 23.4 m + 13 m + 9 m + 19.6 m + 29 m + 9 m = 103 m	
Area of external walls = 103 m × 27 m = 2781 m^2	
Add tank room walls as before	= 48
	= **2851 m^2**
Internal wall area (say) 1200 m^2 as before.	

The approximate cost for this scheme is shown in elemental estimate No 2 (Figure 14.4). This is a much more hopeful design with an estimated cost of £1,918,550, slightly below the approximate estimate and the budget. The allowance for site works has been increased, as additional treatment to the front areas would be required owing to the front elevation being set back on the splay.

It should be realised that outline elemental estimates will not be completely accurate, although the comparisons obtained from them will be valid enough. Each of these breakdowns would only take a few hours of a senior assistant's time, and each hour spent at this stage is worth days spent on cost checks of minor elements later on in a frantic attempt to keep within the budget. This is where the process of cost planning really pays for itself.

14.4 Need for care

This is the place for a word of warning. Because we are dealing in such large figures at the elemental estimate stage, it is vital that all arithmetic, and if possible all measuring, should be checked. A silly mistake in calculating the principal areas would have serious consequences

Elemental estimate no. 2					
Project	Office Block, Midtown				
Date of estimate	March 2013			**Total cost (£)**	**Cost (£/m^2) of floor area (2370 m^2)**
Assumed date of tender	September 2013				
Ground floor area	(A)	387 m^2			
Total floor area	(B)	2370 m^2			
External wall area	(C)	2851 m^2			
Internal wall area	(D)	1200 m^2			
Work below lowest floor finish	(A)	387 × 321.00		124,227	52.42
Upper floors including frame and stairs	(B−A)	1983 × 123.50		244,901	103.33
Roof including frame	(A)	387 × 164.50		63,662	26.86
External walls	(C)	2851 × 212.00		604,412	255.02
Internal walls	(D)	1200 × 50.00		60,000	25.31
Floor finish	(B)	2370 × 44.00		104,280	44.00
Ceiling finish	(B)	2370 × 27.50		65,175	27.50
Wall finish	(C+2D)	5251 × 13.00		68,263	28.80
Decoration	(B)	2370 × 4.50		10,655	4.50
Fittings				2750	1.16
Services				476,225	200.94
Drainage				19,000	8.02
Site works				45,000	18.99
Contingencies				30,000	12.66
				1,913,600	**807.43**
Professional fees				–	–
				1,913,600	**807.43**
(Inclusions and exclusion as approximate estimate unless otherwise stated, VAT not included)					

Figure 14.4 Revised elemental estimate.

later on, and just because they seem (and are) simple, the elemental estimates must not be taken lightly. We should remember that 'everyone makes mistakes', particularly people working under pressure – checking will ensure that there are none. The same remarks, of course, apply to the preliminary estimate, which we dealt with in the previous chapter. It is also important to remember that there are many other considerations in designing a building besides cost, and that the cost planner must not be tempted to try and usurp the architect's function when the shape and type of building is under consideration. The cost planner must be prepared to give the architect all possible assistance at this time, but should avoid making detailed suggestions about matters of planning and architecture, which are entirely the architect's responsibility.

14.5 The cost plan

When the sketch drawings have been finalised and the budget (modified if necessary) has been accepted by the client, it is time to prepare the cost plan itself.

Although the establishment of the brief and the investigation of a satisfactory solution are being dealt with as two separate and consecutive functions, there may be a certain amount of iteration. Design investigation may suggest modifications to the brief, which in turn will need to be investigated. This is all to the good, and will probably result in improved performance. Even if it involves, as it will, a good deal of abortive cost planning work, the cost planner's work at this stage is relatively cheap compared to the potential benefits.

The cost control of design development, on the other hand, demands considerable resources, and should not be carried out until a satisfactory solution has been defined and agreed on. As has already been pointed out, substantial iteration between the second stage (investigation of a solution) and the third stage (cost control of the development of design) of the cost planning process brings nothing but disadvantages.

The basic principle to be adopted is one of moving from the 'ball-park' estimating of outline proposals to the detailed costing of production drawings in a series of steps. The cost plan will probably be based on the most recent elemental cost estimate for the project. It will, however, be developed with a full list of elements instead of the condensed list used so far, complete with an outline specification (agreed on with the designer) for each of the elements.

This expensive document will form the basis for the system of design cost control. It should not be produced prior to approval of sketch design, as it might have to be done again a second (or third) time if the design changes. In any case, the designer would find it difficult to make decisions on detailed specification matters while the design itself is still undecided. But it should not be left until the design is further developed. That may make it easier to do, but it will then become a record of what has been decided rather than a plan for controlling design – just a rather fancy cost estimate, in fact.

The cost plan may take many forms, but all the different systems have much common ground.

14.6 Specification information in the cost plan

Opinions differ on how detailed the specification information should be when the cost plan is prepared and this is a suitable place to discuss the issues involved.

The first approach involves giving a fully detailed specification in the cost plan:

- The cost planner/quantity surveyor will try and get as much detailed information as possible from the architect before preparing the cost plan and will fill in any blanks with typical specifications within the required cost range.
- When the cost plan is complete, the architect will be supplied with a detailed list showing the type of construction and finish on which the cost is based.
- The architect knows that although anything in the list may be altered at will, any such deviation may have an effect on the planned cost.
- The cost planner will feel that this specification list gives some protection in the possible event of an architect failing to design within the agreed limits, as these limits are written into the cost plan and are not just assumed.
- However, this procedure is open to the objection that the cost planner appears to be taking the responsibility for design out of the architect's hands.

The alternative way of dealing with this problem is to leave the responsibility for design entirely where it belongs, with the architect:

- When the cost plan is prepared, the architect's ideas on specification are incorporated into it, but if these are not forthcoming the cost planner does not provide them.

- Instead, a target cost for the element is devised, on the basis of standards of cost performance achieved elsewhere, and it is left to the architect to design within that cost.
- If the element, when designed, costs more than the sum of money allocated to it, then it must either be redesigned or the elemental cost increased at the expense of other elements.

That the theory behind this second approach is sound few will deny, but the first alternative is the one which was always preferred by most practising cost planners, and today is almost universally adopted.

Apart from the factor already mentioned (of protection against an uncooperative architect) it is said that most architects prefer the discipline of a specification to the provision of a cost figure for the element which is unrelated to any specification and may necessitate several attempts at design before it is achieved. The 'detailed specification' method also has the big advantage that if the architect works to the agreed specification, then subsequent cost checks will be unnecessary.

14.7 Elemental cost studies

Cost research or cost studies may be required when the architect is considering design alternatives. It is at this stage that cost models such as those described earlier will be most effective. However, at the present time these studies would normally be done by means of approximate quantities, about which sufficient has already been said.

Cost studies, if done properly, are expensive in professional time, and therefore cannot usually be undertaken in respect of the majority of items in the project. They should therefore be reserved for comparisons of important components, or for projects which are unusual and for which ordinary elemental cost data are of little use.

Large-scale cost studies are inappropriate where the component is not a significant part of the cost structure, or where the difference in cost between the alternatives is obviously going to have little effect on overall costs. Where there is little cost difference between one solution and another, the decision should be taken on grounds other than cost and not on the possibility of a marginal saving.

If the contract is to be awarded in the traditional manner with competitive tendering on BQs, no quantity surveyor can possibly forecast which of two alternatives with a marginal cost difference would actually be priced the cheaper by the (unknown) successful contractor. In connection with this, the cost planner must remember the natural tendency of contractors to play safe when pricing work involving unknown or experimental materials and techniques.

Another point to bear in mind in connection with cost studies is that all constructional systems have certain optimum conditions (of loading, span, and so on) in which they are at their most economical. There is usually a reasonable spread of conditions on either side of the optimum in which the system remains reasonably economical, but once the conditions get outside this range costs will start to rise steeply. Even though the particular system may still be perfectly feasible in these unsuitable conditions, it is likely that there will be a cheaper and better solution.

It is also worth noting that a high standard of fire resistance, thermal insulation or sound insulation normally costs money, and that it is usually wasteful to employ methods of construction or materials which offer these advantages if they are not required.

We will now look at some of the principal elements in a building, and the particular aspects of design costs that affect each.

14.8 Foundations

The type of structure will normally influence the type of foundations required; a structure which imposes heavy point loads cannot be carried on conventional strip foundations, for example. Piling is almost always a very expensive solution and is normally employed only where conventional foundations are impossible because of the depth at which a bearing formation exists, combined sometimes with the waterlogged nature of the ground. Different systems of piling have particular advantages and disadvantages, but the specialist piling firms (most of whom offer several systems) are usually more than ready to offer their services in connection with early cost investigations.

As previously noted, the cost of the piling itself will usually be a complete extra, because the complex of pile caps and ground beams associated with this form of construction is often as expensive as conventional foundations.

14.9 Frame

Cost studies may be necessary to determine the type of frame to be used or indeed whether there should be a frame at all.

External walls of habitable buildings need certain qualities of weather resistance and heat insulation, and such a wall capable of bearing quite substantial loads costs no more than a non-load-bearing wall with similar weathering and insulation performance.

In conditions where normal external walling would be capable of carrying the weight of floors and roof, the cost of a frame is a complete extra, and it follows that for small buildings of not more than three storeys a frame is likely to be an expensive solution, even though it may be desirable for other reasons. A frame for small buildings only becomes economically justified where it is necessary to have a very high proportion of the external walls glazed, or in 'big sheds' such as warehouses and the like where the walls do not need good insulation or aesthetic qualities and cheap non-structural materials such as profiled cladding can be used.

A frame, if required, is likely to be of steel or reinforced concrete, with light alloys and timber as recent and rather specialised competitors. As with other comparisons between materials, if either steel or reinforced concrete held all the cost advantages the other would long since have gone off the market.

For multi-storey construction, there is a general tendency for reinforced concrete to be cheaper in normal conditions of loading, although the difference may often be small. The structural steelwork industry is continually improving its techniques of design and construction, particularly when the cost competition from reinforced concrete becomes severe.

Although steel is inherently cheaper than reinforced concrete for most normal applications, the saving can sometimes be wiped out by the measures necessary to give the structure an adequate fire resistance. This is almost certain to be the case if in situ concrete cladding is required to beams and columns, so that the type and standard of fire resistance is therefore an important factor in any such cost comparisons.

Steel therefore gives its best comparative cost performance as a frame to single-storey buildings or in roof framings where fire resistance is not normally required by the building regulations and where the steel may be used without any protection other than paint. For such applications, reinforced concrete is not usually competitive, except in some proprietary systems for constructing factories or sheds out of standard precast units.

Steel frames have advantages over in situ frames in site programming, and some contractors (particularly small- or medium-sized firms) prefer working with a steel frame to erecting a reinforced concrete structure of their own, and this preference would be reflected both in tendering enthusiasm and in completion time for the project.

In designing cost-effective steel frames, attempting to save weight of steel can be counter-productive if the result is increased complexity – by using compound welded members, for instance, in lieu of simple sections. A steel fabrication firm's advice should be sought as to the point where savings are swallowed up by fabrication costs. Most constructional steel firms and specialist reinforced concrete contractors are helpful in giving cost information for a new project.

If a consulting structural engineer is appointed for the project, the cost planner would obviously work with the consultant in providing cost information. As alternative frame designs may affect other elements, the structural engineer may not be able to ascertain the full cost implications without assistance.

As well as a choice of materials, frame design will involve a choice of frame shapes and spacing. The most uneconomical solution will occur where heavily loaded beams have to span long distances, especially if they are also restricted in depth. The spacing of columns and beams will have an important effect on cost, particularly if the columns are expressed on the elevations and covered with expensive cladding.

If the frames are spaced too closely, the savings in sections will not pay for the additional frames, because although frames spaced at 2.5 m centres will each be carrying two-thirds of the weight of frames spaced at 3.75 m centres, they will cost much more than two-thirds of the latter. This is because the choice of section for a beam is affected by its own weight and span as well as by the load it carries, and the span of the beams will not have been changed (see Figure 14.5).

Because the most economical spacing will depend on the span and the loading, it is necessary to consider each case individually. For normal floor loadings, however, it is unlikely that spacing as close as 2.5 m will give the most economical solution, while spacing much in excess of 5 m will begin to produce additional costs on the floors and roof owing to their increased span, even though the frame design itself may still be economical.

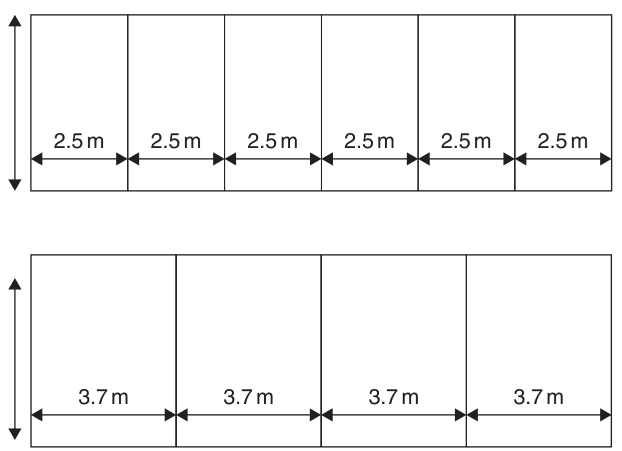


Figure 14.5 Alternative grid layouts.

14.10 Staircases

Because the structure of a concrete staircase represents less than a third of its total cost (the remainder being caused by finishes and by balustrades) and as the whole elemental cost is only a minor one, it is doubtful whether the staircases of a building are the most fruitful field for cost studies.

However, as well as the staircase and its finishing, balustrades, and so on, the true total cost of a staircase would include

- the surrounding walls of the staircase together with foundations,
- windows,
- wall finishes,
- doors,
- roofs, and so on,

and would be quite considerable.

The most rewarding approach is therefore likely to be a reduction in number of staircases rather than in the details of their design.

14.11 Upper floors

In contrast to staircases, upper floors are an important element and require comparatively little work in the evaluation of alternative designs, which may therefore be well worth doing. As with some other elements, it is difficult to arrive at true cost comparisons without considering the 'frame' element as well.

14.12 Roofs

The architect may require cost studies of alternative roofs to which most of the preceding remarks apply. In addition, the comparative costs of flat roofs and pitched roofs may be involved. These will depend more on the level of the two specifications than on the basic difference in roof type. However, for medium to large spans, a satisfactory pitched roof is likely to be rather cheaper than a flat roof of comparable quality, partly because of the simplicity of spanning large areas with roof trusses rather than deep beams. It is also often possible to use the resulting roof space as part of the accommodation area.

Pitched roofs also tend to be more durable than flat roofs, which are sensitive to poor workmanship and poor design detailing unless very expensively built. Bad maintenance experiences with cheap flat roofs have led to the avoidance of these wherever possible.

14.13 Rooflights

Rooflighting is not normally the most economical method of lighting rooms where windows are a possible alternative, and individual domelights or small lantern lights are probably the least satisfactory from a cost point of view. However, there are many reasons why the architect may choose these means of lighting, for instance openable lights for natural ventilation or trickle vents, and the element is not important enough for this to affect the total building cost very considerably.

On some current buildings, steeply pitched roofs effectively form the walls of upper storeys, and these require the same level of fenestration as a wall. This is one of the areas where the theory of elemental cost planning breaks down and it will almost certainly be necessary to consider the walls and the roof together for cost planning purposes.

14.14 External walls

This may be the most important structural element, particularly in a multi-storey building, and being one in which a tremendous range of constructional methods and finishes may be used is a suitable element for cost studies.

In the type of building where the external walls comprise a series of repeating panels, it will be sufficient to study a single panel in detail. It will often be difficult to consider this element in isolation from windows, internal finishes and frame.

Note that ordinary brick or concrete block walls finished with facing bricks externally are likely to be far cheaper than any other construction of comparable performance and durability. Therefore, a considerable area of plain walling on a building may enable smaller areas of luxury construction or finish to be used while still keeping the overall elemental cost quite reasonable.

14.15 Internal walls and partitions

The comparative costs of traditional partitioning methods are well enough known for cost studies to be unnecessary, but if it is proposed to use a special type of partition on a large scale then a cost investigation would be worthwhile. Comparative costs of small areas of special partition or glazed screens, on the other hand, would not have much effect on the total building cost and would not usually be worth investigating.

If the BCIS or a similar list of elements is being used, it is important to remember that the cost of finishings to traditional partitions is included in other elements, but the complete cost of self-finished proprietary partitioning is included in the 'partitions' element, so that in this instance yet again the elemental costs will not be strictly comparable.

14.16 Windows

These are often a major element of modern buildings and have a very large cost range.

Cost differences will normally be due to performance requirements rather than the actual materials used in manufacture; standard metal, unplasticised polyvinyl chloride (UPVC) or timber windows for housing schemes are competitive in cost as are high-class metal or hardwood windows for prestige buildings, but the latter category may be four or five times dearer than the former.

Apart from the actual material and section of framing, the cost of windows is substantially affected by performance, particularly as regards double glazing and weather stripping, but there are also factors affecting individual windows or groups of windows rather than the fenestration of the building as a whole:

- **Size of window**: Small windows tend to be high in cost per square metre, because of both the greater intricacy of the window itself and the cost of forming the opening in the wall; these two costs vary according to perimeter rather than area.

- **Size of panes**: Very small panes increase the cost per square metre, as do panes which are so large that it is necessary to glaze them with stout float glass instead of sheet glass. It is unlikely that any saving on window frame or glazing bars would counterbalance the cost of plate glass unless an extremely expensive type of window was being used.
- **Opening lights**: This is probably one of the most important factors in window cost, particularly where a high standard of weather resistance is required. The heavy comparative cost of opening portions of windows (as against areas of fixed glazing) makes it very difficult to compare window costs on an overall square metre basis unless the pattern of opening and fixed areas is very similar. Unfortunately, it is not even possible to compare the costs of opening portions on a square metre basis as so much of the cost (hinges or pivots, fasteners, framing to angles) varies according to the number of sashes rather than their size.
- **Decoration and glazing**: Some types of window come to the site ready glazed and self-finished, others require to be glazed on-site and painted.
- **Special types of glass**: For example, solar reflective glass or the laminated glass required by building regulations in some windows or screens.

Because of the above-mentioned factors, it is often necessary for any cost studies of windows to require individual consideration of all the window types in the building, rather than being confined to a typical window and the results being applied to the remainder on a square metre basis.

14.17 Doors

Except on buildings which are divided into a large number of very small rooms, such as hostels or flats, or where non-standard sizes or fancy ironmongery are used, the doors are not usually a significant element. As a result of this, because they are one of the components most subject to heavy mechanical wear and because they are also one of the most noticeable features of the building it is probably a mistake to be excessively concerned with cost when designing this element.

14.18 Floor, wall and ceiling finishes and decorations

Cost studies of these elements are likely to be comparatively simple, and where large areas are involved are certainly worth doing.

14.19 Engineering services

On most buildings, this is one of the most important elements. It is essential that cost studies be carried out, and these will be fairly meaningless unless 'whole-life' investigations into running costs, performance and updating/replacement are taken into account.

Most cost planners are unlikely to have access to the data on which such studies should be based and will need to work closely with specialist engineers, preferably with those who are going to be responsible for the design.

14.20 Joinery fittings

Of all the minor building components, single joinery fittings involve the most work in arriving at a cost, and so cost studies of such fittings should not usually be attempted. Where a fitting has been designed for repetition (such as a bedroom fitting for a large hostel or a typical bench to be used as a basis for furnishing a set of laboratories) the position is of course different.

14.21 Cost studies generally

We have seen many ways in which cost studies can contribute to the design of a building. However, it is important to realise that it would not be economically possible to employ more than a few of them on any particular building, as a complete cost study of every element, major and minor, would not produce savings commensurate with the amount of time expended. The only occasion where such a course might be practicable is where a large number of similar buildings are to be erected, as for instance a standard house design for a large housing authority.

14.22 Preparation of the cost plan

We now come back to considering the preparation of the cost plan itself. This may take many forms, but all the different systems have much common ground.

The plan will almost certainly be prepared by elements and the cost will be expressed per square metre of floor area even if it is calculated in a different manner, in order to be able to make comparisons between other schemes of different size on a common basis. If there is a cost target, it will by now have been set up with some degree of finality and the architect will want to go ahead with the working drawings.

As cost planning involves cost control, the architect must design in accordance with the cost plan, which must therefore be available before the working drawings have proceeded very far. What do we need in order to prepare such a plan?

- A drawing and a standard of specification to which the cost plan can be related.
- A cost analysis of a comparable project.

It is not necessary that the 'comparable project' should be for a similar use as long as there is some reasonable compatibility as buildings. For instance, a police station and a health clinic are both public buildings with fairly similar storey heights and are divided into both small and large rooms. The elemental analysis of a police station could therefore be used to prepare the cost plan for a health clinic if nothing better was available, whereas between say a church and a block of multi-storey flats there is no resemblance whatever.

The cost plan must be prepared to a standard format, for reasons that have already been emphasised in connection with analyses and preliminary estimates. The form should show

- the chosen list of elements;
- preliminaries and insurances (if separate);
- contingency sum;
- professional fees (if to be included);
- the cost index value which is being used.

It is common practice in some offices to allow a 'design margin' of between 1% and 5% as a design contingency in addition to the contract contingency, and this margin may come in useful during the cost check when it can be absorbed into any element that needs it.

Although specialist computer software is available for cost planning work, many cost planners prefer to use an ordinary spreadsheet package adapted to the practices of their own particular office. Whichever alternative is used, the software should guide the user through the process of preparing the cost plan, making sure that all necessary adjustments are made and that nothing is forgotten. Prior to the large-scale adoption of computers for the purpose, much the same control was obtained by the use of standard manual forms and procedures. The first page of a typical manual form is shown in Figure 14.6 and the accompanying specification in Figure 14.7.

14.23 Method of relating elemental costs in a proposed project to analysed example

There are two ways of doing this, either by using unit costs of the elements or by proportion. In spite of what may be thought to the contrary, these are really two ways of doing much the same thing. In both methods, the unit quantity of the element (e.g. area of external walls) has to be measured from the sketch drawings of the proposed project.

Using the first, or 'unit cost' method:

- This quantity is priced out at the elemental unit rate per square metre for the same element obtained from the comparable analysis, where this is applicable, but if specifications are different then approximate quantities are more likely to be used.

COST PLAN

Project	Office Block, Midtown		**Note**	This cost plan is based on the attached outline specification, and both documents should be read simultaneously	
Date of cost plan	Apr. 13				
Assumed date of tender	Sept. 13				
Total internal floor area	2,390 m^2				
	Unit quantity	**Unit cost (£)**	**£**	**Total cost (£)**	**Elemental cost/m^2 (£)**
1 Work below lowest floor finish					
Ground floor area	390 m^2	321		125,190	52.38
2 Structural frame	2,390 m^2			125,600	52.55
3 Upper floors					
225 mm Hollow Pot	386 m^2	60	23,160		
150 mm in-situ RC	1,585 m^2	41	64,985		
			88,145	88,145	36.88
4 Staircases					
RCStaircases					
1nr 25 m rise	25 m	1,225	30,625		
1nr secondary 21.5m rise	21.5 m	900	19,350		
			49,975	49,975	20.91
			continued	**388,910**	**162.72**
			1		

Figure 14.6 Front sheet of typical cost plan.

OUTLINE SPECIFICATION for COST PLAN

Project	Office Block, Midtown
Date of cost plan	Apr. 06
Assumed date of tender	Sept. 06
Total internal floor area	2,390 m^2

Work below lowest floor finish	
Foundation to walls and/or columns	In-situ concrete piles average 4 m long (approx. 90 nr) reinforced concrete pile caps and ground beams
Basements, walkway ducts, etc.	Semi-basement 1.5 m deep approx. 8 m × 4 m for boilers Also, lift pits approx. 0.75 m deep in waterproof concrete
Rising walls	Clay common bricks in cement mortar built off ground beams (approx 0.75 m high generally to damp-proof course). Reinforced concrete walls (0.3 m thick) around stairwell and lifts
Ground floor slab	Generally, 150 mm slab reinforced with fabric on building paper and hardcore. Note thickness of hardcore to make up levels (0.65 m average)
Damp-proof courses and membranes	Lead-cored bituminous dpc in walls, three-coat Synthaprufe cold-applied bituminous emulsion, containing synthetic rubber latex, two-coat asphalt tanking to semi-basement
Structural Frame	
Generally	Reinforced concrete beams (at 3.50 m c/c) and columns

Figure 14.7 Specification notes to accompany the cost plan.

- The approximate quantities will give the total cost of the element, and this total is then divided by the floor area of the proposed project to give the elemental price per square metre.

When the second, or 'proportion' method is used:

- The ratio of unit area to floor area in the proposed project is compared to the corresponding ratio in the analysed example.
- The elemental cost per square metre is then adjusted in proportion to the difference in the two ratios.
- With this method, one is not concerned with the actual unit cost (either in total or per square metre) at all, although the total cost for the element will be required for comparison purposes at cost check stage.

What are the advantages and disadvantages of the two methods? The proportion method is the logical choice for use where the elemental cost per square metre is regarded as an index of performance rather than the result of a specification, and it tended to be preferred by central government departments in the early days of cost planning.

However, the unit cost method is almost exclusively used today. It is more in line with the traditional quantity surveying approach and most cost planners would feel less likely to make mistakes when using it, particularly if the workings become complicated. The unit cost method is more easily related to approximate quantities either at cost plan or cost check stage, and we must remember that at one or other of these stages fairly detailed quantities have got to be introduced.

In order to illustrate the systems in use, two examples are worked out below using both methods. It will be seen that either method will allow differences in quality as well as quantity to be adjusted.

Example 1

Total floor area	5000 m^2
External wall area	4000 m^2
Wall:floor ratio	0.80
Cost of external wall per square metre of floor area (elemental cost)	= £75.00
Cost of external wall per square metre of wall (unit cost)	= £93.75

Proposed project

Total floor area 4800 m^2

External wall area 3600 m^2

Elemental cost of external walls on proposed project

Unit cost method	**Proportion method**
3600 m^2 of wall at £93.75 = £337,500	Wall:floor ratio = 3600/4800
£337,500/4800 = £70,312	£75.00 × (0.75/0.80) = £70,312
Total cost 4800 × £70,312 = £337,500	

Example 2

Total floor area 5000 m^2

Internal doors 35nr

Cost of doors per square metre of floor area (elemental cost) = £2.10

Cost of doors each (unit cost) £300

Proposed project

Total floor area 4800 m^2

Internal doors 50nr

Cost of doors each £330 (better quality)

Elemental cost of internal doors on proposed project

Unit cost method	**Proportion method**
50 doors at £350 = £16,500	£2.00 × (5000/35) × (50/4800) × 33/30 = £3.44
£16,500/4800 = £3.44	
Total cost 4800 m^2 × £3.44 = £16,500	

14.23.1 Sources of data

If the analysed example will not yield all the necessary information for preparing the cost plan, this information must be obtained elsewhere.

One approach is to take a price from another analysis. This is potentially dangerous; we have seen how a priced bills of quantities (BQ) will probably contain compensating errors and that these will be incorporated in the analysis. However, if we take items from more than one analysis, we may get cumulative instead of compensating errors.

It would be possible (indeed tempting) to take a number of elements from different analyses, all of which are priced too low, and this would make the total of the cost plan quite unrealistic. This cannot happen where a single analysis is used throughout.

If prices have to be obtained from other analyses, it is wise to collect as many examples of the same item as possible so that any errors are likely to cancel out in the average so obtained.

The alternative is to use approximate quantities. These are likely to be very approximate indeed (remember that we have no working drawings) and herein lies the danger; it is much easier to leave things out than to put extraneous items in. Therefore, when using approximate quantities, the cost planner must be very careful to include all the items which are included in the description of the element (e.g. skirtings and their screeds with 'floor finishes' or rainwater pipes with 'roofs').

It is also important to include the percentages for preliminaries, insurances or contingencies if these are included in the elemental rates.

Needless to say, the quantities must be priced at the same level of market rates as the cost plan itself, although the rates will be higher than ordinary BQ prices because of the need to include the cost of secondary work which would be measured separately in a full BQ.

The approximate quantities themselves will be similar to those normally employed by quantity surveyors for estimating purposes except that the elements must be kept separate. So, for example, the plastering on the underside of a concrete roof slab could not be included in the overall rate for the roof but would be worked out separately as part of 'ceiling finishes'.

In some offices, it is the custom to keep a complete schedule of prices for use when pricing approximate quantities. This certainly gives a consistent level of pricing, but it is doubtful whether any but the largest organisations would find the preparation and maintenance of such a list to be an economic proposition.

Examples of use of information from analysed building

Analysis

Total floor area 2000 m^2
Element: internal partitions
Elemental cost: £27.00 m^2

1400 m^2 of 75 mm breeze partition at £13.00	£18,200
900 m^2 of 225 mm and 300 mm brick walls at £33.00	£29,700
120 m^2 of glazed partitions at £50.80	£6096
2420 m^2	**£53,996**

Average unit cost = £53,996 ÷ 2420 = £22.32 m^2

Proposed project

Total floor area	3100 m^2
Total area of partitions (measured roughly from drawings)	3500 m^2

If we do not know the type of partition required, or if the proportions of various types are likely to be similar to those of the analysed example, we can use the average unit rate or work by the proportion method:

3500 m^2 at £22.32 = £78, 120 total cost divided by 3100 = £25.20/m^{2}elemental cost

But if even at this stage we can see that the proportions of the various sorts of partition are quite different to the analysed example we must use the individual unit cost as shown below.

20% 75 mm breeze partition	= 700 m^2 at £13.00	£9100
10% 225 mm brick wall	= 350 m^2 at £33.00	£11,500
60% glazed partition (cheaper type)	= 2100 m^2 at £45.00	£94,500
10% timber stud partition (no rate for this: price built up by approximate quantities)	= 350 m^2 at £23.00	£8050
		£123,200

£123,200/3100 m^2 = £39.74 elemental cost

When severely altering the proportion of items like this, it is necessary to watch out for any freak rates. For instance, it is possible that the rates for glazed partitions in the analysed example may have been much too low, and being a very small part of the whole job this will not have had much effect on the total price. On the proposed project, however, the proportion of glazed partition has been increased from 10% to 60% and such an error would be much more serious. Again, this emphasises the point which has been made before, that the smaller items in the analysis may well have the least reliable prices.

14.23.2 Elemental costs

By whatever means the total cost of the element has been obtained, it should always be expressed per square metre of floor area, for the following two reasons:

- For comparison of reasonableness with other buildings. If the partitions (for instance) are costing far more per square metre of floor area than on other buildings of the same type, it is worthwhile investigating the reasons. These may be perfectly sound; the cost may include built-in cupboards, there may be a greater degree of insulation required between rooms, but it is also possible that there is inefficient planning of the accommodation and this would also be reflected in other elements.
- The elemental price per square metre enables the importance of any extravagance or economy to be judged in a way that is not possible when considering unit prices only.

14.23.3 Comparison of elemental costs

Let us consider the unit costs for three different specifications of internal doors:

- Hardboard-faced skeleton-framed flush doors hung on steel butts to softwood frames, no architraves. Unit cost £45.00/m^2.
- Plywood-faced semi-solid-core flush doors hung on steel butts to softwood frames with softwood architraves. Unit cost £82.50/m^2.
- Mahogany-veneered plywood-faced solid-core flush doors hung on solid-drawn brass butts to mahogany frames with mahogany architraves. Unit cost £175.00/m^2

From a comparison of the unit costs, it would seem that the third specification is prohibitively expensive for normal work compared with the more usual second specification. Yet, to adopt the better specification in a typical school of 3000 m^2 with 70 internal doors would only increase the elemental cost per square metre by about £2.16/m^2, and to use the completely inadequate first specification would only save £0.88/m^2. Considering that the total cost per square metre of the school would be around £600, these increases and decreases are quite insignificant.

On the other hand, a marginal difference in some other elements, such as the particular choice of hardwood for wood block flooring, which may only alter the unit price by 10%, will have as great an effect on the cost of the school per square metre as a 100% difference in door prices. It will soon become obvious to the cost planner which items need the most time spent on them at cost plan stage – in other words, which elements have the greatest cost significance.

It would be worthwhile to use approximate quantities for a major element such as external walling where a difference of one or two pounds in the unit cost per square metre would have an important effect on total cost, and to check the cost plan very closely when drawings subsequently become available. Such elements as internal doors or ironmongery, on the other hand, can be dealt with much more rapidly.

14.24 Presentation of the cost plan

The cost plan should be presented as neatly as possible; it will almost certainly be going to the client and should reflect well on the firm which has prepared it. To what extent expense should be incurred in order to give the plan an impressive appearance is a matter for individual preference, but if the document has been prepared by computer a high-quality (preferably colour) printer should be used for the purpose.

Another matter for personal decision is the extent to which the detailed build-up of the plan should be made available to the architect. Whether this should be done in all cases will depend on the degree of mutual confidence which exists and also on the available facilities for copying a large quantity of rough working.

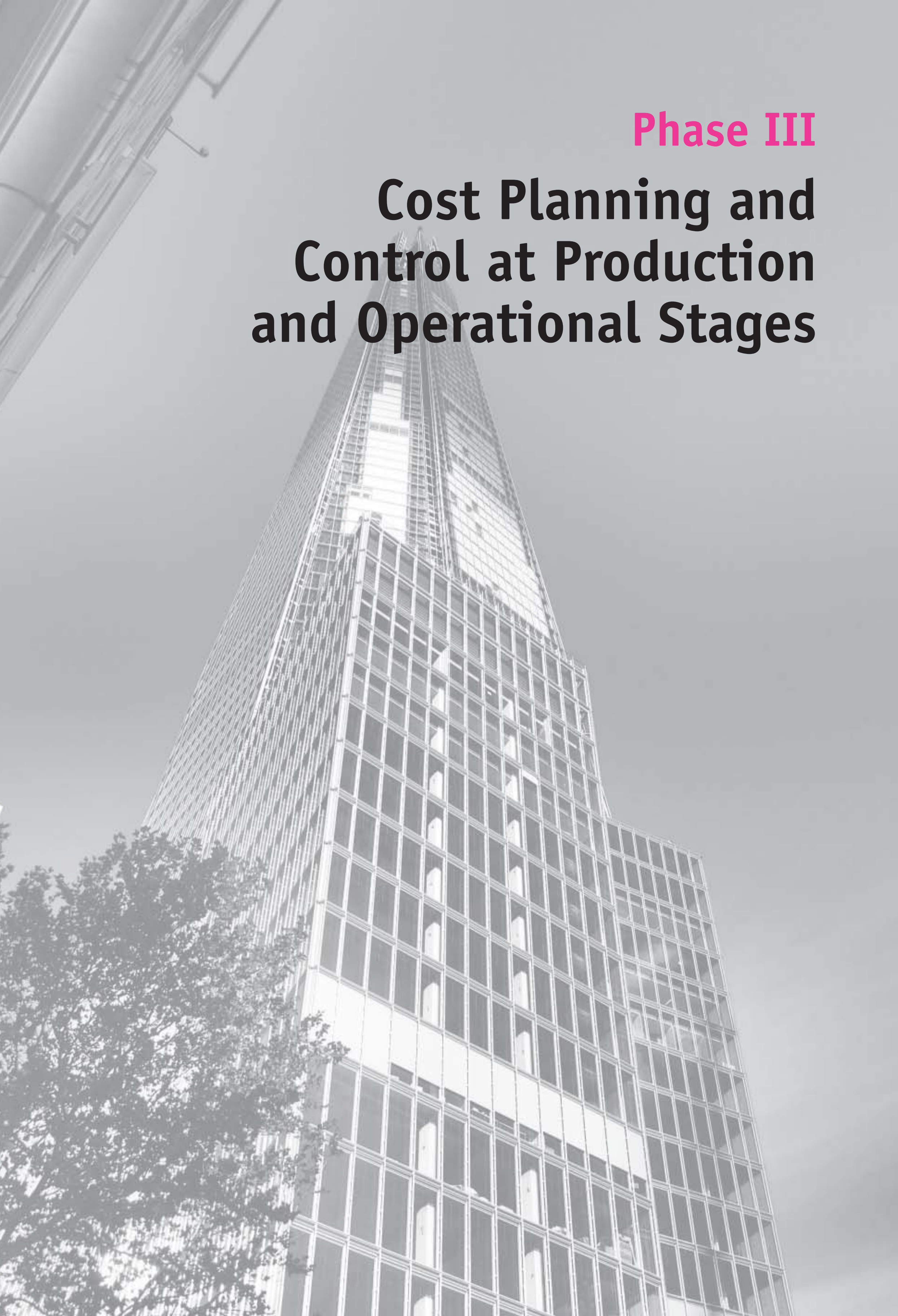
With the cost plan should go the specification, if any, upon which it is based; this will necessarily be more in an outline form than the type of specification, which will eventually be embodied in the BQ. It may either be included as part of the cost plan itself or be prepared as a separate document. A typical example was shown in Figure 14.7. If a separate document is used, it is important that there should be a space for each specific item so that it can be quickly seen whether everything has been dealt with or not. The specification should preferably be filled in by the cost planner in consultation with the architects, rather than being sent to the architects for them to fill in.

14.25 Key points

- Early estimates of the cost of the scheme will probably be done using a shortlist of some half-dozen principal elements only. But because such large figures are being dealt with it is even more vital than usual that all arithmetic, and if possible all measuring, should be checked.
- The cost control of design development demands considerable resources and should not be carried out until a satisfactory solution has been defined and agreed on. Substantial iteration between the second stage (investigation of a solution) and the third stage (cost control of the development of design) of the cost planning process brings nothing but disadvantages. The basic principle to be adopted is one of moving from the 'ball-park' estimating of outline proposals to the detailed costing of production drawings in a series of steps.
- The cost plan will probably be based on the most recent outline elemental cost estimate, but developed in as much detail as a full elemental cost analysis complete with outline specification (agreed with the designer) for each of the elements. It is generally preferred that the cost plan should incorporate the specification on which it is based. Although elemental estimates can be based on approximate quantities or proportion methods, the former is usually preferred today. Cost studies of individual elements are generally expensive, and should be limited to elements of major cost significance or to elements, such as floor finishes, where not much work is involved.

Phase III

Cost Planning and Control at Production and Operational Stages



Chapter 15

Planning and Managing Project Resources and Costs

15.1 Introduction

Once the cost plan has been approved by the client and the working drawings are available, we need to consider the resources required to realise the project.

Developers normally need to involve themselves with construction professionals in order to get their building work undertaken. The building industry and the civil engineering industry together are often referred to as the construction industry, and many firms (certainly most of the large ones) operate in both sectors, even though their staff and organisations will probably be separate.

Smaller contractors often specialise in either civil or building work (such as groundwork in the case of the former).

It is, however, very difficult to separate the two halves of the construction industry statistically, because of the overlap which occurs. For instance, the construction of the foundations of very large buildings could almost be classed as civil engineering (and you will find it so referenced in your library, if this operates the Dewey Decimal Classification or UDC system), and there may be quite a lot of building work on some civil engineering projects.

A further subdivision of the building industry is into housing and other work, many main contractors having divisions which specialise in one or the other (Taylor Woodrow, for example, has a housing division called Bryant Homes).

The building industry in the United Kingdom has changed considerably over the past 40 years, in two ways. First, most general building contractors now undertake only a small proportion of their turnover using their own directly employed operatives, the majority of their work being outsourced to specialist or trade subcontractors. The general contractor's role has changed from being primarily a provider of resources into being a provider of management and financial services. Very often, the supervisory and administrative staff and a handful of labourers will constitute the entire site workforce of the general contractor.

In the second case, between the end of World War II and the late 1970s the building industry was geared largely to serving central and local government departments as its direct clients. Because of changes in the country's economic structure, this is no longer the case. In much of the country, and particularly in the south-east, the industry has had to accustom itself to the different norms of private enterprise clients, more interested in results than in procedures.

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

15.2 Nature of the construction industry

The UK construction industry accounts for a significant proportion of the economic output of the UK economy. As of 2013, the industry, in statistics can be summarised as follows (Construction News):

- Construction's output is £102.4 billion at current prices.
- Construction activity accounts for about 6.3% of the economy.
- Output to grow by 0.8% in 2005 and 2.4% in 2006.
- It provides jobs for 1.7 million people in the United Kingdom, 1 million of which are employed directly by the industry.
- The "black" construction economy is valued at £10 billion a year.
- There are 192,404 construction firms in the United Kingdom.
- Since the change of contracts at an annual rate of 12.4% in December 2012, the industry is now growing at a rate of 4%.
- The UK economy is forecast to grow by 0.9% in 2013, according to the International Monetary Fund.

Because it operates with a relatively small investment in fixed assets in relation to its large turnover, the industry is very flexible and is able to accommodate itself to major changes in workload much more easily than industries which are plant-based. Its workforce can be reduced in periods of recession without the archetypical political crisis caused by the closure of, say, a car factory, and perhaps because of this it has often been used as an economic regulator by the government. Similarly, it can expand its efforts rapidly in order to meet demand without requiring major investment.

15.3 Problems of changes in demand

Nevertheless, violent changes in demand do harm the industry. Workers who are made redundant in times of economic downturn or recession do not always return to the industry afterwards, and the problem is compounded by the need to continually train skilled workers. Firms argue that they are unable to afford to do this when 'the order books are empty', and in times of economic upturn, they are usually argue that there is little time to complete this training. In Liverpool, this was recognised as a major problem by the Chair of Liverpool Vision (Liverpool Vision is an independent company established to bring together key public and private sector agencies to deliver the regeneration of the Liverpool city centre), Sir Joe Dwyer FCIOB. In a recent speech that he delivered, he argued that one of the pivotal problems facing UK construction is the severe underinvestment in training by contractors and the haemorrhaging of the knowledge base. It is also difficult to keep a balanced management team of the right size when demand fluctuates wildly, and, as stated, management expertise is now probably the general contractor's main stock-in-trade.

A further problem concerns the supply of materials, because material and component manufacturers are plant-based and find it more difficult to respond rapidly to changes in demand than the construction industry itself. If a boom is regional in character, this problem can be mitigated by importing materials and components from elsewhere in the United Kingdom or Europe, but for bulk materials in particular (where transportation forms a large part of their cost) this can often be an expensive alternative. It is therefore very important for the cost planner to look at the general and local economic situations when forecasting costs. In the early 1980s, tender prices remained almost static, although official costs of labour and material inputs continued to show an increase. In the 5 years between the third quarter of 1980 and the first quarter of 1985, tender prices increased by less than 1%, but the official index of building costs rose by no less than 38% in the corresponding period! The same thing happened even more violently between 1990 and 1996.

This imbalance between tender prices and building costs was partly due, of course, to tenderers' willingness to take a cut in profits during difficult times. But it was mainly due to the fact that real costs did not increase, whatever the official figures might have said.

Theoretical inflationary increases were totally counterbalanced because of the following aspects:

- Labour could be easily obtained and no longer had to be bribed to work for one employer rather than another.
- With workers fearing the sack if they did not perform, productivity tended to improve.
- Under the stress of competition, materials arrived when they were supposed to, and merchants started to offer discounts instead of requiring extra payments for prompt delivery.

For these reasons, management of projects and the meeting of deadlines became easier, and it was no longer necessary to make a substantial allowance in tenders for risk.

Although the above-mentioned situation occurred on a national scale, it is important to look out for similar supply-and-demand imbalances occurring regionally or even locally. Much of the building industry consists of smaller firms operating within a limited radius, and labour is only mobile to a limited degree.

15.4 Costs and prices

There are two ways in which building costs can be estimated or analysed, based on:

- the prices charged for the finished building or parts thereof; or
- the cost of the resources required to create them.

Most of the cost planning and cost control procedures traditionally used by quantity surveyors on behalf of the client or design team have depended upon 'prices' for finished work-in-place, obtained from bills of quantities (BQs) or elsewhere, because this is what the client will actually have to pay. However, these prices may be little more than notional breakdowns of the contractor's tender offer and may have more of a marketing than a cost basis.

Practical building contractors are often scornful of this approach, and it is often suggested by people from the construction side that the cost planner should be more concerned with 'costs' (or 'real costs' as the proponents of this argument like to call them). This is an important issue and one which we are now going to look at, but it is not the simple choice between fiction and reality that is implied in this argument. In fact, any figure in this context is simultaneously both a 'price' and a 'cost'; it just depends where you are looking at it from. It can generally be said that 'the seller's price is the buyer's cost'. Thus:

- The contractor's price is the client's cost.
- The subcontractor's price is the contractor's cost.
- The materials supplier's price is the subcontractor's cost of materials.

Currently, because so much of the work on major projects is being undertaken by subcontractors on a price basis, and the independent professional quantity surveyor is increasingly involved in the management of projects, it is doubtful whether many general contractors know much more about production costs than the quantity surveyor. But in a market-based economy, the whole notion that there is such a thing as 'real costs' is a mistaken one anyhow.

For cost-planning purposes, both the finished product price approach and the resource cost approach have their strengths and weaknesses, and good cost planners should understand these and know when each should be used, rather than simply adopting the one normally used by their profession in the past.

We have already looked at finished product prices in some detail, and now we need to understand how resource costs are in fact incurred.

15.5 The contractor's own costs

Builders like to think that they know about costs, and they think of them in resource categories, which are rarely thought of separately by traditional quantity surveyors as they manipulate their all-in unit rates.

15.5.1 Contractor's direct costs

15.5.1.1 Direct site labour

These are costs relating to the tradesmen and labourers actually producing the work. At one time, these costs would have been described as 'wages', being almost entirely composed of this single item, but at present they will include substantial payments in respect of National Insurance schemes, holiday schemes, training schemes and so on.

In the strictest sense of the word, there may be almost no 'wages' paid to production employees at all, because so much of the work is done by subcontractors. In addition, because of various reasons to do with taxation, and perhaps the inherent British dislike of the master/servant relationship, the custom grew up whereby the contractor's few production workers were 'self-employed' and were taken on as 'labour-only subcontractors' for a fee. However, recent government legislation has inhibited this practice.

Labour costs are of particular concern to the contractor because they have to be paid out weekly in ready cash as they are incurred and cannot be postponed or put on a credit basis as can most other commitments – we will see later on in this chapter how important this is. It is convenient to include the 'labour-only' subcontractors under this heading, as they will also usually require weekly cash.

15.5.1.2 Materials

The amounts comprising these costs will usually be paid by means of monthly credit accounts, payment being due at the end of the month following that in which the materials are delivered (so that materials delivered in January are paid for at the end of February – rather like credit cards).

Such settlement by the contractor usually entitles the firm to a 'cash discount', 2% being the most common figure, although 5% may occasionally be allowed. It is not unusual for contractors to delay payment beyond the 'cash' settlement date, sometimes for a further month or even 2 months. Since they may lose their cash discount for the sake of 1 or 2 months' credit, this could be an expensive way of borrowing money compared to a bank overdraft, but it has the advantage of being ready and convenient and of not requiring collateral security.

Within reason, and being careful not to let things get out of hand, builders' merchants are used to acting as financiers to the industry in this way (particularly in hard times). This has advantages for the merchant. If a building firm owes a substantial amount, it is difficult for it to withdraw its custom from the supplier, or even reduce its level of buying substantially, as immediate settlement of accounts might be called for. The merchant therefore has a captive customer who cannot afford to be too fussy over prices or delivery dates.

In many cases, the contractor will have been paid by the client for the materials, or for the work in which they are incorporated, before settling with his merchants. Because of the increasing tendency to buy in fabricated components rather than making things on site, a larger proportion of expenditure now falls into this category, and a smaller proportion into labour, than was previously the case.

15.5.1.3 Small plant

This item covers hand tools and small mechanical plants of a kind that can be directly associated with specific pieces of finished work.

15.5.2 Subcontractors and major specialist suppliers

Because of the increasing tendency to employ specialist subcontractors rather than using the builder's own labour and materials, this category has expanded over the past 20 years and is now usually the largest head of expenditure. In terms of payment methods, it very much resembles the 'materials' category, but subcontractors have always tended to be less accommodating than materials suppliers with regard to extended credit.

If subcontractors and suppliers are 'nominated' or 'named' by the architect, they are in a position to complain to the architect if payment is delayed, and since such complaints cast doubts upon the builder's solvency, the builder will usually make efforts to pay them fairly promptly.

Again, the builder will often have been paid by the client for the work before settling with his subcontractors, and some large firms of builders have attempted to formalise this in the past by inserting a 'pay-when-paid' clause in their subcontracts. This practice has now been outlawed by the Housing Grants, Construction and Regeneration Act 1996, which, subject to certain exceptions, gives all the parties to a building contract the right to know the amount to be paid and the right to be paid on a determinable date.

15.5.3 Site indirect costs ('preliminaries')

The term 'preliminaries' is sometimes used to describe these items because they usually appear at the beginning of a BQ under this heading. They comprise all the items of site expenditure that cannot be attributed to individual items of work but to the project as a whole, or to substantial sections of it. Such costs may include the following:

- Salaries and wages of site staff: The salaries paid to management, supervisory and clerical staff employed on the site. In former times, these payments would have been limited to a foreman and a few junior site staff, but at present the total costs of on-site management will often be greater than those of the directly employed production workers on the site.

- Site offices, messrooms and facilities: Again, at one time these were a comparatively minor item, but at present the temporary site office buildings can form a major multi-storey complex.

15.5.4 Major plant

Large items of a mechanical plant may be dealt with in one of two ways:

- They may be charged to the job when brought on to the site and credited (less depreciation) when removed.
- Alternatively, an hourly or weekly hire charge will be made, plus a charge for bringing the plant on site and removing it.

Most large contractors find it convenient to set up a subsidiary plant company, which will charge the plant out to the sites on a hire basis, while plant hired in from outside will be similarly dealt with and paid for by credit account. Lorry (truck) transport is usually arranged in a like manner.

It is unusual for a builder to own large items of a plant except through a subsidiary company. There are substantial advantages in hire purchase through a finance company, as the interest charges (less tax) will be lower than the return which the contractor expects to make on the working capital that he employs; it would therefore be uneconomic for him to invest any of this capital in plant purchase.

It is difficult to attribute the costs of major plant items to specific pieces of direct work, and they are usually treated as a site indirect cost. However, they can sometimes be allocated to major cost centres, such as 'excavation' or 'concrete superstructure'.

15.5.5 Off-site costs (also called 'establishment charges' or 'overheads')

These represent costs incurred in running the company as a whole, and which cannot be attributed to any one particular contract – head office expenses, builder's yard, salaries of central management and directors, insurances and interest on loans.

Off-site costs are usually allocated to projects as a percentage of the direct costs. This can operate unfairly against small simple projects which require little head-office input, and some major contractors have separate 'small works' departments run on more economical lines, to avoid loading their smaller jobs with a large overhead and therefore making it difficult for them to compete with smaller firms.

15.5.6 Profit

Often referred to as 'mark up' in the industry, this is strictly speaking not a cost; it is in fact the difference between the builder's cost and the client's price.

15.6 Two typical examples

The following cost breakdowns relating to two large office buildings in the Home Counties of England in the mid-1980s, undertaken under ordinary lump sum contracts by a main contractor, may be of interest. The figures for project B overstate the proportion of the builder's direct work, since it was not possible to separate out some of the small subcontractors undertaking traditional trade work. Profit is included under the various cost heads, because it was not possible to separate them out on account of commercial secrecy.

	Project A (%)	Project B (%)
(1) Builder's direct costs	21.0	37.0
(2) Subcontractors and major specialist suppliers	70.0	49.5
Total direct costs	**91.0**	**86.5**
(3) Site indirect costs	6.5	10.0
Total site costs	**97.5**	**96.5**
(4) Off-site costs	2.5	3.5
Total costs	**100**	**100**

15.7 Cash flow and the building contractor

The pattern of cash flow on a project is vital to a contractor. As an example, a simple contract for a £410,000 building, to be erected in 30 weeks, has been chosen. The prime cost sum to the contractor is £400,000, leaving £10,000 as profit. This represents 2.5% on turnover, which is fairly usual, but the real profit percentage may be very different from this small figure which is so often quoted as an example of the poor financial returns of the building industry.

Table 15.1 shows the weekly outlay on labour, plant hire and overheads, the weekly value of material deliveries, and the subcontractors' accounts which are received monthly. The table also shows the total prime cost at the end of each month, together with the quantity surveyor's valuation.

In this particular example, it is assumed that 10% of the value of the work is withheld by the client each month as 'retention' until the total of the retention fund amounts to £25,000, after which the remaining work is paid for in full. This arrangement would be less generous to the contractor than the current requirements of the JCT Standard Form of Building Contract, and if this was being used the contractor would have rather more cash in hand than is shown in the examples.

It will be seen from **Table** 15.1 that, as usual, the project progresses slowly in the early stages (following the classical 'S' curve of expenditure plotted against time (**Figure** 15.1)), and because much of the early expenditure is in any case related to setting up rather than producing finished work, the first valuation by the quantity surveyor does not meet the full cost. However, by the time the job is halfway through, it is showing a handsome profit (perhaps the 'loading' of BQ rates for the early trades may have helped) although the finishing off, again as usual, is not very profitable.

Table 15.2 illustrates the contractor's cash flow, on the assumption that everything progresses as expected. The client settles the valuations approximately 14 days after they are issued, and the contractor pays the nominated subcontractors as soon as he receives the money. Materials are paid for at the end of the month following delivery (in practice, the subcontractors and materials suppliers would allow discounts for such prompt payment, but these have been ignored in the example for the purposes of clarity). Labour, for instance, has to be paid for weekly as the costs are incurred. At the conclusion of the project, the client pays half of the retention sum and pays the balance 6 months later.

The cash flow in **Table** 15.2 is also shown graphically in **Figure** 15.2. What is the first thing we notice about the cash flow as shown in **Table** 15.2? Although this is a £410,000 contract, and although the contractor is certainly bearing the risk (and undertaking the organisation) of a project of this size, such a figure has nothing to do with the contractor's financing of the job.

Except for 1 or 2 weeks, the contractor never has more than £25,000 'sunk' in the contract and, in fact, often has no money invested in it at all – for example, by the middle of June, the firm has received £43,000 more than it has paid out. If we, therefore, say that the firm could carry out the job on a working capital of £25,000, its £10,000 profit is not 2.5% but 40%, a very different figure!

Table 15.1 Weekly outlays for a 30-week, £410,000 building.

	Week no.	Wages, plant hire and overheads	Materials delivered	Sub-contractors accounts received	Total prime cost and overheads	QS valuation	Valuation less retention
March	1	1000	2000				
	2	1500	1000				
	3	1500	1000				
	4	2000	3000		13,000	10,000	9000
April	5	3000	10,000				
	6	3000	10,000				
	7	3000	6000				
	8	4000	6000	10,000	68,000	70,000	63,000
May	9	4000	10,000				
	10	4000	3000				
	11	5000	20,000				
	12	5000	10,000				
	13	5000	10,000	10,000	154,000	170,000	153,000
June	14	5000	17,000				
	15	6000	15,000				
	16	6000	10,000				
	17	5000	5000	10,000	233,000	250,000	225,000[a]
July	18	5000	5000				
	19	5000	10,000				
	20	4000	5000				
	21	3000	3000	30,000	303,000	325,000	300,000
August	22	3000	2000				
	23	3000					
	24	2000	5000				
	25	2000					
	26	2000	5000	30,000	357,000	375,000	350,000
September	27	4000	10,000				
	28	4000					
	29	3000					
	30	2000		20,000	400,000	410,000	385,000
	Total	106,000	184,000	110,000	400,000	410,000	385,000
						retention	25,000
							410,000

[a] Maximum retention now withheld.

In fact, the true situation is even better than this, because the contractor's average working capital (setting positive cash flows in some weeks against negative in others) is much less than £25,000, as can be seen from **Figure** 15.2. This is therefore not a £410,000 job, as far as the contractor's budgeting is concerned.

Before we become too excited at the prospect of making 100% (or more) per annum profit as a matter of course, we should look at **Table** 15.3 and the accompanying **Figure** 15.3. This represents the cash flow on the same project where the client is not being quite so helpful. The monthly payments are being delayed for a further 2 weeks, and the QS is being 'prudent' with the valuations, finally undervaluing to the extent of £10,000 (possibly because of variations that have not been agreed), although the full amount is eventually paid over.

Table 15.2 Payments and receipts in £s based on Table 15.1.

	Payments						
	Week no.	**Wages and so on**	**Materials**	**Sub-contractors**	**Total**	**Amounts received**	**Cash flow**
March	1	1000			1000		−1000
	2	1500			1500		−2500
	3	1500			1500		−4000
	4	2000			2000		−6000
April	5	3000			3000		−9000
	6	3000			3000	9000	−3000
	7	3000			3000		−6000
	8	4000	7000 (March)		11,000		−17,000
May	9	4000			4000		−21,000
	10	4000		9000	13,000	54,000	20,000
	11	5000			5000		15,000
	12	5000			5000		10,000
	13	5000	32,000 (April)		37,000		−27,000
June	14	5000			5000		−32,000
	15	6000		9000	15,000	90,000	43,000
	16	6000			6000		37,000
	17	5000	53,000 (May)		58,000		−21,000
July	18	5000			5000		−26,000
	19	5000		9000	14,000	72,000	32,000
	20	4000			4000		28,000
	21	3000	47,000 (June)		50,000		−22,000
August	22	3000			3000		−25,000
	23	3000		27,000	30,000	75,000	20,000
	24	2000			2000		18,000
	25	2000			2000		16,000
	26	2000	23,000 (July)		25,000		−9000
September	27	4000			4000		−13,000
	28	4000		27,000	31,000	50,000	6000
	29	3000			3000		3000
	30	2000	12,000 (August)		14,000		−11,000
October	32			18,000	18,000	35,000	
			Release of retention	5500	5500	12,500	13,000
	34		10,000 (Sept.)		10,000		3000
April	60		Release of retention	5500	5500	12,500	10,000
	Total	**106,000**	**184,000**	**110,000**	**400,000**	**410,000**	**(10,000)**

Table 15.3 As Table 15.2 but with late and underestimated payment in £s by client.

	Payments						
	Week No.	Wages and so on	Materials	Sub-contractors	Total	Amounts received	Cumulative cash flow
March	1	1000			1000		−1000
	2	1500			1500		−2500
	3	1500			1500		−4000
	4	2000			2000		−6000
April	5	3000			3000		−9000
	6	3000			3000		−12,000
	7	3000			3000		−15,000
	8	4000	7000 (March)		11,000	8000	−18,000
May	9	4000			4000		−22,000
	10	4000			4000		−26,000
	11	5000			5000		−31,000
	12	5000		9000	14,000	52,000	7000
	13	5000	32,000 (April)		37,000		−30,000
June	14	5000			5000		−35,000
	15	6000			6000		−41,000
	16	6000			6000		−47,000
	17	5000	53,000 (May)	9000	58,000	88,000	−26,000
July	18	5000			5000		−31,000
	19	5000			5000		−36,000
	20	4000			4000		−40,000
	21	3000	47,000 (June)	9000	50,000	70,000	−29,000
August	22	3000			3000		−32,000
	23	3000			3000		−35,000
	24	2000			2000		−37,000
	25	2000		27,000	29,000	75,000	9000
	26	2000	23,000 (July)		25,000		−16,000
September	27	4000			4000		−20,000
	28	4000			4000		−24,000
	29	3000			3000		−27,000
	30	2000	12,000 (August)	27,000	14,000	48,000	−20,000
October	34		10,000 (Sept.)	18,000	28,000	34,000	
			Release of retention	5500	5500	12,500	−7000
May	64		Release of retention	5500	5500	22,500	10,000
	Total	106,000	184,000	110,000	400,000	410,000	(10,000)

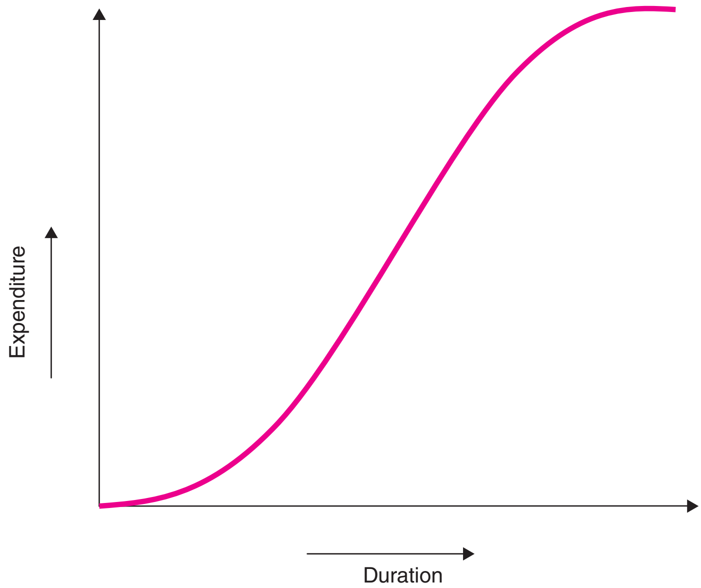


Figure 15.1 Typical project S-curve of expenditure plotted against duration.

This is still the same project with the same costs and the same profit, but as far as the contractor is concerned it is on a completely different scale. The contractor now has an almost permanently negative cash flow, often amounting to £30,000 to £40,000. This project will involve two or three times the capital commitment of the previous one, and as far as the contractor's financing is concerned it is a project of more than double the size, although the profit is still the same. On the other hand, if the contractor were to complain, the client might wonder what all the fuss was about. **As Figure** 15.4 shows, the effect of the different payment pattern on the client's cash flow is proportionately very small.

Many contractors would confirm that this kind of situation is neither unusual nor does it by any means represent the worst that may befall them as regards deferring of payments, although the Construction Act 1996 does afford them some protection.

The contracting firm's remedy has often been to defer payment in turn to its own suppliers, which in the above example could more than restore the cash flow figures to their former satisfactory state (**Table** 15.4 **and Figure** 15.5). It is possible that delaying payment in this way might cause the contractor to forfeit some of the cash discounts which the materials suppliers give. These are normally of the order of 2.5%. In the event of all the suppliers refusing to give any discount, the contractor would stand to lose a total of £4600, although in practice it would be unlikely that more than a few suppliers would do so unless the delays became very serious. However, the loss of a few cash discounts might be regarded as a small price to pay for the benefit of a cash flow so much improved that the project could run without any capital commitment at all after the first 16 weeks.

Finally, however, a dreadful warning: suppose we have an exactly similar job, where the client pays punctually and fully (as in the first example) but where the contractor has underpriced the work by 10% and is therefore not going to make a £10,000 profit but a £20,000 loss. Also, because of financial difficulties, the contractor is paying the suppliers one month late. The resultant cash flow (**Table** 15.5 **and Figure** 15.6) looks very satisfactory until the end of the project in September. It is in many ways better than that of the soundly managed contractor

Table 15.4 As Table 15.3 but with 1 month's delay in payments (£s) to materials suppliers.

	Payments						
	Week no.	Wages and so on	Materials	Sub-contractors	Total	Amounts received	Cumulative cash flow
March	1	1000			1000		−1000
	2	1500			1500		−2500
	3	1500			1500		−4000
	4	2000			2000		−6000
April	5	3000			3000		−9000
	6	3000			3000		−12,000
	7	3000			3000		−15,000
	8	4000			4000	8000	−11,000
May	9	4000			4000		−15,000
	10	4000			4000		−19,000
	11	5000			5000		−24,000
	12	5000		9000	14,000	52,000	14,000
	13	5000	7000 (March)		12,000		2000
June	14	5000			5000		−3000
	15	6000			6000		−9000
	16	6000			6000		−15,000
	17	5000	32,000 (April)	9000	46,000	88,000	27,000
July	18	5000			5000		22,000
	19	5000			5000		17,000
	20	4000			4000		13,000
	21	3000	53,000 (May)	9000	65,000	70,000	18,000
August	22	3000			3000		15,000
	23	3000			3000		12,000
	24	2000			2000		10,000
	25	2000		27,000	29,000	75,000	56,000
	26	2000	47,000 (June)		49,000		7000
September	27	4000			4000		3000
	28	4000			4000		−1000
	29	3000			3000		−4000
	30	2000	23,000 (July)	27,000	52,000	48,000	−8000
October	34		12,000 (August)	18,000	30,000	34,000	
			Release of retention	5500	5500	12,500	3000
November	38		10,000 (Sept.)		10,000		−7000
May	64		Release of retention	5500	5500	22,500	10,000
	Total	**106,000**	**184,000**	**110,000**	**400,000**	**410,000**	**(10,000)**

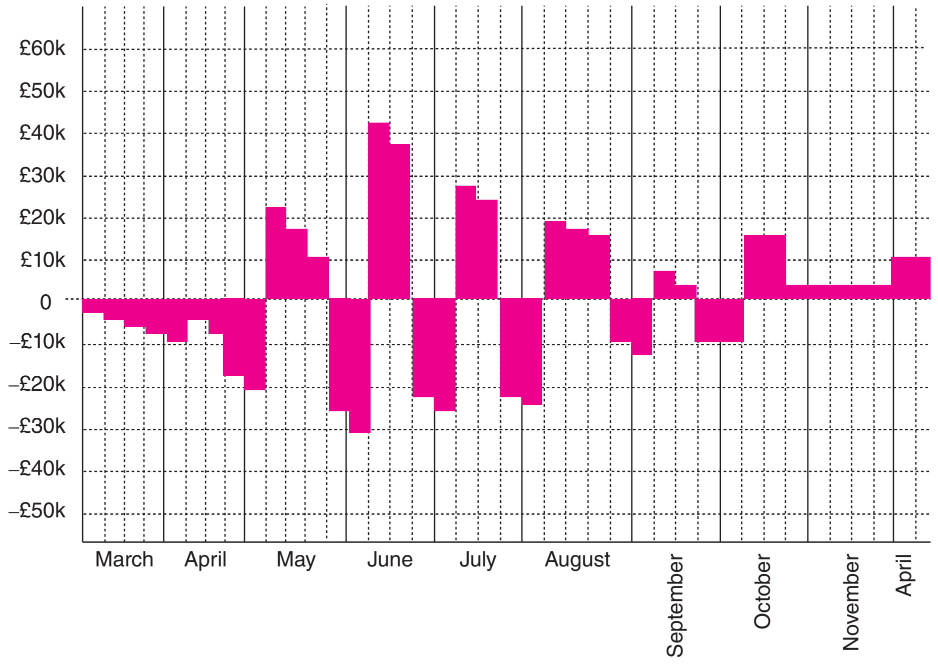


Figure 15.2 Diagram showing cumulative cash flow in Table 15.2.

in **Figures** 15.2 **and** 15.5, and requires a working capital of about £10,000 for a few weeks only. However, instead of a handsome profit, this contractor will finish by losing the whole of his working capital twice over.

If the firm has several such jobs going on concurrently, so that the negative cash flows on one coincide with the positive flows on another, it will be able to keep trading for some time before the crash comes, and meanwhile its cash flow figures may look fairly healthy.

It will be seen how difficult it is to distinguish the early symptoms of insolvency when looking at a contractor's accounts, and indeed it is quite possible that a badly managed contracting firm may not itself realise what is happening until it is too late.

When times are bad in the construction industry, it is common for contractors to submit very low tenders in order to obtain work and so keep their organisation employed, and they can then easily become short of cash. It is also not unknown for contractors who have already got into this position, either for the above-mentioned reason or through bad management, to continue to quote absurdly low prices. This is because they urgently need the cash flow from new work in order to pay their past debts.

If the contracting firm in the given example is receiving payments on another job, by September it will be able to pay its suppliers and keep going (although the new job in turn will be getting into even worse difficulties in due course and will need an even more drastic dose of the same medicine).

Quantity surveyors do well to be suspicious of a building company which is expanding its operations rapidly at prices its competitors cannot match. However, we can see from the earlier examples that even a soundly managed contracting firm will find it tempting to get deeply into debt at the bank if it is able to get returns of more than 50% on money which it is borrowing at less than 15%.

Table 15.5 As Table 15.4 but builders work underestimated by 10%, and 1 month's delay in payments to materials suppliers (£s).

	Payments						
	Week no.	Wages and so on	Materials	Sub-contractors	Total	Amounts received	Cumulative cash flow
March	1	1000			1000		–1000
	2	1500			1500		–2500
	3	1500			1500		–4000
	4	2000			2000		–6000
April	5	3000			3000		–9000
	6	3000			3000	8100	–3900
	7	3000			3000		–6900
	8	4000			4000		–10,900
May	9	4000			4000		–14,900
	10	4000		9000	13,000	49,500	21,600
	11	5000			5000		16,600
	12	5000			5000		11,600
	13	5000	7000 (March)		12,000		–400
June	14	5000			5000		–5400
	15	6000		9000	15,000	81,900	61,500
	16	6000			6000		55,500
	17	5000	32,000 (April)		37,000		18,500
July	18	5000			5000		13,500
	19	5000		9000	14,000	65,700	65,200
	20	4000			4000		61,200
	21	3000	53,000 (May)		56,000		5200
August	22	3000			3000		2200
	23	3000		27,000	3000	70,500	42,700
	24	2000			2000		40,700
	25	2000			2000		38,700
	26	2000	47,000 (June)		49,000		–10,300
September	27	4000			4000		14,300
	28	4000		27,000	31,000	48,000	2700
	29	3000			3000		–300
	30	2000	23,000 (July)		25,000		–25,300
October	32			18,000	18,000	33,500	
			Release of retention				–3900
	34		12,000 (August)		12,000		–15,900
Nov	38		10,000 (Sept.)		10,000		–25,900
April	60		Release of retention	5500	5500	11,400	–20,000
	Total	**106,000**	**184,000**	**110,000**	**400,000**	**380,000**	**–20,000**

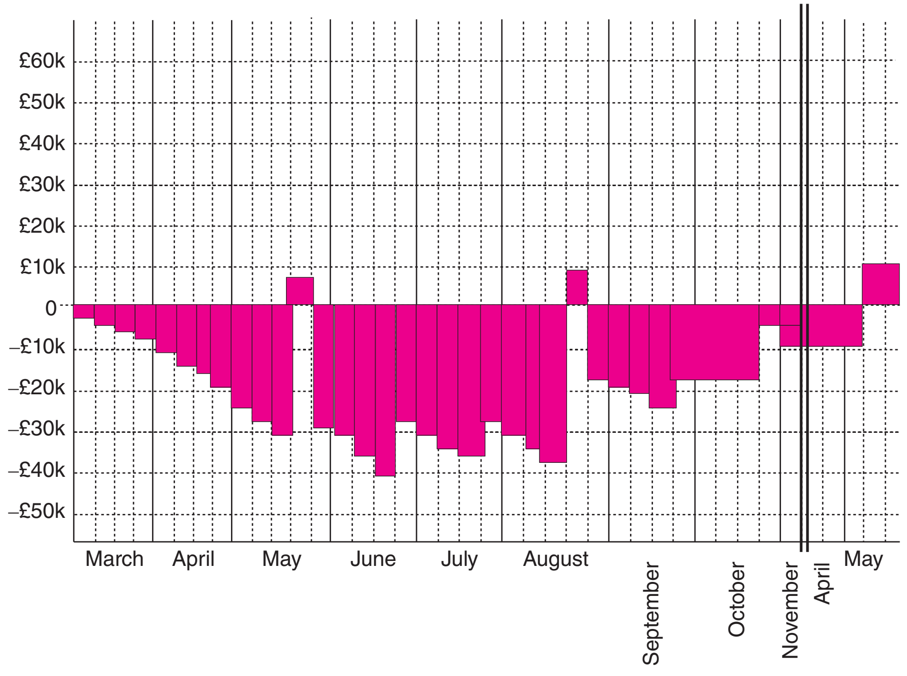


Figure 15.3 Diagram showing cumulative cash flow in Table 15.3.

So, cash flow assessment of accounts must be used carefully; but these examples do demonstrate that quite small percentage differences in estimating can have a dramatic effect on profitability. This is in fact the principal weakness of the construction industry, that the difference between a substantial profit on capital and a substantial loss can lie inside the normal margin of error in estimating.

A greater capital investment in a project on the part of contractors might lead to greater stability, as the required profit on turnover would then have to be much higher than 1% or 2%. If the contractor had to make 10% profit on turnover to get a reasonable return on capital, then estimating errors of 2% or so would have a proportionately smaller effect on the firm's overall profit percentage and would not make the difference between 'boom or bust'. Moves to reduce 'retentions' in recent times have had exactly the opposite effect. However, retention bonds are now coming into vogue.

15.8 Allocation of resource costs to building work

The contractor would appear to be in a much better position than the consulting quantity surveyor as far as knowledge of actual building costs is concerned, but this is not necessarily the case. Keeping an accurate record of costs in the four categories:

- builder's direct costs (site labour, materials, small plant),
- subcontractors and major specialist suppliers,
- site indirect costs and
- major plant

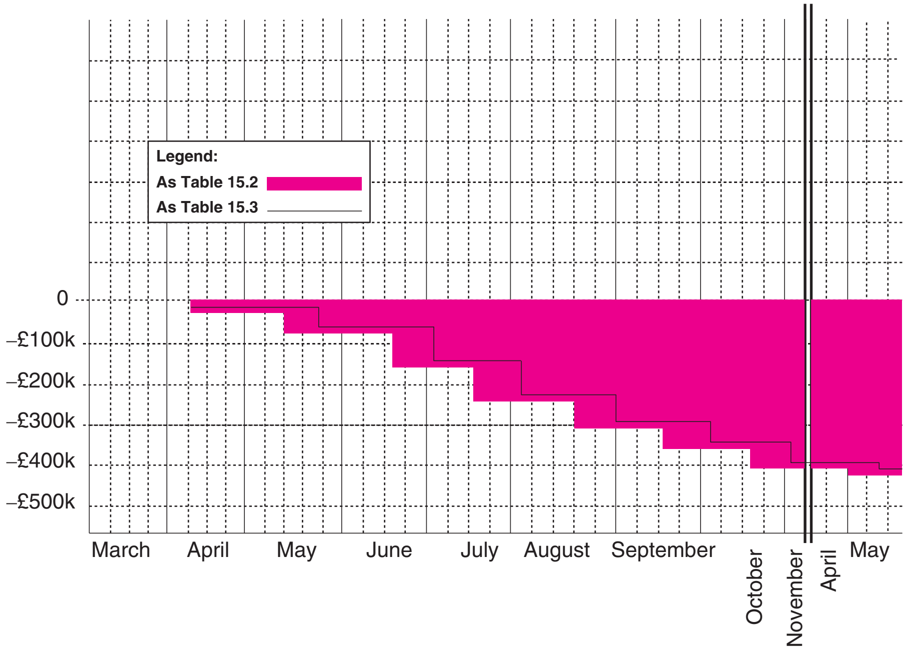


Figure 15.4 Diagram showing the clients cash flow as Tables 15.2 and 15.3.

is not very difficult, but translating them into usable data for cost planning future projects is another matter.

The contractor would in fact be ill-advised to use the actual costs from a particular project for cost planning a quite different one. There are two reasons for this. First, many of the factors which affect site costs on an individual project have nothing to do with the design of the building and will not repeat from job to job. These include

- weather;
- supervision;
- industrial and personal relations;
- obstruction by other trades;
- the skill with which the work is planned and organised;
- alternatively, lack of clear instruction;
- waiting for delivery of materials;
- accidents;
- replacement of defective work;
- failure by subcontractors;
- psychological pressures.

Secondly, in practice, costs are rarely kept in any greater detail than the 'activity' or 'operation'. An operation has been described by the Building Research Establishment as 'a piece of work which can be completed by one man, or a gang of men, without interruption by others', such as the whole of the brickwork to one floor level, or the whole of the first fixings of joinery. Unfortunately, each operation is unique to the project, and the cost information cannot be re-used in this form.

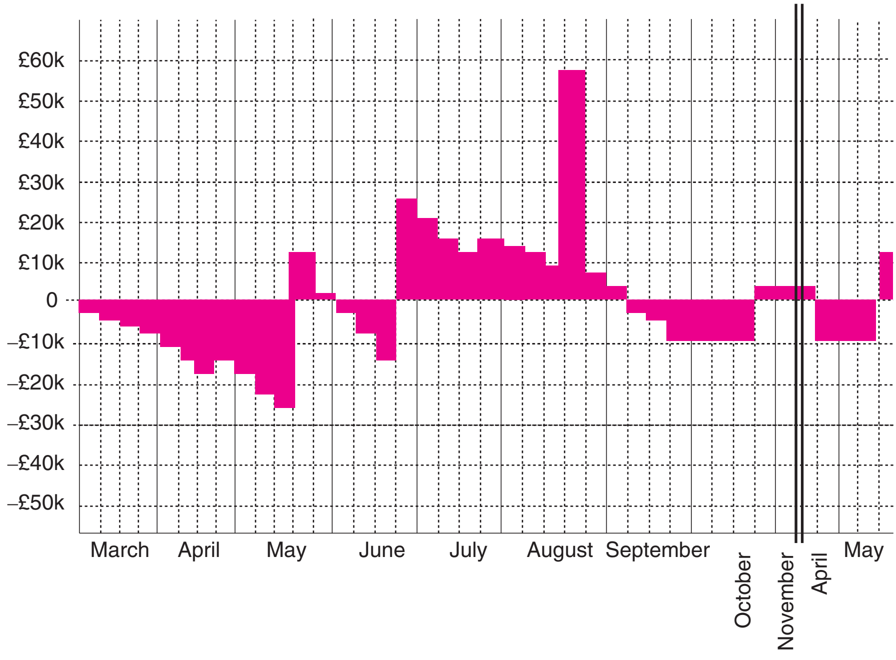


Figure 15.5 Diagram showing cumulative cash flow in Table 15.4.

15.9 System building, modular assembly, prefabrication and cost

No discussion of building costs would be complete without considering the effect of **modular assembly, systems building** and **prefabrication** on costs. The history of systems building in the United Kingdom witnessed accelerated development during the 1950–1960s, although it is argued that this had as much to do with politics as with architecture – this building form provided a rapid response to the social housing needs in the United Kingdom at that time. It has been argued that this led to the construction of buildings that were not only poor in architectural terms but also significantly underachieved in terms of performance and client/end user satisfaction. Examples such as Ronan Point (the reports on which could be described as the antithesis of systems building) contributed in part to the current stigma attached to prefabrication of buildings in the United Kingdom. This resulted in an industry that was dominated by traditional forms of construction, particularly during the period 1970 to mid-1980.

The past 15 years have, however, been characterised by the renaissance of systems building. The Rethinking Construction report could be identified as one of the prime movers, introducing the building as a product, which could be manufactured more efficiently and to a higher standard away from the site itself. Furthermore, newer forms of procurement strategy such as private finance initiative (PFI)/public private partnership (PPP) have also featured in this re-emergence. This 'sea change' is perhaps all the more remarkable in an industry that is renowned for its insistence on resisting the incorporation of benefits found by other industries; automotive and aviation being just two examples.

Off-site manufacturing techniques have progressively developed within UK construction since a renewed interest in the 1990s, borne from the demands for a more sustainable industry and changes to traditional procurement practices in the public sector. Prefabrication and standardisation have, to some extent, been tainted by the stigma created by the 'nightmare'

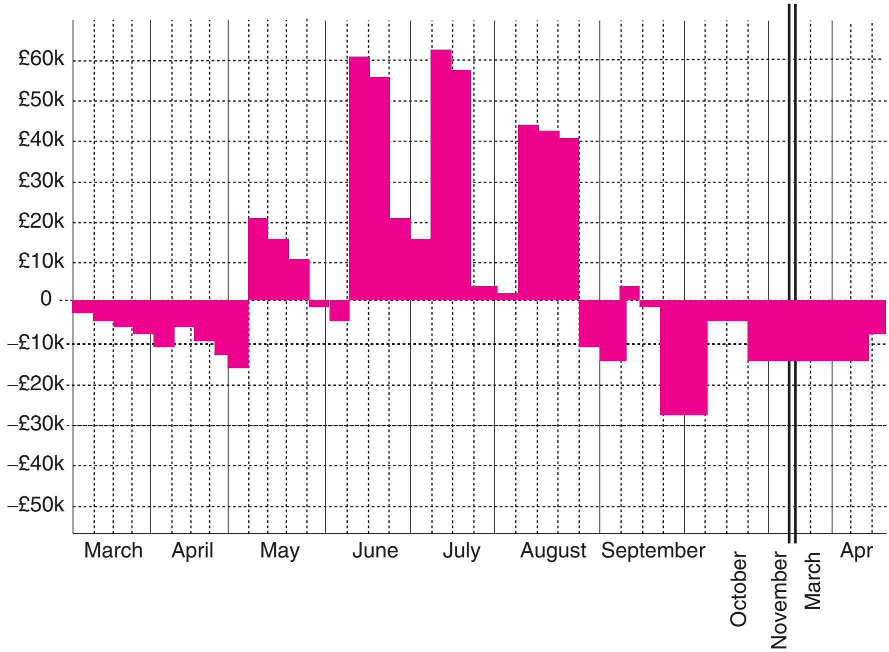


Figure 15.6 Diagram showing cumulative cash flow in Table 15.5.

designs of the 1950s and 1960s. From the accelerated development during this period, the construction technique was all but abandoned in the United Kingdom – yet comparatively thrived in Europe and the United States. The United Kingdom's insistence on traditional construction methods and the characteristics of the property market made it difficult for the development of off-site manufacturing techniques to be presented as a credible alternative to conventional 'bricks and mortar' construction. The advancements in technological and manufacturing capabilities, mainly in the automotive and aviation industries, have been applied to the fabrication of specific user packages, mainly dedicated to public welfare and educational facilities. Choice and individuality are not compromised by the standardisation needed to exploit the advantages of a dedicated production process. New materials have further advanced the viability and application of this building type, with the manufacturers taking note of the past mistakes regarding inadequate design and specification.

15.9.1 Some background to prefabrication and modular assembly

The history of prefabrication and standardisation of buildings can be traced back to the Roman occupation of the British Isles (Gibb 1999). The advantages of prefabrication were embraced in times of increased demand and immediate need. Yet, off-site manufacture has had a rough ride. After the formation of local authority housing in the 1890s and most subsequent to 1919, consecutive governments pressed for or insisted upon standard designs and persuaded local authorities to experiment with new construction methods. But the systems that were developed fell short of expectation and none produced the anticipated savings in the vital factors of labour, money and improvement. This instigated a return to traditional practices (Morton 2002). Across the Atlantic, the production of prefabricated dwelling comparatively thrived; but it was not until 1945 when the first shipment of 30,000 temporary prefabricated houses were imported from the United States. These homes were well accepted and a subsequent housing drive of the early 1950s led to the government issuing substantial advice and directions to local governments on efficient house construction techniques (Morton 2002). This is further evidence that the United Kingdom accepted prefabrication as a stopgap solution to immediate problems.

The United Kingdom indulged in a radical overhaul of the way it built through experimentation in industrialised building techniques. Through the early 1960s, the designs became high-rise and some gave adequate accommodation; unfortunately, many were found to be more expensive than conventional dwellings, with faults embedded in the design and the utilised materials, therefore making them unpleasant to live in (Morton 2002).

The well-documented disaster of 1968, which is cast as the critical event and is generally claimed to have sealed the fate of the industrialised housing programme was the partial collapse of Ronan Point in the London borough of Newham after a gas explosion. This accelerated not only the decreasing use of prefabrication but also the rejection of high-rise living in the United Kingdom (Morton 2002). The revival of systems building, as identified by Gibb (1999), to some extent came through the changes in the National Health Service (NHS) and government reformation of public infrastructure financing through PFI schemes. This led to revived interest in cost-effective design and construction techniques. Also contributing to this was the need for a more sustainable built environment and one that was more accommodating to change. The beginning of this century has seen the continued growth of off-site manufacture, where applicable and beneficial. This is a contributing factor to the degradation of the stigma that has flowed through the veins of the industry and its clients throughout the twentieth century.

15.9.2 Applications and suitability for prefabrication and modular assembly

The CIRIA (1999) report 176 identifies typical applications of modular building, these being hotels/motels, offices, retail outlets, prisons and residential schemes. Many construction product developers have not sought to position themselves as niche 'operators' within the modular assembly market, two examples of these in the United Kingdom being Kingspan and Yorkon. Kingspan off-site, for example, together with HLM Architects and Cyril Sweett, have developed a range of example designs, which comply with NHS Estates and CABE guidelines for District General & Community hospitals, primary care centres and general practices. The options given by manufacturers for the designs of modular buildings have been seen in the past as a limiting factor of systems building. Due to the building not being specified as a generic building type, it allows the manufacturer to offer several options that fall in the boundaries of the function. The options are centred on the main elements of the building, including the services and the fabric, thus making it more applicable nationally in terms that it can fit into the majority of areas with aesthetic differences. Modular assembly forms have also offered learning and student accommodation packages that work on the same theme of function-centred design, which is tailored to the clients' needs through the options list. This is a considerable improvement on the buildings offered through the twentieth century.

15.9.3 Labour and skills availability in the industry

Concerns about the shortage of skilled operatives and the inadequacy of training have recurred throughout the past century (Morton 2002). This is an ever-present problem identified by both Latham (1994) and Egan (1998). A product of this shortage has been the development of new technologies as seen with prefabricated timber-framed housing. A recent article in Construction News (2004) pointed out timber-framed housing manufacturer

Pace and architects Cartwright Pickard joined forces to develop an off-site building system for the house builder (Construction News 2004).

The article identifies that one of the key drivers behind the development is the innovative response of the construction method to the housing and skills shortage. Reaction to the skills shortage is raising issues, one quote in particular emphasises this point " … the contractor trying to de-skill the site-process, reducing the number of labour intensive jobs on site … " (Thompson 2000). The general consensus is that the Egan report is the sole factor for the resurgence in off-site construction, but as the following quote shows the nature of the industry as reactive innovator is still apparent. 'Sir John Egan may have spawned innovation across huge swathes of the industry but necessity is still the mother of invention' (Thompson 2000).

15.9.4 Improvement in health and safety

The main effect on health and safety is the level of control gained by taking construction from the site to the factory. CIRIA (1999) insists that pre-assembly can improve health and safety through moving work to a factory environment where health and safety measures can be implemented more effectively. This was highlighted in a report which stated that 'Champions of prefab stuck to their faith in the undeniable truth that there is much work on a building site that would be more efficiently and safely done in a factory' (Construction News 1993).

Whilst pre-assembly means that larger items are being handled, this does not increase the safety risk. This is because the unit installation on-site has to be planned in advance, providing the opportunity to plan for safer installation (CIRIA 1999). This is best shown by an example of the Quantum CF project previously detailed – this was a prefabricated sports hall erected on to an existing structure. A team of five workers, three contractors, a crane operator and a lorry driver did the majority of the erection and installation work. With a few bolts to connect, 'the erectors carry out the work very quickly from the safety of a mobile access platform due to the building being on an existing structure' (Taylor 2004). This would have posed a higher safety risk if the building was constructed through traditional methods of brick and block wall construction. It is uneconomical to build brick walls in a cherry picker.

15.9.5 Whole life-cycle costs and the environment

Use of pre-assembly reduces the environmental impact from site processes, because on-site work is lessened and there is more control of the process (CIRIA 1999). This quote in terms of the procurement process is valid. Construction activity is placing a significant strain on natural building materials like stone; Figure 15.7 highlights the waste produced by European construction industries. The following chart highlights the waste produced by the construction industries of Europe. What has to be noted is the comparison of manufacturing to the building industry, which highlights a vast difference in waste output. This is something the industry needs to work on to sustain the environment, and the government is pressing for this through taxation changes and guides to sustainability. There are fewer components to be brought to site than with traditional building construction, thereby saving in deliveries to site – it radically changes transportation and handling logistics.

Generally, larger units will be installed, usually requiring mechanical lifting. However, far from these being seen as disadvantages, they tend to result in an increase in on-site productivity by removing the ad hoc approach towards materials delivery and movement that is commonplace in many traditional construction projects (CIRIA 1999).

As with any building, maintenance or changes by the user will have to take place. During the life cycle of a system-built project, maintenance interventions to a traditionally built structure, fabric or services may be more intrusive and extensive in getting to the problem than with system buildings designed to accommodate maintenance. For example, modular plant rooms

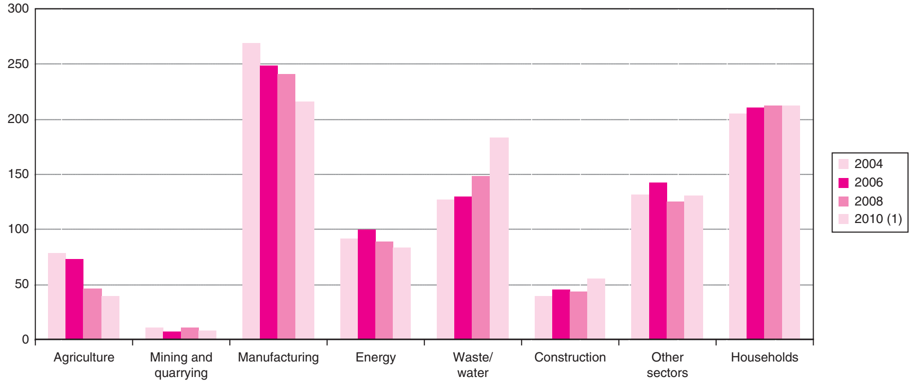


Figure 15.7 Waste generation, excluding major mineral wastes, EU-27, 2004–10 (1).

located on the roof of a building could be removed and replaced in one operation over a weekend shutdown (CIRIA 1999).

In the housing boom of the 1960s, the industry had a concentrated demand to which the industry served the state as a client. Yet, the demand in the private sector was, and still is, variable and unfocused (Bosch and Philips 2003). Since the privatisation programme of the 1970s and 1980s, construction work has focused on private clients; a plethora of demand now exists from small maintenance tasks to large infrastructure programmes (Bosch and Philips 2003). In recent times, the industry has benefited from sustained growth following the recessional period of the early part of the past decade. **Figure** 15.8 highlights this, taking into account the collective distribution of work across the industry.

With the healthy development of the economy and the shift to flexible outsourcing, the industry has seen fragmentation and inefficient coordination of resources and control of production. The result was an increase in constraints on enhancing productivity or adoption of new technologies owing to the lack of investment in development, cost and the use of legislation to control the industry (Bosch and Philips 2003). The industry's demand has a cyclical fluctuation with concentrated growth in domestic and non-domestic areas. The industry is witnessing a growth in the deficit of skilled labour and growing material costs. This presents a problem for the industry in the form of creating new methods of construction, which do not rely upon natural materials with high production cost and the need for skilled labour in their application (Hillebrandt 2000).

15.9.6 Client benefits

'If you are going to build these things before you get to site, you've got to be sure that the client isn't going to change its mind' (Taylor 2004). This quote is written in the context that the clients' position has to change with prefabrication as the design must be finalised prior to the start of the fabrication of the building. This differs from the traditional method of construction as the building and design can be altered during the procurement period (although this does, of course, present problems anyway). But with the design stage traditionally rushed to get the work started on-site, there is more room for conflict.

> 'Litigation, another hidden cost in construction, can be reduced by greater prefabrication' claims Mr. Neale, a senior lecturer at Loughborough. 'It would certainly reduce on-site conflict and it is more likely that whatever is prefabricated would be done on time' (Construction News 1993).

This approach could be applied to the alterations and instructions by clients through architects and the work of agreeing on fees would ultimately be borne by the client in cost and time. With off-site construction 'once you start changing things on site you lose the whole benefit of off-site manufacture' (Taylor 2004). This is true and does pose a considerable disadvantage to the client, but with pre-assembly projects the aim is to get it right first time by taking more care and paying more attention to the client's brief. Therefore, the main reasons for using standardisation or pre-assembly on a project is that they can significantly improve predictability and efficiency in various ways, because they build on the combined knowledge and experience of the participants (CIRIA 1999).

15.9.6.1 Procurement strategies

The use of alternative approaches to the traditional style procurement of buildings has been prevalent in systems-building-led projects. One common example is design and build, this

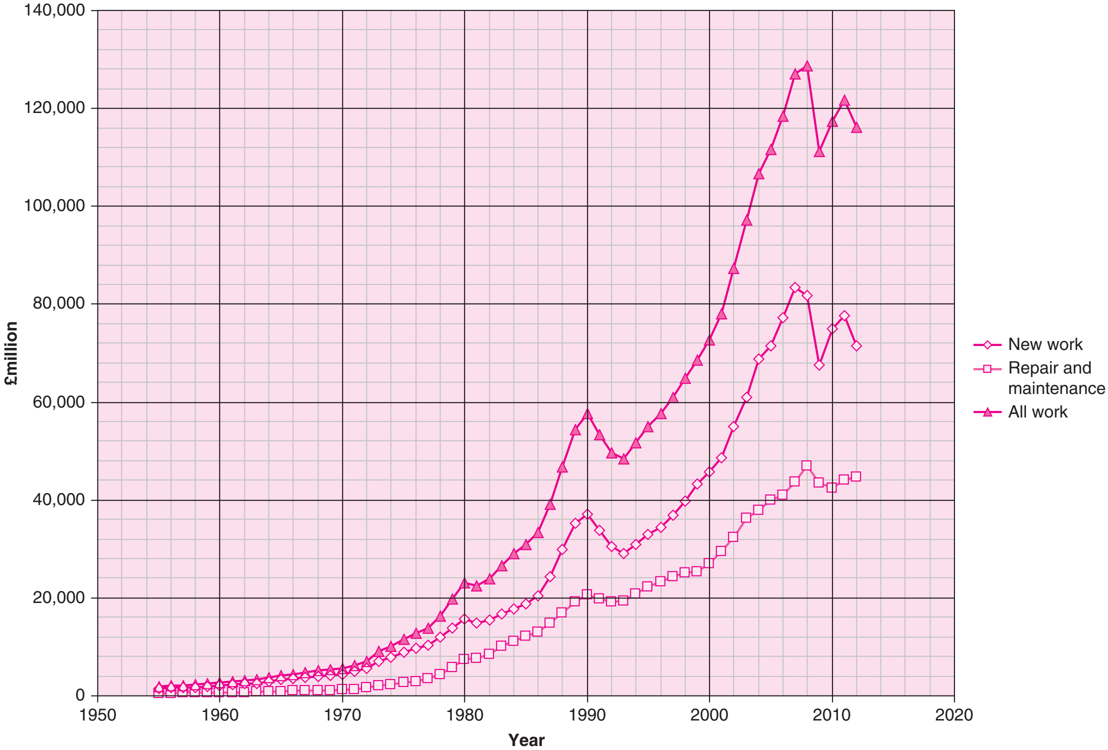


Figure 15.8 Value of construction output in Great Britain: current prices, non seasonally adjusted – by sector (*Source*: Office for National Statistics).

procurement route allows a building or engineering contractor full control of the design and construction process (Mosey 1998). It has been present in many industries for a considerable length of time. Hughes and Murdoch (2000) observed that 'when somebody buys something, the usual process seems to be to buy a product that has been designed by its producer'. This was the practice within the construction industry until the emergence of architecture as a profession distinct from construction, which led to the emergence of general contracting (Murdoch and Hughes 2000). Mosey (1998) argues that for the construction client who is not itself a professional in the design and construction business, there is great comfort in knowing that the person to whom you are talking is the person who is responsible for making your project a reality. This of course means that the contractor has overall responsibility in terms of project cost, as the risk of the cost exceeding the price falls entirely on the contractor's shoulders. This is also true for time control in meeting the project programme (Murdoch and Hughes 2000). With this procurement option having an uneven distribution of risk, more importantly drawing the risk away from the client, the price of the contract can be affected.

Single-point responsibility and fixed price contracts mean that the contractor carries more of the risk than a general contractor, and, thus, risk attracts inflated costs (Murdoch and Hughes 2000). Offsetting this, the ability to allow the contractor and the client to share savings is an important facet of the contract. This creates an incentive to the contractor as any savings made by completing the project below the price may sometimes be shared between the client and the contractor (Murdoch and Hughes 2000). An advantage in terms of time for the project inception as a whole is the allowance for the contractor to start early. As the contractor is carrying out the design work, there are opportunities to overlap the design and construction processes and thus to make an early start on-site. The reason for this is that the design does not have to be fully complete, as with traditional procurement; therefore, the contractor can begin work on-site if the foundation design is complete and even if the superstructure design has not been finalised (Murdoch and Hughes 2000). As discussed previously, design and build has been used by many industries including manufacturing. A system building is a product and the parallels between industries (manufacturing and construction) have led to the use of design and build on many off-site manufacture-building projects.

15.9.6.2 Cost planning issues and the economics of modular assembly

It is difficult to obtain competitive tenders for this sort of work because, if prices are given by two or more firms, each firm will quote for its own patent system and it will be almost impossible to compare the value of the tenders without a considerable amount of work. In these circumstances, cost comparisons based on cost modelling techniques of the type described in this book may provide a truer picture than an attempt to check detailed quantities and prices, even where these are provided.

However, in its more highly developed forms, system building may involve the delivery of the whole building in the form of a kit of parts ready to fit together in a few days (in the case of a house) or in a few weeks in the case of a larger building such as a Travelodge Hotel.

The economics of this practice are not easy to evaluate, partly because of the advertising and hard selling which often go with it, and partly because the economics are in fact much more complicated than the more usual site building costs.

The cost advantages the prefabricating firm possesses are, at first sight, considerable.

- It has the benefit of planned mass production under factory conditions, safe from the weather hold-ups that affect site output and free from the difficulties of supervision and quality control which occur when operatives are working all over a scattered site.

- It can employ expensive but money-saving plants which would be too cumbersome, valuable or delicate for site use, and which in any case could not find full employment for its output on a single site.
- It can take advantage of modern methods of handling and transportation to bring its large fabricated units direct from the factory to the position on-site where they are required.
- In fact, we might tend to accept the view that the lack of development of factory-based building techniques simply shows that the construction industry is hopelessly old-fashioned.

However, there are sound reasons why prefabrication/modular assembly has, historically, had a much smaller impact upon the industry than was at one time expected. One reason was the popular dislike of an environment composed of factory-produced buildings, although this might have been easier to overcome if there really had been a strong economic justification for them. In fact, the economic gains have usually proved to be disappointing. What are the reasons for this? In the traditional site production methods of building:

- The site builder has none of the heavy overheads of factory production (the firm will not have to pay rent for its site workshops and will probably not even have to pay rates).
- Many of the cheap techniques (such as bricks-and-mortar) which the site builder uses are not suitable for off-site production.
- The crude handling methods which can be used with the small and rough components used for site assembly are cheaper than the tackle required for the careful handling of large units.
- The site builder is able to provide a 'made-to-measure' building instead of one 'off-the-peg'.

There are other economic problems that have emerged with experience of prefabrication including:

- A broken brick is simply a broken brick and there are plenty of unbroken ones to use, but if the corner of some special component is damaged another one will have to be ordered.
- The cost of replacement is the least part of the difficulty; the disruption to programme caused by the resultant delay can be far more serious.
- On low-rise projects such as housing, factories, health buildings, etc., the site preparation, levelling, foundations, drainage and site services, roads, paths, car parks, fencing, landscaping and so on, involve so much work on-site and site organisation that the prefabrication of the basic superstructure is only dealing with part of the problem and not always the most significant part. This particularly applies if the finishing and services are not even included in the package.
- This problem is tending to increase rather than decline in importance, because today there are very few projects where the site is a level open field on which a factory-produced building can easily be placed – in fact, the arrangement of the building or buildings is more usually dictated by the shape and configuration of the site.
- The building of the various in situ connections between standard units (especially if these are at different levels on an undulating site), or the work necessary to accommodate them to irregular site boundaries, is piecemeal work which is difficult to organise efficiently, and it can more than swallow any cost savings generated by factory production of the main units. In such circumstances, it might well have been better to build an in situ building designed from the start to fit its location.

15.9.7 Summing-up

The construction industry is exceptionally flexible in dealing with local and national economic variations, but it adjusts its prices accordingly. Contractors' costs and prices therefore do not move in step with each other, except in very settled times – and it is the contractor's price that is the client's cost.

Contractors' costs comprise

- direct costs (labour and materials);
- subcontractors and major specialist suppliers;
- site indirect costs ('preliminaries');
- major plant;
- off-site costs ('establishment charges' or 'overheads').

The building industry works on a very small capital commitment compared to its turnover, and its cash flow pattern is therefore vitally important. Prefabrication of complete buildings (except single-storey warehouses, sheds and the like) has not so far proved to be of economic benefit.

Further reading

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Chapter 16

Resource-Based Cost Models

16.1 Effect of job organisation on costs

Many major costs on building projects are not directly related to the quantity of work produced but are concerned with time and with occurrences (or non-occurrences) of various kinds. The main quantity-related cost is materials, so that given prudent procurement and effective control of waste, there should be little variation in the cost of this part of the work whichever contractor is appointed and however the work is organised and executed.

The real scope of gain (or loss) lies in the non-quantity-related items, and these depend on the way the job is organised and managed. This is where the competition between contractors takes place, especially today when, as we have seen, the contractor's main 'stock-in-trade' is management skill.

16.2 A well-managed construction project

A well-managed project is one where both plant and workers have clear uninterrupted flows of work. Money is not spent on removing or returning workers or plant from the site, or on unproductive time waiting on site because of gaps in the work flow, or on moving workers or plant unnecessarily around the site. Materials are channelled to the spot where they are needed at the right time, and with a minimum of double handling.

It is not merely a question of the actual time spent hanging around – people work much more productively when they can see a clear task in front of them and where they feel they are participating in an efficient operation. It is a constant complaint by contractors that they are usually unable to recover the cost of disruption of this state of affairs when delays or interruptions are caused by the client or the design team.

16.3 Traditional versus resource-based methods of cost planning

Recognising the increasing importance of these management-based costs gives scope for comparing the cost planner's traditional price-oriented approach unfavourably with a resource-based method, which can take account of method and work-flow. But the traditionalist's reply must be that conventional estimates are based on successful past tenders, and that few successful tenderers will have worked out their prices on the basis that the job will be badly run, whatever may have happened afterwards! In fact, it might be claimed that the traditional price-based method automatically allows for good management without ever having to bother about the details of its implementation, and this facility is especially valuable in the early stages of estimating before the project has been fully designed.

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

16.4 Value added tax (VAT)

Value added tax is currently payable on building work other than housing, and also on architects', quantity surveyors', engineers', planning supervisors' and other professional fees. The rate set by HM Revenue & Customs (HMRC) at the time of writing is 20%.

It is customary to exclude this amount from estimates and tenders. This practice is well understood within the construction industry, and has been followed in this book. But this must be clearly pointed out in any figures given to clients, who may otherwise think that the estimate represents their total liability.

16.5 Resource-based cost models

The **real costs** are the detailed cost models which we have examined so far have been largely based on the measurement of finished work in place, and its valuation from bills of quantities (BQs) or other market-price-orientated data. Quite apart from the general fallibility of BQ rates, these models have embodied two major fallacies:

- that the production cost of a building element is proportional to its finished quantity;
- that the cost of a building element has an independent existence, which can be considered separately from the rest of the building.

We have been aware of these drawbacks almost from the start and are able to come to terms with them through the exercise of professional skill. However, it is worthwhile considering whether it would not be better to base our estimates and cost control procedures on production cost criteria, as is done in most (perhaps all) other industries.

One major reason why we do not normally adopt this approach has already been given, which is that under **lump sum contracting arrangements** it is the **market price**, rather than production costs, which concerns clients and their consultants. This reason, however, is not valid if we are considering a **cost-reimbursement** or **management** type of contract, or if we are looking at a situation where cost planning is being executed within a design-and-build organisation.

There is, however, another and quite different criticism of resource-based cost planning. As discussed, a great deal of the resources of modern building are attributable to plant and organisational costs. Both the initial estimating and the subsequent refining of the estimate therefore require the envisaging of technological solutions. Whether the building is masonry steel-framed, pre-cast concrete frame and panel or in situ concrete will demand entirely different approaches with probably significant cost differences for any particular configuration and set of user requirements.

This last paragraph in fact may sound like an argument in favour of a resource basis rather than a criticism, but the principal disadvantage is that it moves the design considerations of a building into the production field much too early in the process.

An economical structural system may be postulated by the resource-based cost planner and the configuration of the building developed, for example, to suit the radius of action of the tower crane (or cranes) placed in the most efficient positions, or to suit the repetition of pre-cast units.

The architect's traditional approach, as we have already discussed, is at direct variance; the form of the building is evolved primarily as a set of user-oriented spaces, and the best technological solution for that configuration is then investigated.

Quite clearly, in both cases, some compromises may have to be reached, but the basic issue is whether the

- user needs and environmental considerations come first and construction methodology follows, or
- production efficiency should be the consideration from which design develops.

There are too many existing buildings which remind us that construction optimisation lasts for months but the consequences last for years (although not always as many years as the designers intended). Unfortunately, production managers are no less indolent than the rest of us and prefer to postulate easy solutions rather than applying themselves to devising an efficient way of building a user-oriented design.

It ought to be possible to take the latter approach, provided the details of construction have not been developed too far before the building contractor is called upon. Nonetheless, while it is true that the quantity surveyor's traditional elemental cost planning approach enables the early design process to proceed with some semblance of cost control prior to construction decisions, such decisions do have to be addressed sooner or later.

Once this point is reached, a resource-oriented approach has much to recommend it in cases other than the competitive price-in-advance situation, particularly where the contractor who will be undertaking the work is a party to the cost planning exercise. If this is not the case, then the method is of doubtful advantage; there are many different ways of organising a construction site and each contractor has preferred methods and equipment, so that there is unlikely to be an optimum solution that any builder would automatically accept.

Much of the advantage of a resource-based estimate is that it can be used for production–cost control purposes, and this benefit will be lost if the estimate has been prepared by someone else and the chosen contractor throws it out of the window. A resource-based estimate will deal quite separately with the different cost components of

- labour,
- plant,
- materials and
- sub-contractors

rather than amalgamating them into a series of 'all-in' rates as is the quantity surveyor's custom. However, having said this, a very substantial part of the total cost will comprise sub-contractors' work.

Much of the resource-based estimate will therefore have to be based on the specialists' all-in prices in exactly the same way as a product-based estimate. So the claim by the builder's estimator to know more about the so-called real cost of building than the independent professional cost planner becomes somewhat questionable. The resource-based estimator's immediate concern will therefore be with that part of the work which is usually undertaken with the contractor's own resources, normally the structure of the building including excavation.

The resource-based estimator's real expertise (and the area where the product-oriented estimator is weak) is in determining and pricing the site organisation and the project duration, including the management of all the specialists' programmes and the integration of their work with the building structure and with each others' efforts.

In a design-and-build, contracting or construction management organisation, the estimator will almost certainly have the assistance of a planning engineer or project manager in this work. They may look at alternative configurations for the proposed building, as well as alternative means of obtaining the same configuration.

As far as estimating the cost of the contractor's own work is concerned, the materials present few problems, because, unlike labour and plant, their cost is reasonably related to the quantities of the finished work. Anybody preparing a resource-based estimate will, therefore, have to start off by measuring (or assuming) quantities of finished work in order to determine material requirements and also as a first step in looking at the scale of the project and the distribution and interrelation of its parts. The person doing this will tend to work in bulk quantities (e.g. cubic metres of concrete) split into categories and locations which seem to be organisationally significant.

Before proceeding much further, however, an outline programme for the works will need to be prepared.

16.6 Resource programming techniques

The estimator, in respect of each different estimate, will need to decide the principal operations to be undertaken and their methodology and duration. The operations cannot be considered in isolation as they will be interrelated by two factors:

- **The need to utilise labour and plant effectively**, so that operatives and machines are not unproductive (downtime) for long periods between operations, are not required to be working in two different places at once and do not spend too much time relocating from one part of the site to another.
- **The inescapable sequence of building**, so that, for example, the walls and columns cannot be constructed until the foundations are completed, and the first floor cannot be placed until the ground floor walls and columns have been built and so on.

There are various techniques in common use to assist the estimator in this task, which tend to rely, in the first instance, upon graphic methods. We shall explore some key techniques briefly here but a useful reference for more detailed coverage of this is Cooke and Williams (2004).

16.7 The Gantt chart

This is perhaps recognised as the most traditional of methods in programming and is often referred to as a bar chart (this is technically incorrect, however). The chart takes its name from Henry Gantt (1861–1919) who developed the technique in 1910.[1]

The widespread use of software applications such as MS Project has facilitated the creation of sophisticated Gantt charts, which previously were often time consuming and expensive to produce. These applications were primarily geared towards the project management market but today, the creation of these charts is often performed by a subordinate to the PM such as a scheduler or programmer.

On a Gantt chart, a horizontal chronological scale is used; this is ordinarily divided into days, weeks or months depending on the time horizon and the various operations comprising the project are listed vertically down the left-hand side. The timing and duration of each operation is then indicated by a horizontal bar spanning the relevant period of days/weeks and shown on the same line as the operation it refers to. An example is shown in **Figure 16.1**; this is a simplified example showing the construction of a new workshop. The 'bars' follow the classic pattern of moving diagonally from the top left-hand to the bottom right-hand of the chart as progress is made through the project.

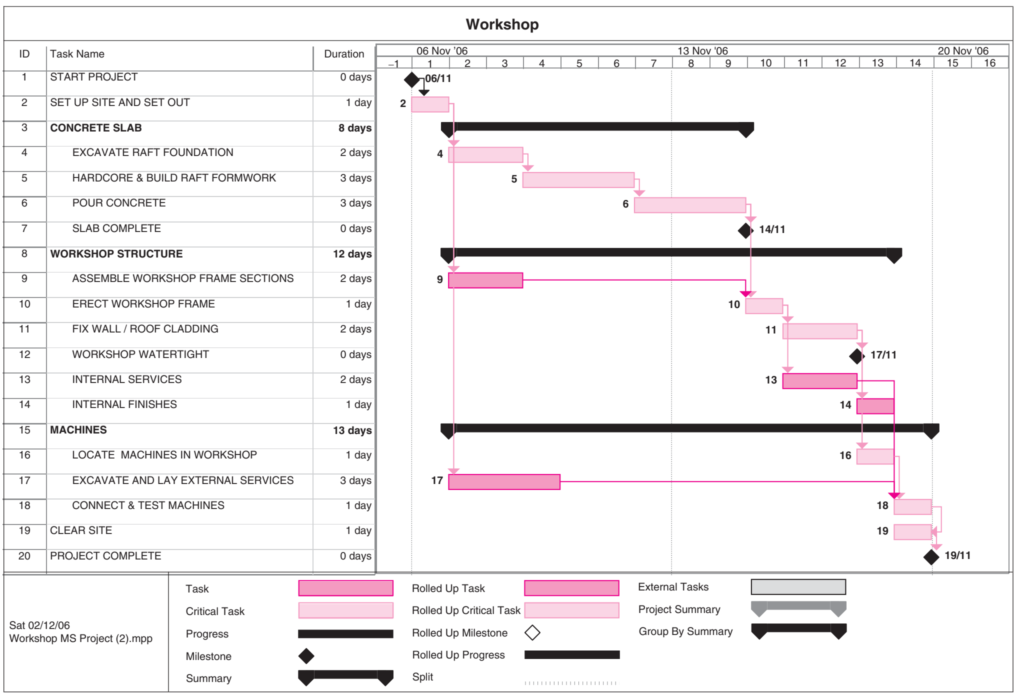

Figure 16.1 Example of a Gantt chart showing the construction of a new workshop.

The bar chart is simple and easy to follow. It provides a useful, at-a-glance indication of the dependences and interdependences of various operations within the contract period. You will often see such a chart on the wall of most construction site offices and it is very popular for the purpose of monitoring progress and logistics management.

For small projects, the Gantt chart is easy to interpret as **Figure 16.1** shows, but for long complex projects it can become quite cumbersome. Larger Gantt charts, for example, are difficult to appreciate on the averaged-sized computer screen. Gantt charts are often criticised for communicating relatively little information on project complexity; and that these types of projects cannot be communicated effectively using such a chart.

Furthermore, Gantt charts only represent part of the constraints of projects as the focus is primarily on schedule management. While Gantt charts can identify task dependencies, displaying a large number of these can result in an untidy chart.

Because the horizontal bars of a Gantt chart have a fixed height, they can misrepresent the planned workload (resource requirements) of a project. In **Figure 16.1**, Tasks 5 and 6 appear to be the same size, but in reality the magnitude of the tasks may be different. A related criticism is that all activities of a Gantt chart show planned workload as constant. In practice, many activities have front-loaded or back-loaded work plans, so a Gantt chart with percent-complete shading may actually mis-communicate the true project performance status (Wikipedia 2006).

16.8 The critical path diagram (or the network diagram)

Network diagram is perhaps a generic term which accounts for **precedence diagrams** and **critical path diagrams**, which are special applications of this approach. The network consists of a series of nodes joined together by lines or arrows, and normally moves from a start at the left-hand side to a finish on the right.

In **Figure** 16.2, a network diagram for the project in **Figure 16.1** is shown; the boxes or **nodes** represent the activities shown on the left-hand side of the chart in **Figure 16.1** and the lines or arrows joining them simply illustrate dependencies. Traditionally, the nodes were usually drawn in the form of sequentially numbered circles, which are large enough to contain some numeric information; the length of the lines joining them is of no significance and is chosen arbitrarily to suit a clear layout of the diagram. Modern charts, such as that shown in **Figure** 16.2 use boxes with information on each task contained within it such as duration, start time, finish time, and so on. Often, these boxes will provide additional information such as early start time/late start time (EST/LST), early finish time/late finish time (EFT/LFT) and float (lack allowed in that task).

A network in an unquantified form is simply a **precedence diagram**. The diagram can thus be drawn without any idea of the length of time which any operation will take; and in this form reflects the earliest planning stage, in which the planner is identifying those operations which fundamentally depend on each other and those which do not. Once this has been done, it will never need to be redrawn (unless the project itself alters); any changes will be made only to the numeric information within the nodes.

Remember, on a building project, it is fundamental construction dependence that counts and not convenience or the efficient use of resources, which are considered at a second stage.

Two important points are worth noting:

1. The network can be expanded to include not merely the construction but also the whole of the planning and design process and can thus become a tool in the hands of the client's

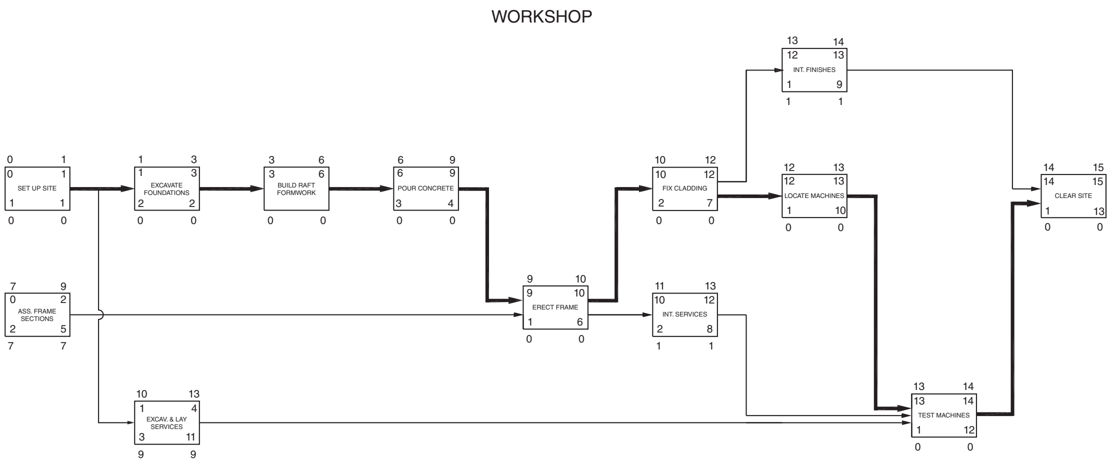

Figure 16.2 Network diagram for project shown in Figure 16.1.

professional representatives. This capability is particularly useful where overall time requirements are important or where design and construction are to run in parallel on a management, design-and-build or fast-track contract.
2. The operations may be shown at a strategic level ('build walls') or at a much more detailed level ('build ground floor external walls', 'build in sills and lintels', and so on).

For eventual control purposes, a fully detailed network may be used, but this is expensive to prepare and would be inappropriate at planning stage, before the actual detailed design has been finalised. On the other hand, a simple planning network cannot show the interdependence of meshing operations. For instance, if the erection of precast beams can commence after only some of the columns have been completed, this would require the work of each group (or even pair) of columns to be shown as separate operations.

This problem occurs throughout the project, but at planning stage is only likely to be considered in those parts which the planner feels to be of crucial importance – probably major structural work rather than finishes.

Once the network has been drawn and the precedences and dependencies settled, it is time to quantify the problem. The procedures for doing this are sufficiently standardised for there to be a number of computer packages as described previously, and the work then entails identifying the estimated durations on a schedule.

If manual methods are being used, however, a suitable method is to mark durations in the node boxes, which are often divided into quadrants (or sometimes seven parts) for the purpose of quantification (see **Figure** 16.3). In this example, we shall consider the node consisting of quadrants. In the top left-hand quadrant is written the reference number of the operation concerned (full description of the operation probably being written out in a numbered list) and in the top right-hand quadrant the estimated duration in days, weeks or whatever unit is being used. When all the individual durations have been inserted, the total project time can be calculated.

Beginning at the start and working along the arrows, the shortest possible elapsed time to the completion of each operation is inserted in the bottom left-hand quadrant. This is arrived at by adding the duration of the operation concerned to the highest elapsed time of any of the other operations which precede it and which are therefore arrowed into it. By the time end is reached, the total time for the project will have been calculated.

In respect of each operation, we will now know the earliest time at which it can be completed. Where the operation concerned is a crucial one, this will also be the latest time at which it can be completed if the project as a whole is to be finished on the calculated date. However, many less important operations may be able to be delayed without delaying the completion of the whole project.

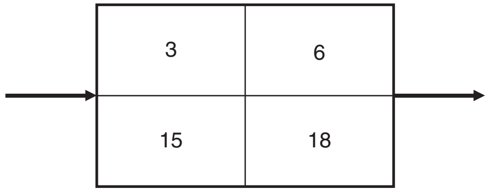

Figure 16.3 Activity node on the critical path diagram.

In order to identify the crucial operations, the bottom right-hand quadrant of each node may be used to show the latest possible date at which the operation can be completed without causing delay. This is calculated by working backwards from the finish and, in the case of each operation, calculating from the earliest start time of any of the operations that immediately follow it.

When this task is completed, it will be found that for some operations the earliest and latest dates for finishing are the same. These are the critical operations, and the sequence of arrows joining them forms the so-called **critical path** through the project.

In the case of a non-critical operation, the difference between the earliest and latest finishing dates represents the **float**, or the period for which that operation can be delayed without affecting the completion date for the project.

All these figures can, of course, be set out in the form of a schedule, instead of on the diagram itself. It should be noted that if part of the float for a particular operation is actually utilised, this may affect the float available for succeeding operations. If all the float is used up, then the operation, and its successors, will have become critical and the critical path will have changed. It is therefore necessary for the project controller to keep a close eye throughout the progress of the job on operations with a very small float, as well as those which are already on the **critical path**.

16.9 Resource levelling (or smoothing)

There may well be two or more operations in a network which do not depend on each other in the construction sequence – for example, foundation excavation and drainage trenches. It will not matter which is done first, and they could in theory be done simultaneously (whereas the foundation excavations and the concreting of them could not).

However, their relative timing may depend on resource utilisation. To dig the foundation and drainage trenches simultaneously would involve bringing an unnecessary number of diggers to the site, while to leave several weeks between the two operations would involve either machines standing idle or else taking them away and bringing them back. If operations were on critical or near-critical paths, then the additional expenditure would have to be accepted (or the time for completion altered), but otherwise their floats would be adjusted to give a more economical sequential programme.

The adjustment of a programme in this way to make the best use of an expensive plant, and to give gangs of operatives a consistent and balanced work pattern, is an important part of the planning exercise, and is often called 'resource smoothing'.

16.10 Resource-based techniques in relation to design cost planning

The use of resource-based methods is not practicable at the earliest budgeting and planning stages as the cost planner who intends to use these methods needs to start off with some idea of the configuration of the proposed building – its size, shape, height and preferred technology.

The cost planner may well suggest a suitable combination of these requirements, and if working for a construction firm these may be based on systems already rationalised in the organisation and which can be built quickly and efficiently. For some types of development (e.g. industrial premises), this could be a valid approach. Alternatively, the cost planner may begin with a solution proposed by the architect, test it in terms of resource use and then investigate alternatives.

At this stage, the main concern will be with those things which can be identified as major time constraints and production cost constraints. By using skills derived from experience, the cost planner will be looking for a solution which gives effective use of labour and equipment by providing smooth and continuous work flows, and enables the most economical type of plant to be used.

For example, if one single heavy component has to be lifted at the extreme reach of the tower crane, this will dictate a much heavier and more expensive type of crane to hire and run, probably for the whole duration of the contract. The crane 'cycle' will also dictate the intervals at which components, or skips of wet concrete, can be lifted into position, which in turn may determine the size of the gang and the method of working. Alternatively, an efficient method of working may require a different cranage configuration to that first thought of.

In turn, formwork usage will have to be considered and the concreting programme planned to allow for optimum reuse, with sufficient time allowed for any necessary alterations. This is where the contractor may look for savings, for example, by keeping column sections constant all the way up the building, because it may be that the cost of the extra material thereby required in the upper storeys will be more than saved on labour, plant and formwork.

Decisions of this kind can often only be made in the light of the actual construction programme which is envisaged, and whether site-mixed or ready-mixed concrete is to be used.

A further matter to be considered is the staffing of the site, the number and type of supervisory and control staff. The contractor will also be very concerned, even at an early estimating stage, with the integration of the engineering services work with the construction programme. Some of this integration concerns the way in which the contractor and the various subcontractors will have to work together, because the installation of pipes, conduits and components may be incorporated into the design in a way which means that they will interfere with other contractors' work sequences.

The planner/estimator will also be on the lookout for major items of equipment whose placing may cause difficulties. Equally important will be the question of whether, and if so when, the permanent engineering facilities – lighting, heating, toilets and passenger and goods lifts, in particular – may be used to facilitate the construction work.

The duration of the complete project, and of major stages in it, will have a most substantial effect on plant, supervisory and establishment costs, and this duration may in the end be determined as much by service subcontractor requirements as by the builder's own work. In highly serviced buildings, in fact, they may be the prime determinant.

The criticism is sometimes made that, in assessing and balancing all the above-mentioned matters, builders' estimators and planners tend to attach too much importance to optimising their 'own' part of the work, whereas in the end it is often the work of the specialists and their coordination which proves to have dictated the time for a project. This is perhaps where the independent professional cost planner can take a more balanced view.

Resource-based estimates are certainly no cheaper to prepare than a quantity surveyor's elemental estimate. Much the same sequence will therefore be employed.

Strategic estimates taking account of major factors only, often those which are of importance in a comparison between alternative schemes. A resource-use plan at this level may also be used in the preparation of a competitive tender based on BQs.

A detailed production plan and estimate, probably incorporating a full critical-path network. This would be intended for use as a production control document, and would be unlikely to be prepared until the design itself had been finalised and until the contractor was expecting to be chosen to construct it. It would almost certainly involve consultation with major subcontractors, and the use of an appropriate computer package.

16.11 Obtaining resource cost data for building work

Keeping an accurate record of costs split into

- site labour,
- materials and subcontractors,
- plant and
- establishment charges

and allocating them to the right contracts is comparatively easy, but the lump sums obtained do not really contribute very much to the understanding of how costs are incurred.

A detailed site costing system is much more difficult to arrange. In theory, it might be possible to cost each contract in terms of finished work, attaching costs to the measured items (or groups of items) in the BQs, but this is rarely done because it is difficult and expensive to keep records of time and material for a multiplicity of items and subsequently process them.

In addition, many costs are not directly related to specific quantities of work. We can identify four types of cost, as follows:

- **Quantity related**: These are the costs which bear a straight relationship to quantity of finished work – many material costs fall into this category as do some components of labour cost. With this type of cost, twice the quantity of work costs twice as much.
- **Occurrence related**: These costs are related to a particular event, or occurrence, such as the bringing of excavation plant to the site, or the moving of a plasterer's equipment from room to room. While the scale of the occurrence is obviously affected by the scale of the work, which is anticipated, its costs will not vary in proportion to actual quantity of work executed.
- **Time related**: Some costs (such as the hiring of a major item of plant) are related to a length of time, and not to the amount of work done in that time.
- **Value related**: Fire insurance, for instance, will be related to the value of the project. Establishment charges are also often allocated on a basis of project value and can be included under this heading.

In addition to these four types of costs, it must be remembered that some of the work done will relate to temporary items (such as erection of site huts and conveniences) which do not form part of the permanent works. On many projects the shuttering of concrete work is a very large item in this category.

16.12 Identification of differing variable costs

It is all very well to make these rather academic distinctions between different types of costs, but in practice they may be difficult to separate. For instance, the plasterers are unlikely to keep separate the time involved in moving from room to room, and the charge for a major item of plant may well incorporate several cost types, for example:

- **Quantity related**: Fuel, and part of the hire charge.
- **Occurrence related**: Bringing to site and removal, moving, assembling and dismantling.
- **Time related**: Part of the hire charge.

However, even an arbitrary division into these different types will be better than trying to allocate total cost pro rata to quantity of finished work, and would form a more suitable basis for using cost information for estimating or cost planning purposes.

Recent revisions of the Standard Method of Measurement have taken a welcome step towards identifying costs under these various categories.

16.13 Costing by 'operations'

In practice, costs are rarely kept to any lower level than an 'operation', which has been defined by the Building Research Establishment as 'a piece of work that can be completed by one man, or a gang of men, without interruption by others'. A typical operation might be the whole of the brickwork to one floor level, or the whole of the first fixings of joinery.

It is comparatively simple to record costs on site for such overall parcels of work, and to allocate materials to them, and it is much more meaningful to attach the time-related and occurrence-related costs to total operations than to try to split them up among quantities of measured work to which they bear little relation.

If the contractor's estimate can be similarly subdivided, it will be possible to compare the cost with the estimate at each stage of the project. But comparing actual costs with the estimate is one of the main purposes of costing by operations; as already explained, this approach does not lend itself to the provision of cost planning data for future projects.

16.14 Use of resource-based cost information for design cost planning

The contractor would appear to be in a much better position than the consulting quantity surveyor/cost planner as far as real cost information is concerned, yet would be ill-advised to use the actual costs from a particular project for cost planning another quite different one. There are two reasons for this.

Many of the factors which affect site costs on a particular project have nothing to do with the design of the building and will not repeat from job to job. These include site conditions, the weather, industrial and personal relations, the skill with which the work was organised, accidents, late delivery of materials, defective work and failure by subcontractors.

Although the 'operation' is an excellent concept for collecting costs, it is difficult to reuse the information arising from it because each operation is unique. The only way in which, say, first fixing of the joinery on one project can be compared with another quite different one is by looking at the quantities of the different types of work involved, and the whole essence of operational costing is that the costs are not broken down in this way. If they were, we would be back to costing work items from the BQ, and, as explained, this is impracticable. In some instances, the operation may embrace more than one cost planning element.

However, the contractor's operationally based estimates have neither of these disadvantages when considered as a data base for cost planning:

- They are based on an assessment of 'average' costs, and as such will have a closer relationship to future tender prices than ascertained costs from a particular project.
- They will break down each operation into measurable characteristics for pricing purposes (the estimated costs of which may be based either on experience or work study methods) and these can be used for the purposes of design cost analysis.

Insofar as the contractor has access to this kind of estimate, and the consulting quantity surveyor has not, the contractor may be said to have an advantage in cost knowledge. Against this, the average quantity surveyor is much more experienced than the average builder in translating project cost data into terms that are relevant at early design stage, and this expertise is essential to cost planning and control – the quantity surveyor's need is for a BQ which reflects more closely the way in which operational estimates are built up.

For instance, if the preliminaries section of the BQ were always priced in a consistently itemised way (like the other sections of the BQ) the consulting quantity surveyor could analyse and manipulate this important part of the cost in detail instead of as a **percentage of the measured work**. It must also be remembered that the proportion of project cost represented by the execution of the measured builder's work is steadily declining, and the proportion represented by specialist work, fixed charges and management costs is increasing.

16.15 Key points

- Because all contractors pay much the same prices for labour and materials, the differences in their costs are mainly to do with how well they organise and manage their projects.
- In order to prepare a resource-based estimate, they therefore need to plan the construction, and this is almost impossible to do until some sort of drawings exist.
- A resource-based estimate is therefore not appropriate for the earliest stages of budgeting or planning the accommodation to be provided for the client. The contractor will need to plan the construction using a bar chart and/or a network diagram.
- The proportion of total costs represented by the main contractor's direct costs is steadily declining. It is much more difficult to use the costs of a previous job to forecast the cost of a new one than it is to do the same thing with prices.

Further reading

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Endnote

1 In *Work, Wages and Profit* by H. L. Gantt, published by The Engineering Magazine, NY, 1910 (Source; Wikipedia).

Chapter 17

Cost Control (1): Final Design and Production Drawing Stage

17.1 Cost checks on working drawings

After the cost plan has been prepared and agreed, it will be the cost planner's responsibility to ensure that the work shown on the production drawings and measured in the bills of quantities (BQ) corresponds with the plan, as otherwise the tender figure is likely to be quite different from the amount of the estimate. Any necessary adjustments must be made before the contract documentation, including the BQ, is finalised, **not afterwards**. For this purpose, all drawings should be cost checked as they come into the cost planner's office; this must be a matter of routine and a system for tracking the cost checking routines performed on the drawings should be devised.

Unfortunately, this stage in the quantity surveyor's (QS's) work (the receipt of working drawings and subsequent revisions and details) is usually a hectic one and there is little time to spare for things like cost checks! Again, it is unfortunate that these checks can best be done by a senior person, who is usually very busy in other directions. Where the cost plan has been based on **approximate quantities tied to a fairly detailed specification**, and where the design has proceeded in accordance with it, the work involved in cost checking should be minimal. If, however, the design has been radically changed for some reason it may be better to start the process again and prepare a fresh cost plan at as early a stage as possible, rather than attempting to check the detailed drawings against a cost plan prepared for a somewhat different building.

Cost checking procedures are quite the most time-consuming and error-prone part of the whole process and the more they can be legitimately minimised the better. Should it prove to be necessary to undertake a thorough cost check of the whole design (perhaps because the cost plan did not give the architect sufficient guidance), then the drawings will have to be prepared by elements if the feedback from the cost checks is to be of any real use.

The extent to which cost checking should be carried out will depend on the following aspects:

1. **The amount of extra time the QS can be allowed**. This will vary from job to job, but it must be realised that if lack of time prevents essential cost checks from being carried out then the whole attempt at cost planning will largely be a waste of time.
2. **The amount of apparent alteration to the scheme since the cost plan was prepared**. If the cost plan was based on a very similar project for the same architects and client and the details of specification and design were therefore known fairly well, the cost check may

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

entail little more than a quick glance at the drawings to see that nothing is substantially different. Even where the circumstances are not quite as ideal as this, it may still be possible for the QS to be satisfied by a quick inspection that the drawings show what the cost plan envisaged. The drawings should be stamped and initialled, even so.

3. **The amount of detail in the cost plan**. If it was possible to take out fairly full approximate quantities, the cost check may simply consist of comparing these quantities with the working drawings and checking that the specification is unaltered. The degree of confidence which exists between cost planner and architect – if the architect is known to be cost conscious, capable of and enthusiastic about cost design, the cost checks will be much less important than where this confidence is lacking.
4. **The familiarity of the type of project**. Most cost planners would feel fairly confident of cost planning a school, whereas a planetarium would be a very different proposition. In the latter case, the cost plan would probably incorporate rather a lot of assumptions and it would be necessary to check these in detail.
5. **The importance of the element**. It would be a very self-confident cost planner who would not bother to check the external walling, or the roof of a single-storey building, even under the most ideal conditions. On the other hand, if time is pressing some of the smaller elements can often be ignored.

17.2 Carrying out the cost check

Again, this is a suitable occasion for using standard forms. Where the architect is designing by elements, the procedure will be considerably simplified; but even if this is not the case, the check must still be done by elements. The design of the cost check form may be left to the tastes of the firm or other organisation. It should show at least the following information:

1. **Number of checks**. The checks on a particular project should be numbered consecutively, starting at 01.
2. **Total estimated cost of project after completion of previous checks**. (This amount will be got from the previous cost check form, or if this is the first check it will be the unaltered total of the cost plan.)
3. **Reference number** of drawing(s) or other information being checked.
4. **Element being checked**.
5. **Amount allowed in cost plan in respect of element** (or as amended by previous checks).
6. **Estimated cost of element** as calculated from the drawing(s), or other information, being checked.
7. **Difference (plus or minus) between the two last checks**.
8. **Estimated cost of project after this difference has been added to or deducted from the previous estimated project cost**.

A typical example of a cost check form is shown in **Figure** 17.1. As each cost check is carried out, a copy of the cost check form should be sent to the architects so that they have an up-to-date running total of the project. If any check shows a substantial increase or decrease, it would be as well to discuss the matter with the architects rather than merely sending the results of the check to them. Similarly, they should be warned if the general standard of detailing appears to be more lavish than was allowed for.

If a drawing shows changes in more than one element, a separate form should be used for each. The rough workings in connection with each check can be done on dimension paper and stapled to the office copy of the form.

COST CHECK

Contract:
Cost check:
Element:

Date:

Gross internal floor area:

Total cost of project forward from cost check no. 2

			£ total	£/m2
Total cost of element from updated cost plan			£125,600.00	52.55
Elemental cost check (see attached dimensions)				
380 m^3 reinforced concrete in beams and columns	£90.00	£34,200.00		
2950 m^2 formwork to beams and columns	£16.00	£47,200.00		
31 tonnes Reinfct (as Mr Smith of Consulting Engineers 28.06.99)	£31,200.00	£37,200.00		
Sundries		£10,000.00		
Revised cost of element carried forward		£128,600.00	£128,600.00	53.80
Amount of saving/extra			£3020.00	£1.26
Revised total cost of project carried forward to next cost check	£1,907,222 + £3020 = £1,910,240			

Figure 17.1 Example of cost check form.

A list should be kept of all drawings or other information received, with columns for marking:

1. that the cost check has been carried out;
2. the reference numbers of the cost check form or forms.

The purpose of checking the elements involved is to enable the checker, on receiving a drawing showing (say) a part of the roof, to look back through the list to see whether any adjustments have already been made to this element.

If it appears that a detailed cost check of any particular drawing or information is not necessary, the list can be marked accordingly. However, all drawings and information (such as subcontractors' quotations or replies to queries) must come to the cost checker in the first instance, even if someone else is waiting for them. In connection with cost checking, it is as well to remember the total cost of the project and also the inherent margin of error in cost planning. A cost planner whose estimates consistently get within plus or minus 5% of the accepted tender is doing well. In these circumstances, it is obviously not worthwhile spending much time cost checking isolated details of a large project, as the possible differences in cost are so small compared to the probable overall margin of error.

Prices for cost checking may be obtained from the same sources as have been used earlier. But as there will be a tendency for the items to be more detailed than at cost plan or estimate stage, the cost planner is likely to be using either built-up rates, price book rates or actual rates from the BQ from which the example analysis was prepared. Again, it must be remembered that the contractor's permission must have been obtained for this latter course.

It will be very tempting to lift prices from BQs for other projects at this stage, but the errors that can arise from this practice have previously been pointed out. If prices are built up or obtained from price books, the level of market prices on which the estimate is based must be remembered. It will also be necessary to include a realistic percentage for preliminaries and insurances; this will not necessarily be the same percentage as the contractor showed in the analysed example.

17.3 Use of an integrated computer package at production drawing stage

Figure 17.2a–d illustrates an extract from the output of an integrated computer cost planning package (CATOpro) relating to an urban site development for a housing association. Perhaps the biggest advantages of a computer package such as this is that the figures for the total project are automatically updated whenever a change is made to any element or part element, without the opportunities for error or omission, which are always present with a manual system. Figure 17.2a shows a revision to the substructure element of sites A, B and C. The input to Figure 17.2a is the measurement of approximate quantities from the drawings, either manually or entered by digitiser, or measured and calculated using a lower level

URBAN SITE REDEVELOPMENT SITES A, B and C — 2.0 SUBSTRUCTURE — HOUSING ASSOCIATION

Description		+	Quantity	Unit	Rate £	Calc	Total £	Notes
1	Clear/strip site		10,587.00	m^2	2.00		£21,174.00	Site layout
2	Strip foundations		2061.00	m^2	60.00		£123,660.00	To houses
3	Extra over allowance for stepped foundations		1.00	Item	3000.00		£3000.00	
4	Piles, ground beams and pile caps			m^2	105.00		£17,325.00	To flats
5	In situ reinforced concrete ground slab with dpm and screed		2226.00	m^2	60.00		£133,560.00	
6	Allowance for cut and fill earthworks		1.00	Item	25,000.00		£25,000.00	
U/D	**4350 m^2**						**£323,719.00**	

Figure 17.2a Revision to the substructure element of sites A, B and C.

	Element Code	Element	%	Cost £/m²	Cost £/ft²	Quantity	Unit	Rate £	Sub Total	Total £	Notes
		URBAN SITE REDEVELOPMENT SITES A, B and C							**HOUSING ASSOCIATION**		
1		1.1 Demolitions									In enabling works
3		**TOTAL**									
4											
5		1.2 Alterations									In enabling works
6											
7		**TOTAL**									
8											
9		2.0 Substructure	10.84	74.42	6.92				3,237,190	3,237,190	
10											
11											
12		**TOTAL**	**10.84**	**74.42**	**6.92**				**3,237,190**	**3,237,190**	
13											
14		3.0 Superstructures									
15											
16		3.1 Roof	6.77	46.46	4.32				202,098.00	202,098.00	
17		3.2 External walls	10.51	72.14	6.7				313,805.00	313,805.00	
18		3.3 Upper floors	4.51	30.97	2.88				134,728.00	134,728.00	
19		3.4 Windows and external doors	12.18	83.61	7.77				363,725.00	363,725.00	
20		3.5 Internal walls and partitions	6.42	44.08	4.1				191,741.00	191,741.00	
21		3.6 Internal doors	3.57	24.51	2.28				106,600.00	106,600.00	
22		3.7 Stairs	3.06	21.03	1.95				91,500.00	91,500.00	
23											
24		**TOTAL**	**47.02**	**322.8**	**30**				**1,404,197.00**	**1,404,197.00**	
25											

Figure 17.2b Revised elemental summary page for sites A, B and C (Level 2).

		URBAN SITE REDEVELOPMENT SITES A, B and C					HOUSING ASSOCIATION				
	Element code	Element	%	Cost £/m²	Cost £/ft²	Quantity	Unit	Rate £	Sub total	Total £	Notes
26		4.0 Internal finishes									
27											
28		4.1 Wall finishes	6.34	43.49	4.04				189,177.00	189,177.00	
29		4.2 Floor finishes	4.33	29.72	2.76				129,268.00	129,268.00	
30		4.3 Ceiling finishes	2.48	17.03	1.58				74,097.00	74,097.00	
31											
32		**TOTAL**	**13.15**	**90.24**	**8.38**				**392,542.00**	**392,542.00**	
33											
34		5.0 Fittings and furnishings									
35											
36		5.1 Fittings	5.42	37.17	3.45				161,700.00	161,700.00	
37											
38		**TOTAL**	**5.42**	**37.17**	**3.45**				**161,700.00**	**161,700.00**	
39											
40		6.0 Services installations									
41											
42		6.1 Mechanical services	13.11	90	8.36				391,500.00	391,500.00	
43		6.2 Electrical services	9.78	67.11	6.24				291,910.00	291,910.00	
44		6.3 BWIC with services	0.67	4.6	0.43				20,000.00	20,000.00	
45											
46		**TOTAL**	**23.56**	**161.71**	**15.03**				**703,410.00**	**703,410.00**	
47											
48											
U/D		**4350/m²**	**100**	**686.34**	**63.78**				**2,985,56**	**2,985,56**	
										2,985,56	

Figure 17.2c Revised elemental summary page for sites A, B and C (Level 2).

Summary		URBAN SITE REDEVELOPMENT Cost	Calc	Total £	Area	Cost £/m²	HOUSING ASSOCIATION Cost £/ft²
1 Enabling works		77,231.00		77,000.00			
2 Sites A, B and C		2,985,568.00		2,986,000.00	4350	686.00	64.00
3 External works associated with units		288,216.00		288,000.00	4350	66.00	6.00
4 Preliminaries		327,300.00		327,000.00	4350	75.00	7.00
5 Infrastructure		809,084.00		809,000.00			
6 Contingencies		226,660.00		227,000.00			
	Project	**4,714,059.00**		**4,714,000.00**			

Figure 17.2d Updated summary of project cost (Level 1).

of the computer package (not shown here). Figure 17.2b and c (level 2) shows the next stage, the revised elemental summary page for sites A, B and C. The various figures can either be inserted directly on an elemental basis per element or automatically derived from a level 3 cost check. In this case, the figures for '2.0 Substructure' have been transferred by the computer from the level 3 elemental cost check shown in Figure 17.2a. Figure 17.2d (level 1) shows the updated summary of the cost for the whole project, automatically updated from the more detailed levels of working, examples of which have been given. The figure for sites A, B and C has been transferred by the computer from the level 2 elemental summary (Figure 17.2c). It will be noted that costs are given in £/ft^2 as well as in £/m^2, this being the unit of measure preferred by most real estate clients.

17.4 Use of resource-based techniques at production drawing stage

This technique was introduced in the previous chapter. If this approach is being used, a detailed production plan and estimate would be prepared at this stage, probably incorporating a full critical-path network. Intended for use as a production control document, this would not be prepared until the design itself had been finalised and until the contractor was expecting to be chosen to construct it. It would almost certainly involve consultation with major subcontractors, and the use of an appropriate computer package.

17.5 Cost reconciliation

If tenders have been called for and received, the tender that is most likely to be accepted should be reconciled with the cost plan. If, as should occur, there is little difference between the totals, this is still worth doing; there are quite likely to be large compensating discrepancies in the various elements and these may provide information for future use. The reconciliation is in fact a comparison of the final cost plan (as amended by cost checks) with a cost analysis of the tender. This also ensures that the cost analysis will be done at the earliest possible moment instead of being left until 'someone has time to do it'. There may be all sorts of explanations for a considerable difference between the cost plan estimate and the actual cost of a particular element; perhaps the cost planner made a mistake, quite possibly the builder's estimator made a mistake or did a deliberate price adjustment. However, if there is a definite one-way divergence between cost plan and tender right through all the elements, it is likely that either the cost planner misjudged market levels or that the tenders themselves are abnormally high or low. If the cost planner feels that the latter is the case, then this could be pointed out. Note that permission is never required to analyse the contractor's tender for cost reconciliation purposes. It is only if the analysis is to be published, or if the individual prices are to be used for cost checking other projects, that the question arises.

17.6 Completion of working drawings and contract documentation

The completion of the working drawings and the contract documentation will normally mark the end of the cost planning process as such, although the vital task of cost control will have to continue throughout the project to ensure that the planned cost is achieved.

17.7 A critical assessment of elemental cost planning procedures

It has been suggested that elemental cost planning techniques will be justified if they consistently succeed in forecasting cost within a margin of 5% up or down, and indeed more recent research suggests that even this target may be over-optimistic, given the variability which exists in tender levels. It might well be asked whether all this work is worthwhile if, at the end of it all, the tender is liable to differ from the estimate by such an amount. Simple single-price rate methods of estimating have often come far closer than this and involve much less work. The answer is threefold:

1. Most budgets are flexible by at least this percentage or, if they are not, it is simple enough to make the requisite modest alterations in the scheme.
2. It must be emphasised that traditional single-rate methods cannot be relied upon to achieve anything like this standard of accuracy, and that for every 'spot-on' square metre estimate there is another instance of such an estimate being up to 50% out. But where an estimate, however prepared, forecasts the cost to within 1% or 2% under traditional competitive tendering conditions, then luck as well as skill will have played its part in the result.
3. Elemental cost planning achieves a balance and economy in the building which cannot be attained by any other method using traditional tendering procedures. A real-life example concerns a technical school which was estimated on a square-metre single-price basis and where the difference between estimate and tender was much less than 5%. Satisfactory though this was, nobody was able to answer a very simple question from the architect during the design stage as to whether that estimate would cover a certain type of wall cladding. There was nothing in the estimate with which it could be compared.

In view of the alleged unreliability of estimates prepared by single-rate square-metre methods, it is as well to explain again why these methods can safely be used for the preliminary estimate before the cost plan is prepared. It is because the cost plan will show up any error in the estimate before working drawings or BQs have been prepared, and the necessary adjustments can be made before any of the detail work is started. This is a very different situation to discovering the error at tender stage when time and money have been spent designing and tendering for an impossible scheme in detail.

While elemental cost planning has made an outstanding contribution to the study, forecasting and control of building costs, it nevertheless suffers from a number of basic limitations which have prevented it from developing much beyond the stage it reached within the first few years. One might wonder whether it is doomed to be like the lead-acid electric battery which, although very useful for over a century, has never been capable of development into the kind of power-storage unit that the world is waiting for.

The limitations in question are as follows:

- Nobody has yet produced a set of elements each of which performs a single function but which can be easily cost-related, nor are they ever likely to.
  This means, amongst other things, that it is not really possible to compare the cost performance of the same element on two different buildings, nor, within one element, to compare two different technical solutions concerning one building. In order to attempt this task (which the QS is often asked to do), it is necessary to consider all sorts of extraneous matters, some of which are difficult to quantify. It might be thought that it would be possible to overcome this limitation by the use of sophisticated computer programs, which would enable the interaction of the elements to be worked out exhaustively. This might well be possible, but it would be expensive and at the present time is not worth doing because of the next limitation.
- As we have already seen, but as is worth repeating here, the 'costs' which are being manipulated may bear no relation to fact; they are not really 'data' in any scientific sense.
  It is a waste of time and money to use sophisticated methods to manipulate inaccurate data, as is recognised in the computer world where the maxim 'garbage in, garbage out' is well known. In fact, such processing is worse than useless, because the fact that sophisticated analysis methods have been employed leads people to attach undue importance to the results. They would immediately recognise the original data as unreliable if it were presented to them in an unprocessed form.

It must be remembered that there is no pressure on contractors to insert rates in the BQ which represent carefully estimated production costs for each of the items, and there are many reasons (as set out previously) why they do not. The rates in the BQ are not 'retail' prices for which the contractor is offering to execute individual pieces of work in isolation, but are merely a notional breakdown of the total offer.

However, even if it were possible to compel the contractor to show true cost estimates, and to enforce standard practice in defining and allocating overhead costs, there would still be the difficulty of setting production costs against square metres of design elements, as so many of these costs (e.g. the tower crane) are not directly related to element unit quantity.

Even if the two previous limitations could be overcome, the whole system suffers because under normal conditions there is no contractual commitment to the cost plan.

The QS has no responsibility for the tender amounts and the contractor has no interest in the cost plan. The exercise thus has a great deal in common with weather forecasting. The cost planner is able to draw on a considerable body of past experience and can consider present trends, but is in no position to guarantee the result. The forecast will often be right, but if any unusual circumstances manifest themselves it can still be badly wrong.

The comparatively crude methods set out in this and the preceding chapters are usually adequate for forecasting within the wide limits of market pricing; any attempt to get much closer in these conditions is unlikely to be a worthwhile use of resources. Therefore, if the cost planner cannot offer any kind of guarantee to the client, the latter is unlikely to agree to expenditure on expensive and sophisticated methods of 'control', which are not in fact controlling anything but are just hopeful forecasts.

If a higher standard of cost control is required than is provided by the reasonable development of these traditional methods, then it will be necessary to sacrifice some measure of market freedom to obtain it, for example, by involving the contractor at an early stage. There is just no way round this.

17.8 Key points

- Elemental cost planning should ensure that the tender amount is close to the first estimate or, alternatively, that any likely difference between the two is anticipated and is acceptable.
- Elemental cost planning should ensure that the money available for the project is allocated consciously and economically to the various components and finishes.
- Elemental cost planning does not mean minimum standards and a 'cheap job'; it aims to achieve good value at the desired level of expenditure.
- Elemental cost planning always involves the measurement and pricing of approximate quantities at some stage of the cost plan or cost check.

Further reading

Cartlidge, D. (2006) New Aspects of Quantity Surveying Practice, Butterworth-Heinemann Ltd, ISBN: 0750668415.

Jaggar, D., Ross, A., Smith, J. and Love, P. (2002) Building Design Cost Management, Blackwell Science Ltd, ISBN: 0632058056.

Smith, J. and Jaggar, D. (2006) Building Cost Planning for the Design Team, Butterworth-Heinemann Ltd, ISBN: 0750680164.

Chapter 18
Cost Control (2): Real Time

18.1 Why real-time cost control?

The methods of cost planning and control that have been covered so far are concerned with planning and monitoring costs during the

- investigation stage,
- planning stage and
- design stage

and finishes at the point where tenders are received or a contract entered into. During these stages nothing is irrevocable:

- drawings can be revised and updated,
- the scheme can be reduced in size or its configuration altered,
- the whole thing can be started again from scratch or postponed, or
- the scheme can even be totally abandoned

at what will be (from the point of view of the total project cost) a negligible cost for abortive professional work. Even if the project has got as far as the submission of tenders by contractors, the scheme can still be radically changed or abandoned without any commitment to the tenderers or any need to recompense them for their trouble. This situation can often arise as a consequence of the client making late-change requests or significantly altering the design intent. Building Information Modelling (BIM) should provide clients with a greater insight into the effect that such changes can have on cost, time and performance, but the use of such technology is really still in its infancy.

However, while the accurate forecasting of a tender amount and the signing of a contract for that sum (or an amended one where the forecast hasn't quite worked out) is of considerable importance, the matter does not end there. The final agreed cost, after both the project and the various financial negotiations arising from it have been completed, is rarely the same as the original contract amount. It is this final figure which the client actually has to pay and which is the building cost for which the finance will have had to be raised and serviced. On profit-oriented projects in particular, it is the figure on which the success or failure of the project will be judged.

In many cases the 'contract sum' may be merely an intermediate stage in arriving at this final cost, and a system of cost planning and control which stops at this halfway point will only be of limited use (and possibly not worth the money which it costs). It is important, therefore,

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

Companion website: www.wiley.com/go/kirkham/costplanningbuildings

that the cost control process continues to the point of completion and handover the project. This continuation is often termed 'post-contract' cost control for obvious reasons. It differs from design cost planning in many ways, and these will depend on the exact contractual arrangements, but two differences will be inescapable:

- The interests of a contractor or contractors now form an important addition to the considerations involved.
- Major expenditure is currently being incurred and future options proportionately reduced.

It becomes increasingly difficult to make major alterations of any kind at the stroke of a pen, once drawings and specifications are being translated into an expensive organisation of resources and finished work. Even delay caused by hesitation or reconsideration may involve the client in heavy costs.

It is to emphasise this similarity with real-time computer control systems, and because in some circumstances there may not even be a contract, that we have chosen to use the more appropriate term 'real-time' rather than 'post-contract' to describe this type of control.

The basis of real-time cost control is reporting at regular (often monthly) intervals or on a special occasion when a major decision has to be made. This cost control report will set out the client's likely final cost commitment in some detail and also the cost consequences of any remaining major options. In some instances, this report may be made to the architect or other professional project controller, but it is preferable that it should be made direct to the client.

This service should be envisaged when the quantity surveyor's (QS's) fee is being negotiated, and should be written into the agreement. Its purpose is to

- enable the client to budget for the likely expenditure;
- enable the cost effect of any major changes to be seen in the context of the project as a whole;
- enable avoiding action to be taken if the total cost appears to be escalating unduly.

One of the problems attached to this service is the extent to which sums of money should be kept in hidden reserve by

- the underestimation of savings, and
- the overestimation, or at least the pessimistic evaluation, of additional costs.

There is a natural tendency towards this type of caution. In its most extreme forms, this may be taken to the extent of inflating the projections sufficiently to cover without disclosure of any mistakes which may be made by the architect or QS and which will still leave the client with a pleasant surprise when the final account is inevitably settled at below the forecast amount. Such conduct would be as unprofessional and unhelpful as inflating the quantities in the BQ for similar reasons.

Nevertheless, caution dictates that some allowance be made for inevitable minor additions that are not immediately apparent, or for things going slightly wrong. This particularly applies where final costs will be subject to negotiation or where the full consequences of decisions or events cannot be exactly foreseen. The reasonable judgement of these allowances, avoiding both excessive pessimism and optimism are one of the major factors in making this a truly professional task. In particular, the QS who is successful in this role will develop a feeling for the average project, where not everything is going to go wrong, and for the occasional project where it would be wise to assume that it might.

18.2 The problem of information

In carrying out real-time cost control, it is essential for the QS always to be fully informed as to what is happening and what is intended. Ensuring this may well be one of the more difficult parts of the operation.

Ideally the QS should be part of the decision-making process, in which case the difficulty should not arise, but this is not usually the situation. However, merely sitting in the office waiting for information to come in is not going to be good enough. Most contracts contain no requirement for communication to and from the contractor to flow through the QS's office. The QS is likely to be informed eventually of everything necessary for the final settlement of accounts, but this information will be far too late to be of any use for real-time cost control purposes.

It must be remembered that cost control requires not just a record of costs incurred to date but also of likely eventual cost commitments arising from

- current proposals for variations;
- other decisions which have been taken by the design team and/or the client which will create variations and/or cause delay or difficulties in working;
- failure by the design team to meet deadlines for supply of information or for appointing nominated sub-contractors and so on, which will have the same effect.

The QS must, therefore, instigate 'current awareness' procedures, and in particular must

- insist on seeing immediate copies of all official orders, drawings and letters;
- attend all site meetings and generally look around the site to see what is going on;
- use this opportunity to find out what verbal instructions might have been given.

It has often been alleged that on many projects, the 'official' documentation is merely trying to catch up with the real but informal site communications system. The preparation of interim valuations for payment purposes provides an excellent opportunity to monitor what is actually happening and should always be used for this purpose. The maintenance and updation of real-time cost control records is an ideal system within e-Procurement systems, whether these be based on simple spreadsheets or specialist control systems.

Although, as shown above, many of the factors in real-time cost control are common to any type of contractual situation, it will be most convenient to look at the detail in the context of each of the different types.

18.3 Real-time cost control of lump sum contracts based on BQs

- In the real-time cost control system for this type of project, the starting point will be the contract sum, and then the provisions that the contract makes for amending it. These provisions will usually cover:
- The adjustment of 'provisional' sums of money or quantities of work, which are embodied in the contract, in the light of the actual cost or quantity of work carried out. This type of provision is often made for work such as foundation excavation which cannot be foreseen exactly.
- Payment for variations and for additions to, and omissions from, the work.

- The adjustment of amounts included in the contract for work to be carried out by nominated sub-contractors and others in the light of actual cost.
- The correction of errors in BQs and other contract documents.
- Adjustment for the effects of inflation (if applicable).
- Adjustment for the effects of new legislation.
- Compensation to the contractor for the cost of delays in the work caused by circumstances for which the client is responsible (or, in more generous contracts, by circumstances for which the contractor is not responsible). These circumstances may include delays caused by the instruction of variations or by delay in the provision of drawings and so on, or where the more generous provisions apply, in which the delay is caused by bad weather or industrial action.

In addition to the likely revised contract amount, the QS's cost projections should include

- updated additional amounts for professional fees;
- furnishings (unless it has been agreed to exclude these);
- any other items which the client wishes to consider as part of the total cost.

18.3.1 Adjusting the contingency sum

An item which can give rise to controversy is the adjustment of the provisional contingency sum, which is an amount included in the contract sum by the design team to cover unforeseen expenditure. The controversy centres around whether this sum is at the architect's disposal to cover design development (or more bluntly, mistakes) or is at the disposal of the client to spend on extra items.

Some public authorities hold the second view so strongly as to demand the omission of the contingency sum as the first variation on the contract, so as to effectively take it out of the architect's control (while of course retaining it as a buffer in their own calculations).

Except where the client holds such extreme views, it is probably best to show the contingency sum separately in the cost control report, deducting any incidental extras of the appropriate kind and carrying the balance forward to cover further similar extras which can occur at any stage of the project. In any case, a provision of some kind must be made for contingencies during the remainder of the project. This sum is sometimes split into two, in order to make separate provision for

- design development and unforeseen circumstances.
- additional items (i.e. extras).

18.3.2 Variations

A general difficulty which faces the QS is that although the contractor is required by most contracts to give written notice to the architect of circumstances having arisen which will give rise to an extra cost, this notice is usually only required to be given within a 'reasonable time' of the occurrence. In contractual terms, this has to be interpreted fairly generously, and may well be too late for cost control purposes. The remarks already made about current awareness therefore apply strongly.

A further difficulty under the British JCT Standard Form of Contract (although not always overseas) is that there is no requirement for the financial effect to be stated or agreed at the same time, and in fact this is positively discouraged both by the contract clauses and by traditional practice.

The QS's estimates, therefore, have to bear in mind that the figures may be subject to negotiation, and if the contractor also suggests a figure at this stage (although not legally bound to do so) the QS will have to guess the point between them at which a deal is likely to be made. For this reason the QS's real-time cost projections on this type of contract should never be shown to the contractor, since the QS may have prudently assumed a higher figure for extras than would at that time be conceded.

Although the contract usually contains a similar provision for notification of reduced or omitted work by the contractor, there is obviously less incentive for this to be done, and the duty is easily 'forgotten'. The QS again must be in a position to see that omissions are duly notified and adjusted.

18.3.3 Nominated and named sub-contracts

The growing tendency for main contractors to attempt to transfer blame for project variations onto nominated sub-contractors (i.e. for delays) and thereby escape responsibility has led to a sharp decline in the use of nominated sub-contractors. Naming has become far more common, this is where the employer provides the principal contractor with a list of firms to send tenders out to – this is the naming process.

When a problem occurs, the first adjustment will be done when a nominated sub-contractor's tender is accepted for the work; this tender is likely to contain similar types of provision for further adjustment as the main contract does, and similar subsequent changes in cost are likely to occur which will have to be reflected in the cost control report.

18.3.4 Inflation

On 'fluctuation' contracts the adjustment of the cost control report for inflation is a difficult one, particularly at an early stage of the project. It involves

- a forecast of rises in building costs over the contract period;
- an estimate of the likely progress of the work in cost terms so that the forecast increases can be applied to an appropriate proportion of the cost.

There are three different figures to be calculated for inflation, and this will apply whether the contract adjustment is on the basis of the difference between ascertained actual costs of resources and costs at the time of tender, or whether it is done on an index-linked basis:

- increased cost incurred to date;
- estimated additional cost for remainder of contract of increases announced to date;
- allowances for effect of future increases.

The figure which the client will require for budgeting purposes is the total of the three, although the total should be split into the three categories to emphasise the progressively more conjectural nature of the estimates. Although it is theoretically possible for there to be a decrease in cost through the operation of this clause of a contract, there have been no known instances of a reduction in the contract sum from this cause in the United Kingdom during the 60 years prior to 1999.

18.3.5 Budgetary control versus best deal

A most important point regarding cost control of lump sum contracts is the perennial conflict between tight budgetary control and getting the best deal from market forces. The best budgetary control is achieved if a firm contractual commitment can be obtained at the earliest possible moment – in the case of extra work, for instance, before the order is given to go ahead. Even the British JCT Standard Form of Contract makes some provision for this in its use of the words 'unless otherwise agreed' in its set of procedures for valuing variations. However, as previously mentioned, the contractor is under no obligation to agree a firm figure beforehand, with its attendant risk of underestimation, and may prefer to leave negotiation until the final costs are available.

It is up to the QS to advise the client on the advantages and disadvantages of agreeing extras at an early stage in the light of issues such as the client's particular budgetary problems and the apparent willingness or otherwise of the contractor to do a reasonable deal on this basis.

18.3.6 Cost reports

As an example of a system of cost reporting, two consecutive monthly cost reports on the early stages of a job are shown in Figures 18.1 and 18.2. In order to illustrate the difficulties involved, a 'fluctuations' contract has been assumed. The references A.I.1, A.I.3 and so on refer to sequentially numbered architect's instructions.

There are many possible ways of setting out such reports, and readers may well be able to devise what they consider to be a better format. What is most important is that any changes since the previous report should be clearly highlighted, either by the use of asterisks and notes, as in the example, or else by simply giving the previous figures as totals. Using the latter system the figures in the second example for 'Net additions' could simply have been shown thus:

Net additions	**£**
As before	53,100
Extra work to entrance vestibule and staircase (A.I.6)	6000
	59,100

Points where other people's tastes might differ include

- The rounding off of estimated figures (a figure of £18,577 implies a standard of accuracy which £18,600 does not).
- The item of 'sundry minor variations' which could have been shown in detail.

It is the authors' view that this document is prepared to assist budgetary control, not to start a premature 'witch-hunt' against the architect by highlighting minor problems which have arisen. Consideration of such matters can usually be better left until the final account, when these problems can be seen in the context of the finished project.

It will be noted that the report takes account of variations ordered, and quotations accepted, for work which is not yet done or even started. The possible claim for delay has been charged against the contingency fund, which will not be able to stand many such demands upon it.

Finally, it must again be emphasised that under normal contractual arrangements, the contractor has no duty to participate in any cost control scheme or cash flow control scheme of the client, and there are sound commercial reasons for refusing to do so. Any such requirement, to be binding, must be written into the form of contract with legal advice and cannot simply be stated in the preliminaries of the BQ.

OFFICE BLOCK MIDTOWN

Cost Report No 2 10-Jun-06		**Contract sum**	£1,910,200
Net omissions		**£**	
Partial substitution of 'Conglint' panels for Portland stone (A.I.3)		27,050	
*Savings in foundations and piling		7000	
		34,050	34,050
			1,876,150
Net additions			
Decorations and partitions in offices (A.I.1)		44,000	
Carpeting in offices in lieu of wood block flooring		9100	
		53,100	53,100
			1,929,250
Adjustment of prime cost sums	**Omit**	**Add**	
	£	£	
Heating installation (Midland Heating Company Ltd)		7500	
Electrical installation (Sparks and Co.)		975	
*Curtain walling (The Curtain Walling Co.)	2065		
	2065	**8475**	
	2065		
		6410	
Profit and attendance		500	
Net addition		**6910**	6910
			1,936,160
Adjustment for fluctuations (inflation) including sub-contractors			
*(i) increase on work to date		2000	
*(ii) allowance for effect on of current increases on remainder of work		60,000	
*(ii) allowance for possible future increases (say)		50,000	
		112,000	112,000
	Total estimated final cost		**2,048,160**
Amount included for contingencies			
Contingency sum in contract			30,000
*Sundry minor variations (net extra)			1000
	Balance remaining		**29,000**

VAT and professional fees not included in above figures.
*Indicates changed or additional item since previous cost report.

Figure 18.1 Real-time cost report no. 2.

18.4 Real-time cost control of negotiated contracts

A negotiated contract provides excellent opportunities for cost control. Indeed, this is one of its principal advantages for which, as usual, some measures of market force benefit may have to be sacrificed.

From the moment of involvement in the scheme, the contractor should be committed by the architect and QS to participate in the cost control process both during the design stage and subsequently. This requirement should be made clear during the early stages of negotiation and duly written into the contractual arrangements, together with a provision for prior negotiation and agreement of extra costs.

	OFFICE BLOCK MIDTOWN		
Cost Report No 3 10-Jul-06		**Contract sum**	£1,910,200
Net omissions		**£**	
Partial substitution of 'Conglint' panels for Portland stone (A.I.3)		27,050	
*Savings in foundations and piling		6652	
		33,702	33,702
			1,876,498
Net additions			
Decorations and partitions in offices (A.I.1)		44,000	
Carpeting in offices in lieu of wood block flooring		9100	
*Extra work to entrance vestibulke and staircase (A.I.6)		6000	
		59,100	59,100
			1,935,598
Adjustment of prime cost sums	**Omit**	**Add**	
	£	£	
Heating installation (Midland Heating Company Ltd)		7500	
Electrical installation (Sparks and Co.)		975	
*Curtain walling (The Curtain Walling Co.)	2065		
*Lifts (Ascenseurs Ltd)	1995		
	4060	**8475**	
		4060	
		4415	
Profit and attendance		450	
Net addition		**4865**	4865
			1,940,463
Adjustment for fluctuations (inflation) including sub-contractors			
*(i) increase on work to date		6500	
*(ii) allowance for effect on of current increases on remainder of work		65,000	
*(ii) allowance for possible future increases (say)		40,000	
		111,500	111,500
	Total estimated final cost		**2,051,963**
Amount included for contingencies			
Contingency sum in contract			30,000
*Sundry minor variations (net extra)		2200	
Likely claim for delay in connection with GF *walling layout (site meeting 05.07.2006)		12,000	
		14,200	14,200
	Balance remaining		**15,800**

VAT and professional fees not included in above figures.
*Indicates changed or additional item since previous cost report.

Figure 18.2 Real-time cost report no. 3.

18.5 Real-time cost control of cost reimbursement contracts

The situation here is quite different. There is no contract sum as a starting-off point and no possibility of contractual commitment to estimates of original or extra costs, so that real-time cost control by the QS becomes of fundamental importance.

On the other hand, there is no price mechanism to cloud the issue, and thus no valid commercial reason why the contractor's own estimates and costings should not be made fully available to the client's representatives on a so-called open-book basis.

It is preferable that cost control of the project should be carried out by the QS cooperatively with the contractor, since two heads will certainly be better than one and full advantage can be taken of the absence of commercial secrecy, which is one of the main benefits of this type of contract. At any point in the project, the QS's cost control report is likely to be based on the following:

- the QS's original estimate of cost, which should have incorporated an allowance for inflation;
- the QS's estimate of cost of variations, which also should have incorporated an allowance for inflation;
- any adjustment of estimated cost for actual cost of work completed or expenditure committed, where this is different to what was envisaged;
- any adjustment to the estimated cost of current or future work in the light of this experience.

Towards the end of the project, the QS will probably switch to a simpler system involving the ascertained cost of work completed plus the estimated cost of the remaining work required.

The QS's original estimate is likely to be based on approximate quantities, and so are the QS estimates of the likely cost of variations. However, in both cases, and especially the latter, a 'resource-based' approach may be adopted in cooperation with the contractor.

Even where approximate quantities are used, however, all estimates should be discussed with the contractor before being given to the client. The purpose of this cooperation is twofold:

- to ensure that the QS has not made any false assumptions;
- to enable a positive contribution to be made where the QS thinks that the methods or equipment which the contractor is proposing to use are unnecessarily expensive or inefficient.

It must be remembered that the builder's usual incentive to cost cutting will be absent, since it is the client's money, not the contractor's, which is being spent. In such an event there may have to be a meeting between the architect, QS and contractor to decide what is to be done; this could in some instances involve minor redesign to enable something to be built more efficiently. This aspect of cost control is an important part of the QS's contribution.

A most difficult part of the whole task will be the replacement of estimated costs by actual ascertained costs. Under some forms used for cost-reimbursement contracts, the contractor's responsibility for costs is limited to providing a periodic statement of total labour and plant costs to date, and a list of invoices received. Such a document is totally useless for cost control purposes both in format and in timing, since invoices are often not available until weeks or even months after the cost commitment has been incurred. The QS must, therefore, ensure that the contractual arrangements provide for the following.

- Facilities for the client's representatives to participate in the contractor's estimating and work planning procedures and in the appointment and control of sub-contractors.
- The use of the contractor's own detailed costing system for the benefit of the client's representatives, or alternatively the installation of a suitable system where the contractor's system is unsuitable or non-existent.
- Early disclosure of all papers concerned with ordering, costing, delivery or pricing.

It must be made clear prior to the contractor's appointment that these requirements exist, and they must be incorporated into the contract. The arrangements must not rely upon goodwill, since at the least they are inconvenient to the contractor and are certain to involve some expense. This will need to be reflected in the contractor's fee.

The costing system will have to separate the costs in respect of specific parts of the work which correspond to identifiable portions of the QS's estimate, otherwise any form of reconciliation between costs and estimate will be impossible until the whole job is complete. This means in turn that the QS's estimate will need to be structured suitably with this need in mind, an elemental basis being quite a good one. However, work executed by different trades at different times should not be telescoped into a single priced item (e.g. roof carcassing and roof tiling).

A further point to watch is delay in reporting; costs of plant and materials may take some time to work through the contractor's office system and a method has to be devised for overcoming this delay. For example, materials could be priced from delivery dockets – which should be instantly available. Reconciliation of delivered materials with measurements of major items of work should also be carried out to ensure that there are no unexplained differences up or down because of theft, excessive wastage or clerical error.

Reconciliation of allowances for inflation poses some further problems, since these will often not be separately identified in the ascertained costs of resources. In most cases, some form of approximation will be adequate in showing how much of the cost of some particular operation should be set against the allowance for inflation, since expensive and complicated book-keeping arrangements which do not affect the total to be paid are unlikely to yield any commensurate benefit to the client. Under this type of contract, the client is always going to have to meet the cost of inflation. Allowances for future inflation may need to be revised from time to time, as was the case with cost control of 'fluctuating' lump sum contracts.

18.5.1 Cost control of sub-contractors on cost reimbursement contracts

It is necessary to watch closely the arrangements for sub-contractors. The builder, in collaboration with the QS, will be seeking separate tenders from all the specialist sub-contractors, and each of these has to be dealt with separately. It might seem a good idea to try and obtain the most important tenders at more or less the same time, since it would then be possible to consider their total effect on the cost of the project. However, this is rarely advantageous in practice since cost reimbursement is most likely to be used on projects where design and construction proceed more or less simultaneously, with the design of later stages of the work going on while earlier stages are being executed.

Specialist work should not be tendered for until the design work on that particular specialism has been completed, otherwise unnecessary variations are likely (and this will be no help whatever to cost control). So it is more usual to carry out the cost control of such projects with the budgets for the specialist works contractors being turned into firm prices one by one. This means that it may often be possible to appoint the specialists on a price basis rather than a cost basis, as the work may be more clearly defined by the time they are involved. For example, the structural items to which finishes are to be applied may actually have been built.

Competitive tendering for sub-contracts might well be possible; again if the QS does not look after this then nobody else will. Without such control, it is much easier for the builder just to ring up a friendly sub-contractor and make the necessary arrangements.

Leaving the calling of tenders for specialist work until they are needed also has the advantage that it is possible to amend the budgets (and specifications) for later specialists if there are cost over-runs on the earlier ones, so that tenders can be sought on the revised basis. This gives better cost control than having to amend work contracts to obtain savings, as may happen if tenders have been called too early.

18.5.2 Difficulties with combining price-based work and cost-reimbursed work on the one project

Great care is necessary when work on a price basis and work on a cost reimbursement basis are both included in the same contract. This is only likely to be satisfactory where one or more of the following circumstances exists:

- The cost reimbursement work is only a negligible proportion of the whole (e.g. incidental dayworks on a lump sum contract).
- The two types of payment apply to two separate organisations (e.g. the main contractor and a sub-contractor).
- The cost reimbursement work is carried out by a separate gang of people using special materials.
- The two types of work are carried out at different periods or at different sites.

Unless at least one of these conditions is fulfilled, there will be a tendency for labour and/or materials used in the price-based work to be charged to the cost reimbursement work, thus being paid for twice. This is almost impossible to check without continuous monitoring. An example of the type of project where this could happen would be an extension to an existing building where the extension was to be paid for as a lump sum but the alterations in the existing building were done on a cost reimbursement basis. It would be very difficult to ensure that operatives' time was charged to the correct part of the work if it was all proceeding simultaneously, and even more difficult to check afterwards that this had been done. Such hybrid arrangements should therefore be avoided.

It has been seen that the real-time cost control of cost reimbursement contracts involves the skilful combination of contractors' costing systems and client budgeting and cost strategies, and is likely to be expensive. There is no halfway house, however; cost control of this type of project can only be done properly or not at all. Clients must make up their minds about this at the beginning, under appropriate advisement. The internal cost control of a package deal contract would have many features in common with the above procedures.

18.6 Real-time cost control of management contracts

In many ways, the procedures would resemble those on a cost reimbursement contract, but probably at a more strategic level since the work will be undertaken using a number of different contracts, any of which in turn may require its own cost control procedures of the appropriate type already discussed. The remarks made above concerning sub-contracts on cost reimbursement work will apply to all the work contracts.

On a really large project, it is not necessary that the whole of a particular work package must be let at once, and there would be advantages in letting a package in several parts at different times if only some areas of the project have been fully designed.

Nevertheless, the general pattern set out in Sections 18.3 and 18.4 will also apply to the project as a whole.

18.6.1 A spreadsheet cost report on a management contract

In Figure 18.3, a financial report (No. 5) on a sports training centre is shown. Where reports such as this are being generated by computer, they are likely to be updated as changes occur, rather than on a monthly or other period basis.

Trade package	Package reference	Estimated value Cost plan (A)	Transfers within cost plan	Adjusted cost plan (A2)	Package sum (B)	Confirmed instructions (C)	Anticipated instructions (D)	Anticipated Final cost E = (B + C + D)	Difference with adjusted cost plan (E − A2)	Package procurement status
Sub-structure and ground works	1100	282,000.00	81,313.00	363,313.00	370,086.07	3200.00	5300.00	378,586.07	15,273.07	Contract let and on site
Steelwork	1200	275,000.00		275,000.00	258,921.00	1000.00	15,000.00	274,921.00	−79.00	Contract let and on site
Precast floors and stairs	1300	44,500.00		44,500.00	42,194.00			42,194.00	−2306.00	Contract let
Roof system and rainwater goods	1400	199,000.00		199,000.00	192,545.00			192,545.00	−6455.00	Out to tender
Rooflights, patent glazing, windows and curtain walling	1500	110,000.00		110,000.00	110,000.00			110,000.00	0.00	Out to tender
Masonry	1600	109,000.00	13,600.00	122,600.00	122,600.00			122,600.00	0.00	Out to tender
Internal partitions	1700	35,000.00		35,000.00	35,000.00			35,000.00	0.00	
Joinery, doors and ironmongery	2000	100,000.00	12,000.00	112,000.00	112,000.00			112,000.00	0.00	
Plastering/ screeds	2100	60,000.00		60,000.00	60,000.00			60,000.00	0.00	

Trade package	Package reference	Estimated value Cost plan (A)	Transfers within cost plan	Adjusted cost plan (A2)	Package sum (B)	Confirmed instruc-tions (C)	Anticipated instruc-tions (D)	Anticipated Final cost E = (B +C + D)	Difference with adjusted cost plan (E − A2)	Package procure-ment status
Decorations/ painting	2200	55,000.00		55,000.00	55,000.00			55,000.00	0.00	
Floor finishes	2500	145,000.00		145,000.00	145,000.00			145,000.00	0.00	
Ceilings	2700	45,000.00		45,000.00	45,000.00			45,000.00	0.00	
Mechnical and electrical instalations	3000	800,000.00	−81,313.00	718,687.00	718,687.00			718,687.00	0.00	Out to tender
Builders work in connection with services	3500	30,000.00		30,000.00	30,000.00			30,000.00	0.00	
Toilet cubicles, back panels and vanity units	4000	40,000.00		40,000.00	40,000.00			40,000.00	0.00	
Loose fittings, furniture and equipment	5000	270,000.00		270,000.00	270,000.00			270,000.00	0.00	
External works and landscaping	6000	220,000.00		220,000.00	220,000.00			220,000.00	0.00	
Sub total		**2,819,500.00**	**25,600.00**	**2,845,100.00**	**2,827,033.07**	**4200.00**	**20,300.00**	**2,851,533.07**	**6433.07**	

Trade package	Package reference	Estimated value Cost plan (A)	Transfers within cost plan	Adjusted cost plan (A2)	Package sum (B)	Confirmed instructions (C)	Anticipated instructions (D)	Anticipated Final cost E = (B +C + D)	Difference with adjusted cost plan (E − A2)	Package procurement status
Contractors percentage for overheads and profit at 4%		**112,780.00**	**1024.00**	**113,804.00**	**113,081.32**	**168.00**	**812.00**	**114,061.32**	**257.32**	
Contractors preliminaries		291,556.16		291,556.16	291,556.16		20,000.00	311,556.16	20,000.00	
Package interface (contingencies)		189,900.84		163,276.84	182,066.45		−45,480.00	136,586.45	−26,690.39	
Total project cost (£)		**3,413,737.00**	**26,624.00**	**3,413,737.00**	**3,413,737.00**	**4368.00**	**−4368.00**	**3,413,737.00**	**0.00**	

Figure 18.3 Bloggsville United Training Centre Financial Summary No. 5.

Spreadsheet output should always be checked arithmetically, as a matter of good practice. Although computers do not make mistakes in carrying out the calculations which they have been instructed to do, it is always possible to give them the wrong instructions in compiling a spreadsheet.

Some points to note in this example:

1. The figures exclude VAT and professional fees.
2. The 'Estimated value' column represents the cost plan, against which the client's budget has been set. The client may be holding additional project contingencies, not displayed here, as on the 'open book' basis the contractor has input to, and receives, this summary.
3. Figures in the 'Transfers within cost plan' column indicate where amounts have been transferred between packages in the cost plan, for example, the transfer of drainage from 'M&E Installations' to the 'Groundworks' package. These changes result in the adjusted cost plan, which should always total the same as the 'cost plan', although constituent parts will vary.
4. In the 'Package sum (B)' column, the figures are the same as in the adjusted cost plan unless tenders have been received and sub-contractors appointed, when the revised figures are inserted (in italics, to make clear that this has been done).
5. Columns C and D represent variations to the package values, whether formally instructed or merely anticipated.
6. The most important column is the 'Anticipated final cost' (B+C+D) column, which indicates where the project is heading financially, both on a package-by-package basis and overall. It will be seen that this total is at the moment the same as the 'Adjusted cost plan', but note that this has been achieved by a reduction in the 'Package interface (contingencies)' figure. A 'zero' (0.00) in the 'Diff. with adjusted cost plan' column confirms that the anticipated final cost does not exceed the budget.
7. The main contractor's (construction manager's) costs and the preliminary costs are included as a percentage of the package costs. (These were determined by competitive tender.)
8. Note that a sum of £200,000 is included for estimated preliminary costs associated with an anticipated 2-week extension of time relating to problems encountered with the sub-structure and foundations.

18.6.2 Control of cash flow

So far in this chapter, we have ignored the phasing of expenditure, except in so far as the effect of inflation on costs is concerned. However, in practice, client organisations are usually very concerned about the sums of money they will be called upon to pay at any given time, and may require a cash flow estimate from the QS before signing the contract, rather of the type shown in Table 3 (Chapter 6) with respect to the block of flats. They will need this in order to make adequate arrangements to raise the money, irrespective of whether they are operating in the profit sector or in the social sector. Quite clearly they are unlikely to be able to place the whole contract amount in their bank trading accounts at the beginning of the project, ready to be drawn upon as required over the contract period. Even if they were theoretically in a position to do this, they would still have more profitable uses for the money in the interim, which would probably mean that it would not be instantly available.

The cash flow estimate will require to be revised by the QS from time to time, preferably at the same intervals as the real-time cost control reports. These revisions will take into account not only any changes in total cost but also the extent to which some aspects of the programme are running faster or slower than anticipated, or indeed whether the whole programme has slipped. In many cases, a periodic report of this kind may be all that is required, giving the client an updated warning of cash requirements. In addition to the performance of this function, such a report may also be very useful in monitoring programme slippage, because the level of cash flow required to complete on time may be seen to be quite impossible in the light of experience to date.

However, in some instances, a client will need not merely a report of what is likely to happen but some positive form of control. In the case of a cost reimbursement contract, it should be possible to order an increased or decreased tempo of work, and few problems arise. In management projects also, the placing of contracts can be deferred or work accelerated, but serious difficulties occur in the case of lump sum BQ contracts on the standard form. Once a contract has been signed using the British JCT Standard Form of Contract, the contractor is not answerable for the phasing of expenditure. The contracting firm does not have to provide an estimate of client's cash flow, and even if they agree to do so as a favour they cannot be held to perform in accordance with it. Their only duty is to proceed 'regularly and diligently' and to complete by the appointed date or a later date which may be agreed upon because of delays.

It is in the contractor's interest to obtain high levels of payment in the early stages of the project in order to finance the later stages and so the prices for earlier parts of the work may be inflated, and early deliveries of materials arranged, to achieve this. Therefore, if a positive form of cash flow control is required, a suitable provision will have to be made in the actual contract (with legal advice), and not merely in the BQ or in correspondence. The contract might state a month-by-month cash flow programme with the following provisions.

The contractor would not be reimbursed ahead of this programme if the work was carried out faster than scheduled.

If expenditure fell behind the programme, there could either be a provision for damages to be ascertained or, more constructively, for the difference between the programmed amount and the actual expenditure to be paid into a trust fund. It might be thought that there would be no damage to the client's interests if expenditure fell behind the programme (provided the job was finally completed on time), but in the public sector and in some large private corporations construction is often funded on an annual basis and amounts unspent at the end of the financial year may be permanently lost to the authority or department concerned.

In the profit sector, however, quite apart from their general wish to reduce the cost of financing their cash flow, clients may find it difficult to raise the total cost of construction until nearer the time when the building will actually be producing an income. They might therefore arrange for the contractor to bear part of the building cost during construction or even to take a share in the risk of the development. In such cases, it would be essential for the arrangements for funding during the progress of the works to be formalised in the contract.

18.6.3 Cash flow control of major development schemes

Major development schemes may extend over many years and may include a large number of building contracts entered into at different times. Cash flow control is necessary in the running of public development schemes to ensure that money is available to meet outgoings. If a development scheme is funded on an accrual basis (i.e. unspent funds, which have been allocated to, can be carried forward from year to year), and if it is not possible to lend out money at a profit (perhaps because the authority has not got the necessary powers), then nothing more than a 'passive' control of cash flow will be required. The authority will simply need to order its financial affairs to suit what is happening.

However, public funding is often on a yearly basis, in which unspent funds in one sector are not carried forward for the benefit of the project or authority for which they were allocated, but are used to meet overspending in other sectors or applied to a reduction in government expenditure. In addition, most major building projects involve an unavoidable commitment to expenditure for some years ahead, although the authority's budget for these years may be unconfirmed when the commitment is entered into.

Trouble may then occur if major construction projects fall behind schedule, so that much of the expenditure which should have taken place in the current year becomes a commitment in future years, and the cash balance which is left at the end of the current year will be lost to the authority with no certainty of picking it up again when it is needed. It is, therefore, necessary to manipulate cashflow in the light of changes so that:

- The year's allocation of funds is completely but productively spent and a realistic revision can be made of cash requirements for ensuing years.
- The ongoing programme can be hastily amended if funds are reduced (or increased!) in any particular year.

This could be called 'active' or 'positive' control of cash flow.

In any authority's development budget the expenditure will fall into three categories, and in each of these categories the discretionary factor in expenditure is progressively increased.

Old projects

These are projects which have been completed but for which full payment has not yet been made (possibly depending on the outcome of litigation, arbitration or negotiation). Once payments are due they will have to be met.

Current projects

It may be possible, and worthwhile, for an authority to order a speed-up or slow-down of current projects in order to change its cash commitment during the year, even at the expense of an eventual increase in total cost. What more usually happens, however, is that circumstances beyond the authority's control cause such changes, and the cash flow budgeting has to be revised to suit. Almost invariably, expenditure tends to fall behind estimate because of delays in progress, although this may sometimes be counterbalanced to some extent by extras and by inflation.

It might be thought that if an authority had a large number of projects on hand (such as a programme of 10 schools), the differences would tend to average out. But this tends not to happen in practice because the causes of delay are often national or regional in character – weather, industrial disputes, labour shortages and so on.

New projects

It is these which offer the greatest scope for control. If the start of a 2-year project worth £10,000,000 is brought forward or put back by 1 month, the effect is likely to be an increase or decrease by £400,000 in the current year's cash flow, and correspondingly greater for longer periods than 1 month. There are two major difficulties however:

- The starting of a major project may have a comparatively small effect in the year in which the go ahead is given (but it will then join the ranks of the current projects and will be an inescapable and major commitment for the following 2 years or more).

- Expenditure on projects tends to follow the well-known 'S' curve where the rate of spending is at its greatest in the middle period of the project, with a comparatively slow build-up in the early stages.

In many ways, the best way to control the cash flow situation is by having a number of smaller short-term projects ready to roll. These can be largely completed during the financial year in question, even if the order is not given until the year is quite well advanced.

An obvious method of disbursing funds on a project which is falling behind programme is to pay for the work, or for materials, ahead of the legal liability to do so. There are obvious dangers in doing this, and a public auditor would be unlikely to accept a straightforward attempt to do it. It might, however, be possible to pay money into a joint trust fund.

18.6.4 Control of short-term cash flow

Up to now, we have been considering cash flow as though we are simply concerned with the year as a whole, but this is rarely the case. Funds are not normally paid across to an authority in a single sum at the beginning of the year, nor are they paid as each cash commitment arises, but are usually paid in quarterly instalments or something of the kind.

Quite clearly, therefore, the authority must avoid too much cash expenditure in the early part of the year since funds will not be available, while if it is empowered to lend surplus short-term money profitably it may be able to arrange matters so that it can do this. With quarterly funding, even where there is a smooth monthly outgoing throughout the year, the money for the third month of any quarter will be available for an alternative use during the first 2 months.

18.6.5 Payment delays on profit projects will be to the client's advantage

Although the previous section has been written in the context of public or social development, much of it is equally applicable to profit schemes, except that the problem of 'spending all the money by the end of the year' is not so likely to occur. Any pressure is likely to be in the opposite direction; the question of interest on money borrowed becomes of paramount importance so that any pushing back of payment dates will be welcomed, so long as final completion is not held up. It is not unknown for this to happen in the public domain.

An overseas regional government, which was anxious to minimise the effects of a slump in the local building industry, but had spent all its funds for the year, let contracts on the basis that no payment would be made until the following financial year, so that for the first 6 months or more the contractors were totally financing the programme. However, as would be expected, the tenders reflected this additional burden.

18.6.6 Cost control on a resource basis

As with real-time cost control on any other basis, this fundamentally depends on swift and reliable reporting of what is actually happening, and the rapid reconciliation of this with the control document.

The cost controller will be concerned with two different aspects. The first is the overall time for the project. The preparation of the network will have involved a large number of assumptions about the time to be taken by the various activities, and revisions must be made in the light of actual progress. In this context, it is only the activities on the critical or near-critical paths which have to be considered, but any substantial change (for better or worse) may cause a change in the critical path itself and in the duration of the works. Decisions will then have to be made as to whether a different duration is acceptable, or whether the time for remaining activities must be adjusted somehow. In both cases, cost will be substantially affected.

- The second aspect is the cost of individual activities. A costing system has three objectives:
- to measure actual expenditure against estimated cost;
- to indicate whether performance needs to be improved;
- to provide feedback which will improve future estimating performance.

Costs are recorded under 'cost centres'. These can be anything from the whole project to a tiny part of it, but to meet the above-mentioned objectives, costs need to be recorded under headings which can be identified with sections of the estimate. The estimate in turn needs to be prepared in a suitable format to achieve this.

There is a need to establish a level of breakdown which is neither so fine as to make the recording and allocation of labour and material costs unduly detailed, nor so crude that the 'cost centres' are too broad to mean anything. Individual BQ items are normally at too fine a level, a whole trade section would be too crude. A single activity, or a group of activities, from the network is usually a suitable basis.

Costing of site work has two main difficulties that distinguish it from normal production costing as practised in factories and as described in most textbooks on costing. Both difficulties spring from the one-off nature of most of the work in terms of the finished product and of the conditions under which it is produced.

The first problem is that the usual costing system of 'standard costs' does not really apply. A standard cost is an ascertained cost of carrying out an operation which can then be built into an estimating system, and which should normally be achieved in future – any substantial deviation requiring to be investigated. Machining operations in a wood-working shop can be costed on this basis – once a standard sequence of events has been carried out on a machine a number of times (inserting the work, operating on it, withdrawing it), there is no reason why the same operation should not always cost exactly the same in the future.

Site operations are not only less standardised than this, but the position of the work, weather conditions and so on varies continuously. It is very difficult to get a sufficient run of identical work to establish standard costs and still have enough similar work ahead to make it worthwhile to apply them. Certainly it is not usually possible to apply such data from job to job, as a joinery works or engineering works would do.

The second difficulty is that of actually recording and processing costs of labour and materials. When operatives are dispersed about the site, it is almost impossible to record accurately what they are doing except in fairly general terms, unless a quite unacceptably expensive staff is engaged for the purpose. Many sophisticated costing systems have failed through the time sheets being filled in on a Friday afternoon in the foreman's office from memory.

Materials to some extent are an equal problem, as nothing like a factory control system is operated on most sites when materials are drawn from stock. The invoice is often the main weapon in materials cost control, so it is convenient if the cost centres are sufficiently large and identifiable for particular invoices to be identified with them. However, some contractors' systems do not bother overmuch about materials. As we have already seen, these are much less liable than labour and plant costs to deviate from estimate, given a reasonable level of management. This is another advantage, from the contractor's point of view, of not using 'all-in' labour-and-material rates.

All this may sound very defeatist – difficulties exist to be overcome, not to be excused. They can indeed be overcome, but except in some limited circumstances (such as repetitive house building) nobody has found that the cost and trouble of doing this have produced economically worthwhile results, because of the already mentioned difficulty of deriving 'standard costs' from the data for re-use. All one is likely to get is an expensive post-mortem report. A further point to remember is that some of the people on a site, particularly labourers, are doing work which has to be done but which may not have been identified as an operation in the network – sweeping up, carrying odd materials, attending on the Clerk of Works.

It is, therefore, preferable to use fairly broad cost centres 'fixing formwork to second storey', and devote one's attention to getting the feedback rapidly and with a fair degree of reliability. It should then be possible to measure actual expenditure against estimated cost with reasonable accuracy, and also to a somewhat lesser extent fulfil the other two objectives of a costing system.

In the reconciliation of costs and estimate, the difficulties concerning inflation and alterations to the scope of the work, which were mentioned in Chapter 19, will again be encountered. However, the inflation problem can be minimised by working in operative-hours and machine-hours rather than money, for comparison purposes. A contractor's costing system will in any case need to highlight the cost of alterations, because very often these will form an extra to be charged to the client. It will also be necessary to ensure that the cost performance of sub-contractors is kept up-to-date in order to arrive at the projected total for the project, complicated by the fact that these may often be on a price, rather than a cost reimbursement, basis.

18.7 Key points

- 'Real-time'or 'post-contract' cost control differs from design cost planning in many ways, and these will depend on the exact contractual arrangements, but two differences will be inescapable:
  - The interests of a contractor or contractors now form an important addition to the considerations involved.
- Major expenditure is currently being incurred and future options proportionately reduced.
- However, today most clients are even more interested in the final figure than in the amount of the tender. Real-time cost control depends above all things on the QS/cost planner being kept informed as to what is going on. If necessary, requirements to this end must be included in the contract arrangements.
- Regular reports on the financial progress of the job must be submitted to the client during the progress of the work, so that any necessary steps to prevent cost over-runs can be taken before it is too late.

Chapter 19

Cost Planning and Control of Refurbishment, Life Cycle Renewal and Repair Work

19.1 Introduction

The **sustainability** paradigm has irrevocably changed the way that clients procure work and the response to this demand from the construction industry. This, in combination with the heavy demand for development opportunities and increasing land costs, has led to unprecedented growth in refurbishment work, particularly in the residential sector. Liverpool, for example, (which became the European Capital of Culture in 2008) experienced unprecedented levels of construction activity on complex, conservation-based refurbishment projects including façade retention and complete structural renovation. More recently, the Royal Institute of British Architects awarded the prestigous 'Stirling Prize' for 2013 (named after architect James Stirling, who read architecture at the University of Liverpool from 1945–1950) to Astley Castle, a modern two-storey house within the relic of an ancient castle located in Nuneaton, North Warwickshire – the architect is Witherford Watson Mann Architects for the Landmark Trust.

Perhaps the archetypal exemplar of this is the refurbishment/construction of the new London International Eurostar terminal at St Pancras railway station on the Euston Road. Prior to the redevelopment, St Pancras was comprised of two of the most important Victorian era structures – the train shed (completed in 1868), by engineer William Henry Barlow and the St Pancras Chambers, formerly the Midland Grand Hotel (1868–1977) by the renowned architect George Gilbert Scot. The former was the largest single-span structure of that time. The current project involves the complete renovation of the train shed and the hotel buildings plus the construction of new platforms and a permanent way to link the station with other National Rail networks. It is truly one of the most ambitious schemes to grace the UK and is fitting, given the St Pancras has stood empty and decadent since the demise of the London Midland and Scottish railway company prior to nationalisation of British Rail.

Historically, this approach has not been the norm; 40 years or more earlier it was perhaps habitual to think of building schemes in terms of 'green field' projects, that is to say projects erected on an open site (preferably one which had never been built on previously without any of the issues associated with this such as contaminated land, etc.). The classical cost planning techniques which emerged in this era tended to be oriented towards such projects as being the norm. This was rather a convenient assumption, of course; it avoided a good deal of complications but it is doubtful whether it was ever completely appropriate.

Ferry and Brandon's Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

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Today, it is clearly untrue, and a very substantial part of the current UK construction programme comprises

- refurbishment
- renewal work
- life cycle replacement, major maintenance and repair work programmes.

As the last two categories nearly always include some element of improvement, and as refurbishment will usually involve renewal and repair, they can all be considered together for the purposes of cost planning.

Some of what is considered here will also apply to a large proportion of the so-called 'new' work which is being undertaken and involves building on very restricted urban sites between existing buildings with complicated access and close proximity to the general public.

19.2 The appropriateness of lump sum competitive tenders

The uncertainties associated with many major refurbishment projects usually dictate that it is unsuitable and perhaps inadvisable to undertake the scheme on the traditional basis of lump sum competitive tenders for the whole of the works. Lump sum competitive tenders usually

- require that the work to be done can be accurately foreseen, and
- formalise an adversarial relationship between contractor and client's representatives, which is wholly inappropriate for this type of work.

There are exceptions to this, of course, but not very many. The major exception is where a series of similar buildings are being refurbished (on local authority housing estates, for example), and experience with the first few projects by both design team and contractors will enable a schedule of rates, or even a BQ, to be prepared and priced. But normally, **collaborative** methods of procurement strategy will be applied, either on a cost-plus basis or perhaps through management contracting, partnering or a bespoke approach negotiated between the parties.

As part of the **Constructing Excellence demonstration projects**, Oldham Metropolitan Borough Council Housing Department entered into a **partnering** agreement for the delivery of £10 m of external refurbishment work over a three-year period. The works were procured in accordance with EU procurement directives and through a two-stage evaluation method based on an 80/20 quality/price matrix.[1] At Benwell in Newcastle upon Tyne, another demonstration project involved the refurbishment of 163 homes (to include homes and flats) together with a community centre and associated environmental works. This project was procured using a **3-stage selection procedure** to obtain **partnering** contractors and subcontractors.[2]

19.3 Elemental cost planning inappropriate

Whilst it is possible to set out any estimates in an elemental format, the normal process of elemental cost planning is not really appropriate. Principally, it will not be practicable to produce the element-by-element cost comparisons with other projects, which lie at the heart of this technique. The costs will depend on the state of the individual building in relation to what is proposed within the refurbishment works; thus, comparisons with other projects on an elemental basis would effectively be futile. In essence, the cost planning and control of refurbishment work should start from first principles.

19.4 Conflict of objectives

The most important initial step is to recognise the conflict of objectives, which is inherent in refurbishment work. There is of course a conflict between cost, time, quality and size in carrying out straightforward new work, but on such projects the client's interest is simply to optimise the scheme in these terms, and elemental cost planning allows this to be done. However, in refurbishment work these basic objectives are usually supplemented, or even outweighed, by major secondary objectives.

Occasionally a single objective, such as speed of completion, may be strongly dominant and this is little different to new work. But more often, two or more conflicting objectives are perceived as dominant – for instance, continuing occupation required by a 'user' client may hinder the achievement of speedy completion, which is the priority of the 'owner' client.

Even the emergence of a single dominant secondary objective, such as safety of the structure or of the public, may have consequences, which cut across normal procedures, particularly procedures for efficient construction methods or financial control.

The likely extent of conflict can only be identified after a thorough assessment of risks and objectives, and the trade-offs between them. Frequent reviews of the relative benefits compared with the likely cost, time and quality implications will probably be required.

19.5 Risk and uncertainty

Uncertainty is a major characteristic of refurbishment work. Generally, there is a high level of uncertainty, not only in the client objectives but also in available physical data. This is generally due to the rather bespoke nature that refurbishment work assumes. Such uncertainties will probably extend into the construction period with a high likelihood that unforeseen events will occur. This is likely to have a consequence on cost, so careful management is essential. Problems due to uncertainty may be mitigated by

- allowing a longer lead-in time;
- assembling the work into discrete packages;
- seeking advice both of the principal contractor (or construction manager) and any specialist subcontractors and involving them within the project as early as is possible.

Even so there will remain a need for the client, designer and constructor to respond quickly to the discovery of previously unknown features of, or defects in, the existing building.

19.6 Safety

Safety is perhaps the most dominant feature of refurbishment work, and the problems in this area are intensified by the general uncertainty already referred to. Safety affects:

- operatives
- the users of the building
- the general public

and may relate either to the safety of the structure or to the safety of the operations.

Clearly, where safety and cost are in conflict then safety must be paramount, so that it is vital that safety issues be identified at an early stage if estimates are to be relied on. However, safety is not discretionary, so that there are no real choices to be made as regards the level of safety, only the means of ensuring it.

19.7 Occupation and/or relocation costs

Another major issue does, however, involve fundamental choice, and that is the extent to which (if at all) the building should remain in use during the works – often referred to as **partial possession**.[3] Here we can be dogmatic. Just as real estate agents are supposed to believe that the three most important things about a property are location, location and location, so the three most important decisions in connection with refurbishment are undoubtedly occupation, occupation and occupation!

The effects on costs, programme and safety if the building remains in use are so enormous that a client who wishes to do this should be encouraged to think again – and again – to see if some other alternative can be found. It is incumbent on the cost planner to keep pointing this out. A problem in this regard is that, seen in advance, the difficulties of moving out seem much greater than the difficulties of staying put.

Staying put surely only means having to put up with a little dirt, noise and inconvenience for a year or so, whereas moving out will involve

- finding alternative premises;
- moving in to them, and out again at completion;
- getting customers and staff to come to terms with the new location;
- reprinting stationery and literature; and so on.

Seen in advance, moving out appears to be far more of a hassle. This is an illusion!! Staying put involves much more than slight inconvenience!

Recently, Network Rail assumed a **possession**[4] of the West Coast main line south of Birmingham; where possible trains were diverted to other routes but, on the whole, passengers had to travel by rail replacement bus services. The possession was in order to install a new permanent way, overhead line equipment and upgrade the signalling. The project could certainly have been done piecemeal without such drastic action but the time, cost and safety aspects would all have been badly affected, and there would have been just as much inconvenience, only spread over a longer time scale. And exactly the same situation applies to buildings.

If relocation is decided upon, it may be worthwhile to make the timing of the whole project dependent on the availability of suitable alternative accommodation, rather than deciding on the programme first and then trying to see if anything is available at that time.

If relocation does prove to be impossible or unacceptable, then a very realistic allowance must be made for the additional cost and time involved. However, this will not represent the total penalty imposed by the decision – the wear and tear on staff and inconvenience to customers or residents, caused by dust and dirt, continuous noise of plant, temporary access arrangements, and so on, will not appear on the project balance sheet but will show itself in staffing difficulties and reduced patronage.

Even if most of the work is carried out at weekends and at night the dust problem is difficult to overcome. Finding stock, papers, furniture, and so on, covered in dust every morning is one of the greatest irritants to occupants and tends to lead to complaints about everything else. These problems are bad enough for workers and casual users in public and commercial buildings, but are even worse if peoples' homes are concerned.

Unless it is possible to move them out, occupiers will be subjected to the effects of noise, vibration and dust on a more-or-less permanent basis, and the option of mitigating the nuisance by working at night or at weekends will not of course be available. Householders are likely to be a good deal more militant than office or shop workers when subjected to these annoyances, and the presence of children on the site will give rise to problems of their safety on the one hand and of security of the works and vandalism on the other.

19.8 The need for effective liaison and oversight

The problems connected with refurbishment of buildings in occupation underline the importance of the client having a very senior manager employed full time to liaise between the building team and the occupants, with ultimate authority to override either party. The client's buildings officer, who is likely to be the first person thought of for this role, is unlikely to be suitable. In the case of the refurbishment of commercial or public buildings, this person will not be senior enough to be able to dictate to departmental managers, and is probably more used to being ordered around by them. And in the case of housing refurbishment, the role of liaison between residents and contractors will be a particularly demanding one, requiring a person with exceptional interpersonal skills.

This cost of the time of a senior person – who in a commercial organisation would need to be at the Board level – must be allowed for. Allowance will also have to be made for the cost consequences of the decisions which this liaison manager will have to make in order to keep the client's organisation running as smoothly as possible or in order to satisfy the reasonable demands of tenants.

It is almost impossible, within the bounds of reason, to overestimate the total costs of refurbishing a building, which is in occupation!

19.9 Costs excluding occupation

Even without occupation the costs of refurbishment are difficult to estimate, because of the factors associated with uncertainty, which have already been mentioned.

But before any figures are given, the position of the building with regard to 'listed status' must be investigated, as the planning authorities may be able to impose extremely expensive requirements on the scheme. The cost of obtaining, and working with, obsolete or obsolescent materials if this is either required or dictated is likely to be considerable.

A further point to notice is that the cost of temporary works – scaffolding, shoring, and so on, is almost certain to play a much greater part than in the case of new works. Where a major gutting of a building's interior is taking place within retained external walls, such works are likely to be very sophisticated and expensive indeed. This is a type of work where the average cost planner's knowledge of both technology and cost is sometimes weaker than it is with new permanent works. It is therefore essential that a structural engineer be involved in the estimates at an early stage if any major structural work is contemplated.

The advantages of working with companies with an established competence in refurbishment work cannot be overestimated; this applies equally to design and management consultants as it does to construction staff and contractors. Such firms are likely to reflect this within their costs. One method of identifying such organisations within the UK (for public sector clients) is through the **Department for Business, Innovation and Skills Constructionline database**. A response to the Rethinking Construction initiative, it is the UK's register of prequalified construction contractors and consultants. Constructionline is designed to streamline prequalification procedures and is thus ideal for this type of work. The database has been revised and updated for 2006 and at the time of writing, over 12,500 contractors and consultants are registered and have achieved the prequalification requirements supported by the DTI. Constructionline is used regularly by large central government departments and local authorities, universities and NHS Trusts where refurbishment works are required. Constructionline is currently working with e-procurement solution providers (see Chapter 2) to help public sector buyers migrate towards e-procurement whilst continuing to access accredited construction suppliers at no extra cost.

This really leads to the conclusion that if there is a choice between new-build and refurbishment for the client's premises, the problems must be faced squarely at the start – tight, overoptimistic estimating has absolutely no place here. Cost overruns are not preferable at any time; but if the implication is that on hindsight an incorrect decision had been taken by the client (with professional advice), then the consequences are likely to be more than usually serious.

The cost control process should follow the usual real-time methods set out in Chapter 18. A particular point to observe, however, concerns the letting of work packages to trade or specialist contractors. On new-build work it is usually considered beneficial to secure this fairly early in the project, so that actual quotations can go into the estimated cost in place of the cost planner's estimates. However, it is often better in refurbishment work to wait until the efforts of other trades have reached a point where the specialist's work package can be properly defined and a firm price obtained (perhaps even in competition). In the case of a large project, the inconvenience of letting, say, the plastering work in several separate packages could well be justified by the ability to get firm prices for each stage of the work.

Finally, it is essential to be aware, and keep the client aware also, of the current cost situation as the project develops. It is crucial on this type of project, as the probability of cost escalation is higher than it would be on other types of project.

19.10 Summing up

Uncertainty is a major characteristic of refurbishment work, and this means that it will usually be inadvisable to undertake the project on the traditional basis of lump sum competitive tenders for the whole of the work. So, other more collaborative methods of procurement have to be used – either cost-plus or some form of management contracting. And although it is obviously possible to set out any estimates in an elemental format, the normal process of elemental cost planning is not really applicable, and cost planning must start from first principles.

The most important initial step is to recognise the conflict of objectives, which is inherent in such work. The effect on costs, programme and safety if the building remains in use are so enormous that a client who wishes to do this should be encouraged to see if some other alternative can be found. If not, it is important for the client to have a very senior manager employed full time to liaise between the building team and the occupants, with ultimate authority to override either party.

Further Reading

RICS (2012) BCIS Alterations and Refurbishment Price Book 2012, Building Cost Information, ISBN: 9781907196201.

RICS Building Maintenance Panel (2000) Building Maintenance: Strategy, Planning and Procurement, RICS Books, ISBN: 0854069771.

Highfield, D (2000) Refurbishment and Upgrading of Buildings, Spon Press, ISBN 9780419231608.

Endnotes

1 Client: First Choice Homes (Oldham Metropolitan Borough Council), Construction Value, £10.0M, Refurbishment Works, November 2000, Collaborative Procurement (Partnering) agreement using PPC 2000.
2 Client: The Guinness Trust, Construction Value £1.0M, Refurbishment Works, November 2000, Collaborative Procurement (Partnering) agreement using PPC 2000.
3 It should be noted that partial possession is an important concept in contractual issues (such as in the JCT 11 Standard Forms) and occurs when the employer takes possession of part of the works before the project has been fully completed.
4 A possession, in railway parlance, is the occupation of a section of permanent way by a contractor in order to complete a project. This requires that no trains use the "possessed" section during the period set aside for the works.

Appendix A

A.1 Discounting and interest formulae and tables

You should refer to Chapter 6 of this text book for the relevant formulae associated with these tables.

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Table A.1 Compound interest. Value at end of each period of £1 invested at the beginning of period 1 and accumulating at compound interest from 1 to 30% per period.

Period	1% £	1.5% £	2% £	2.5% £	3% £	3.5% £	4% £	5% £	6% £	7% £	8% £	9% £	10% £	11% £	12% £	13% £	14% £	15% £	20% £	25% £	30% £
1	1.01	1.02	1.02	1.03	1.03	1.04	1.40	1.06	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.20	1.25	1.30
2	1.02	1.03	1.04	1.05	1.06	1.07	1.96	1.12	1.12	1.14	1.17	1.19	1.21	1.23	1.25	1.28	1.30	1.32	1.44	1.56	1.69
3	1.03	1.05	1.06	1.08	1.09	1.11	2.74	1.19	1.19	1.23	1.26	1.30	1.33	1.37	1.40	1.44	1.48	1.52	1.73	1.95	2.20
4	1.04	1.06	1.08	1.10	1.13	1.15	3.84	1.26	1.26	1.31	1.36	1.41	1.46	1.52	1.57	1.63	1.69	1.75	2.07	2.44	2.86
5	1.05	1.08	1.10	1.13	1.16	1.19	5.38	1.34	1.34	1.40	1.47	1.54	1.61	1.69	1.76	1.84	1.93	2.01	2.49	3.05	3.71
6	1.06	1.09	1.13	1.16	1.19	1.23	7.53	1.42	1.42	1.50	1.59	1.68	1.77	1.87	1.97	2.08	2.19	2.31	2.99	3.81	4.83
7	1.07	1.11	1.15	1.19	1.23	1.27	10.54	1.50	1.50	1.61	1.71	1.83	1.95	2.08	2.21	2.35	2.50	2.66	3.58	4.77	6.27
8	1.08	1.13	1.17	1.22	1.27	1.32	14.76	1.59	1.59	1.72	1.85	1.99	2.14	2.30	2.48	2.66	2.85	3.06	4.30	5.96	8.16
9	1.09	1.14	1.20	1.25	1.30	1.36	20.66	1.69	1.69	1.84	2.00	2.17	2.36	2.56	2.77	3.00	3.25	3.52	5.16	7.45	10.60
10	1.10	1.16	1.22	1.28	1.34	1.41	28.93	1.79	1.79	1.97	2.16	2.37	2.59	2.84	3.11	3.39	3.71	4.05	6.19	9.31	13.79
11	1.12	1.18	1.24	1.31	1.38	1.46	40.50	1.90	1.90	2.10	2.33	2.58	2.85	3.15	3.48	3.84	4.23	4.65	7.43	11.64	17.92
12	1.13	1.20	1.27	1.34	1.43	1.51	56.69	2.01	2.01	2.25	2.52	2.81	3.14	3.50	3.90	4.33	4.82	5.35	8.92	14.55	23.30
13	1.14	1.21	1.29	1.38	1.47	1.56	79.37	2.13	2.13	2.41	2.72	3.07	3.45	3.88	4.36	4.90	5.49	6.15	10.70	18.19	30.29
14	1.15	1.23	1.32	1.41	1.51	1.62	111.12	2.26	2.26	2.58	2.94	3.34	3.80	4.31	4.89	5.53	6.26	7.08	12.84	22.74	39.37
15	1.16	1.25	1.35	1.45	1.56	1.68	155.57	2.40	2.40	2.76	3.17	3.64	4.18	4.78	5.47	6.25	7.14	8.14	15.41	28.42	51.19
16	1.17	1.27	1.37	1.48	1.60	1.73	217.80	2.54	2.54	2.95	3.43	3.97	4.59	5.31	6.13	7.07	8.14	9.36	18.49	35.53	66.54
17	1.18	1.29	1.40	1.52	1.65	1.79	304.91	2.69	2.69	3.16	3.70	4.33	5.05	5.90	6.87	7.99	9.28	10.76	22.19	44.41	86.50
18	1.20	1.31	1.43	1.56	1.70	1.86	426.88	2.85	2.85	3.38	4.00	4.72	5.56	6.54	7.69	9.02	10.58	12.38	26.62	55.51	112.46
19	1.21	1.33	1.46	1.60	1.75	1.92	597.63	3.03	3.03	3.62	4.32	5.14	6.12	7.26	8.61	10.20	12.06	14.23	31.95	69.39	146.19
20	1.22	1.35	1.49	1.64	1.81	1.99	836.68	3.21	3.21	3.87	4.66	5.60	6.73	8.06	9.65	11.52	13.74	16.37	38.34	86.74	190.05
21	1.23	1.37	1.52	1.68	1.86	2.06	1171.36	3.40	3.40	4.14	5.03	6.11	7.40	8.95	10.80	13.02	15.67	18.82	46.01	108.42	247.06
22	1.24	1.39	1.55	1.72	1.92	2.13	1639.90	3.60	3.60	4.43	5.44	6.66	8.14	9.93	12.10	14.71	17.86	21.64	55.21	135.53	321.18
23	1.26	1.41	1.58	1.76	1.97	2.21	2295.86	3.82	3.82	4.74	5.87	7.26	8.95	11.03	13.55	16.63	20.36	24.89	66.25	169.41	417.54
24	1.27	1.43	1.61	1.81	2.03	2.28	3214.20	4.05	4.05	5.07	6.34	7.91	9.85	12.24	15.18	18.79	23.21	28.63	79.50	211.76	542.80
25	1.28	1.45	1.64	1.85	2.09	2.36	4499.88	4.29	4.29	5.43	6.85	8.62	10.83	13.59	17.00	21.23	26.46	32.92	95.40	264.70	705.64

26	1.30	1.47	1.67	1.90	2.16	2.45	6299.83	4.55	4.55	5.81	7.40	9.40	11.92	15.08	19.04	23.99	30.17	37.86	114.48	330.87	917.33
27	1.31	1.49	1.71	1.95	2.22	2.53	8819.76	4.82	4.82	6.21	7.99	10.25	13.11	16.74	21.32	27.11	34.39	43.54	137.37	413.59	1192.53
28	1.32	1.52	1.74	2.00	2.29	2.62	12347.67	5.11	5.11	6.65	8.63	11.17	14.42	18.58	23.88	30.63	39.20	50.07	164.84	516.99	1550.29
29	1.33	1.54	1.78	2.05	2.36	2.71	17286.74	5.42	5.42	7.11	9.32	12.17	15.86	20.62	26.75	34.62	44.69	57.58	197.81	646.23	2015.38
30	1.35	1.56	1.81	2.10	2.43	2.81	24201.43	5.74	5.74	7.61	10.06	13.27	17.45	22.89	29.96	39.12	50.95	66.21	237.38	807.79	2620.00
31	1.36	1.59	1.85	2.15	2.50	2.91	33882.01	6.09	6.09	8.15	10.87	14.46	19.19	25.41	33.56	44.20	58.08	76.14	284.85	1009.74	3405.99
32	1.37	1.61	1.88	2.20	2.58	3.01	47434.81	6.45	6.45	8.72	11.74	15.76	21.11	28.21	37.58	49.95	66.21	87.57	341.82	1262.18	4427.79
33	1.39	1.63	1.92	2.26	2.65	3.11	66408.73	6.84	6.84	9.33	12.68	17.18	23.23	31.31	42.09	56.44	75.48	100.70	410.19	1577.72	5756.13
34	1.40	1.66	1.96	2.32	2.73	3.22	92972.22	7.25	7.25	9.98	13.69	18.73	25.55	34.75	47.14	63.78	86.05	115.80	492.22	1972.15	7482.97
35	1.42	1.68	2.00	2.37	2.81	3.33	130161.11	7.69	7.69	10.68	14.79	20.41	28.10	38.57	52.80	72.07	98.10	133.18	590.67	2465.19	9727.86
36	1.43	1.71	2.04	2.43	2.90	3.45	182225.56	8.15	8.15	11.42	15.97	22.25	30.91	42.82	59.14	81.44	111.83	153.15	708.80	3081.49	12646.22
37	1.45	1.73	2.08	2.49	2.99	3.57	255115.78	8.64	8.64	12.22	17.25	24.25	34.00	47.53	66.23	92.02	127.49	176.12	850.56	3851.86	16440.08
38	1.46	1.76	2.12	2.56	3.07	3.70	357162.09	9.15	9.15	13.08	18.63	26.44	37.40	52.76	74.18	103.99	145.34	202.54	1020.67	4814.82	21372.11
39	1.47	1.79	2.16	2.62	3.17	3.83	500026.93	9.70	9.70	13.99	20.12	28.82	41.14	58.56	83.08	117.51	165.69	232.92	1224.81	6018.53	27783.74
40	1.49	1.81	2.21	2.69	3.26	3.96	700037.70	10.29	10.29	14.97	21.72	31.41	45.26	65.00	93.05	132.78	188.88	267.86	1469.77	7523.16	36118.86

Table A.2 Future value of £1 invested at regular intervals (value of £1 invested regularly at end of each period (i.e. weekly, monthly, annually) accumulating at compound interest.

Period	1% £	1.5% £	2% £	2.5% £	3% £	3.5% £	4% £	5% £	6% £	7% £	8% £	9% £	10% £	11% £	12% £	13% £	14% £	15% £	20% £	25% £	30% £
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	2.01	2.01	2.02	2.03	2.03	2.04	2.04	2.05	2.06	2.07	2.08	2.09	2.10	2.11	2.12	2.13	2.14	2.15	2.20	2.25	2.30
3	3.03	3.05	3.06	3.08	3.09	3.11	3.12	3.15	3.18	3.21	3.25	3.28	3.31	3.34	3.37	3.41	3.44	3.47	3.64	3.81	3.99
4	4.06	4.09	4.12	4.15	4.18	4.21	4.25	4.31	4.37	4.44	4.51	4.57	4.64	4.71	4.78	4.85	4.92	4.99	5.37	5.77	6.19
5	5.10	5.15	5.20	5.26	5.31	5.36	5.42	5.53	5.64	5.75	5.87	5.98	6.11	6.23	6.35	6.48	6.61	6.74	7.44	8.21	9.04
6	6.15	6.23	6.31	6.39	6.47	6.55	6.63	6.80	6.98	7.15	7.34	7.52	7.72	7.91	8.12	8.32	8.54	8.75	9.93	11.26	12.76
7	7.21	7.32	7.43	7.55	7.66	7.78	7.90	8.14	8.39	8.65	8.92	9.20	9.49	9.78	10.09	10.40	10.73	11.07	12.92	15.07	17.58
8	8.29	8.43	8.58	8.74	8.89	9.05	9.21	9.55	9.90	10.26	10.64	11.03	11.44	11.86	12.30	12.76	13.23	13.73	16.50	19.84	23.86
9	9.37	9.56	9.75	9.95	10.16	10.37	10.58	11.03	11.49	11.98	12.49	13.02	13.58	14.16	14.78	15.42	16.09	16.79	20.80	25.80	32.01
10	10.46	10.70	10.95	11.20	11.46	11.73	12.01	12.58	13.18	13.82	14.49	15.19	15.94	16.72	17.55	18.42	19.34	20.30	25.96	33.25	42.62
11	11.57	11.86	12.17	12.48	12.81	13.14	13.49	14.21	14.97	15.78	16.65	17.56	18.53	19.56	20.65	21.81	23.04	24.35	32.15	42.57	56.41
12	12.68	13.04	13.41	13.80	14.19	14.60	15.03	15.92	16.87	17.89	18.98	20.14	21.38	22.71	24.13	25.65	27.27	29.00	39.58	54.21	74.33
13	13.81	14.24	14.68	15.14	15.62	16.11	16.63	17.71	18.88	20.14	21.50	22.95	24.52	26.21	28.03	29.98	32.09	34.35	48.50	68.76	97.63
14	14.95	15.45	15.97	16.52	17.09	17.68	18.29	19.60	21.02	22.55	24.21	26.02	27.97	30.09	32.39	34.88	37.58	40.50	59.20	86.95	127.91
15	16.10	16.68	17.29	17.93	18.60	19.30	20.02	21.58	23.28	25.13	27.15	29.36	31.77	34.41	37.28	40.42	43.84	47.58	72.04	109.69	167.29
16	17.26	17.93	18.64	19.38	20.16	20.97	21.82	23.66	25.67	27.89	30.32	33.00	35.95	39.19	42.75	46.67	50.98	55.72	87.44	138.11	218.47
17	18.43	19.20	20.01	20.86	21.76	22.71	23.70	25.84	28.21	30.84	33.75	36.97	40.54	44.50	48.88	53.74	59.12	65.08	105.93	173.64	285.01
18	19.61	20.49	21.41	22.39	23.41	24.50	25.65	28.13	30.91	34.00	37.45	41.30	45.60	50.40	55.75	61.73	68.39	75.84	128.12	218.04	371.52
19	20.81	21.80	22.84	23.95	25.12	26.36	27.67	30.54	33.76	37.38	41.45	46.02	51.16	56.94	63.44	70.75	78.97	88.21	154.74	273.56	483.97
20	22.02	23.12	24.30	25.54	26.87	28.28	29.78	33.07	36.79	41.00	45.76	51.16	57.27	64.20	72.05	80.95	91.02	102.44	186.69	342.94	630.17
21	23.24	24.47	25.78	27.18	28.68	30.27	31.97	35.72	39.99	44.87	50.42	56.76	64.00	72.27	81.70	92.47	104.77	118.81	225.03	429.68	820.22
22	24.47	25.84	27.30	28.86	30.54	32.33	34.25	38.51	43.39	49.01	55.46	62.87	71.40	81.21	92.50	105.49	120.44	137.63	271.03	538.10	1067.28
23	25.72	27.23	28.84	30.58	32.45	34.46	36.62	41.43	47.00	53.44	60.89	69.53	79.54	91.15	104.60	120.20	138.30	159.28	326.24	673.63	1388.46
24	26.97	28.63	30.42	32.35	34.43	36.67	39.08	44.50	50.82	58.18	66.76	76.79	88.50	102.17	118.16	136.83	158.66	184.17	392.48	843.03	1806.00
25	28.24	30.06	32.03	34.16	36.46	38.95	41.65	47.73	54.86	63.25	73.11	84.70	98.35	114.41	133.33	155.62	181.87	212.79	471.98	1054.79	2348.80

26	29.53	31.51	33.67	36.01	38.55	41.31	44.31	51.11	59.16	68.68	79.95	93.32	109.18	128.00	150.33	176.85	208.33	245.71	567.38	1319.49	3054.44
27	30.82	32.99	35.34	37.91	40.71	43.76	47.08	54.67	63.71	74.48	87.35	102.72	121.10	143.08	169.37	200.84	238.50	283.57	681.85	1650.36	3971.78
28	32.13	34.48	37.05	39.86	42.93	46.29	49.97	58.40	68.53	80.70	95.34	112.97	134.21	159.82	190.70	227.95	272.89	327.10	819.22	2063.95	5164.31
29	33.45	36.00	38.79	41.86	45.22	48.91	52.97	62.32	73.64	87.35	103.97	124.14	148.63	178.40	214.58	258.58	312.09	377.17	984.07	2580.94	6714.60
30	34.78	37.54	40.57	43.90	47.58	51.62	56.08	66.44	79.06	94.46	113.28	136.31	164.49	199.02	241.33	293.20	356.79	434.75	1181.88	3227.17	8729.99
31	36.13	39.10	42.38	46.00	50.00	54.43	59.33	70.76	84.80	102.07	123.35	149.58	181.94	221.91	271.29	332.32	407.74	500.96	1419.26	4034.97	11349.98
32	37.49	40.69	44.23	48.15	52.50	57.33	62.70	75.30	90.89	110.22	134.21	164.04	201.14	247.32	304.85	376.52	465.82	577.10	1704.11	5044.71	14755.98
33	38.87	42.30	46.11	50.35	55.08	60.34	66.21	80.06	97.34	118.93	145.95	179.80	222.25	275.53	342.43	426.46	532.04	664.67	2045.93	6306.89	19183.77
34	40.26	43.93	48.03	52.61	57.73	63.45	69.86	85.07	104.18	128.26	158.63	196.98	245.48	306.84	384.52	482.90	607.52	765.37	2456.12	7884.61	24939.90
35	41.66	45.59	49.99	54.93	60.46	66.67	73.65	90.32	111.43	138.24	172.32	215.71	271.02	341.59	431.66	546.68	693.57	881.17	2948.34	9856.76	32422.87
36	43.08	47.28	51.99	57.30	63.28	70.01	77.60	95.84	119.12	148.91	187.10	236.12	299.13	380.16	484.46	618.75	791.67	1014.35	3539.01	12321.95	42150.73
37	44.51	48.99	54.03	59.73	66.17	73.46	81.70	101.63	127.27	160.34	203.07	258.38	330.04	422.98	543.60	700.19	903.51	1167.50	4247.81	15403.44	54796.95
38	45.95	50.72	56.11	62.23	69.16	77.03	85.97	107.71	135.90	172.56	220.32	282.63	364.04	470.51	609.83	792.21	1031.00	1343.62	5098.37	19255.30	71237.03
39	47.41	52.48	58.24	64.78	72.23	80.72	90.41	114.10	145.06	185.64	238.94	309.07	401.45	523.27	684.01	896.20	1176.34	1546.17	6119.05	24070.12	92609.14
40	48.89	54.27	60.40	67.40	75.40	84.55	95.03	120.80	154.76	199.64	259.06	337.88	442.59	581.83	767.09	1013.70	1342.03	1779.09	7343.86	30088.66	120392.88

Table A.3 Present value of £1: present value of £1 payable (or receivable) at the end of any period 1–40, discounted at interest rates from 1 to 30% per period.

Period	1% £	1.5% £	2% £	2.5% £	3% £	3.5% £	4% £	5% £	6% £	7% £	8% £	9% £	10% £	11% £	12% £	13% £	14% £	15% £	20% £	25% £	30% £
1	0.990	0.985	0.980	0.976	0.971	0.966	0.962	0.952	0.943	0.935	0.926	0.917	0.909	0.901	0.893	0.885	0.877	0.870	0.833	0.800	0.769
2	0.980	0.971	0.961	0.952	0.943	0.934	0.925	0.907	0.890	0.873	0.857	0.842	0.826	0.812	0.797	0.783	0.769	0.756	0.694	0.640	0.592
3	0.971	0.956	0.942	0.929	0.915	0.902	0.889	0.864	0.840	0.816	0.794	0.772	0.751	0.731	0.712	0.693	0.675	0.658	0.579	0.512	0.455
4	0.961	0.942	0.924	0.906	0.888	0.871	0.855	0.823	0.792	0.763	0.735	0.708	0.683	0.659	0.636	0.613	0.592	0.572	0.482	0.410	0.350
5	0.951	0.928	0.906	0.884	0.863	0.842	0.822	0.784	0.747	0.713	0.681	0.650	0.621	0.593	0.567	0.543	0.519	0.497	0.402	0.328	0.269
6	0.942	0.915	0.888	0.862	0.837	0.814	0.790	0.746	0.705	0.666	0.630	0.596	0.564	0.535	0.507	0.480	0.456	0.432	0.335	0.262	0.207
7	0.933	0.901	0.871	0.841	0.813	0.786	0.760	0.711	0.665	0.623	0.583	0.547	0.513	0.482	0.452	0.425	0.400	0.376	0.279	0.210	0.159
8	0.923	0.888	0.853	0.821	0.789	0.759	0.731	0.677	0.627	0.582	0.540	0.502	0.467	0.434	0.404	0.376	0.351	0.327	0.233	0.168	0.123
9	0.914	0.875	0.837	0.801	0.766	0.734	0.703	0.645	0.592	0.544	0.500	0.460	0.424	0.391	0.361	0.333	0.308	0.284	0.194	0.134	0.094
10	0.905	0.862	0.820	0.781	0.744	0.709	0.676	0.614	0.558	0.508	0.463	0.422	0.386	0.352	0.322	0.295	0.270	0.247	0.162	0.107	0.073
11	0.896	0.849	0.804	0.762	0.722	0.685	0.650	0.585	0.527	0.475	0.429	0.388	0.350	0.317	0.287	0.261	0.237	0.215	0.135	0.086	0.056
12	0.887	0.836	0.788	0.744	0.701	0.662	0.625	0.557	0.497	0.444	0.397	0.356	0.319	0.286	0.257	0.231	0.208	0.187	0.112	0.069	0.043
13	0.879	0.824	0.773	0.725	0.681	0.639	0.601	0.530	0.469	0.415	0.368	0.326	0.290	0.258	0.229	0.204	0.182	0.163	0.093	0.055	0.033
14	0.870	0.812	0.758	0.708	0.661	0.618	0.577	0.505	0.442	0.388	0.340	0.299	0.263	0.232	0.205	0.181	0.160	0.141	0.078	0.044	0.025
15	0.861	0.800	0.743	0.690	0.642	0.597	0.555	0.481	0.417	0.362	0.315	0.275	0.239	0.209	0.183	0.160	0.140	0.123	0.065	0.035	0.020
16	0.853	0.788	0.728	0.674	0.623	0.577	0.534	0.458	0.394	0.339	0.292	0.252	0.218	0.188	0.163	0.141	0.123	0.107	0.054	0.028	0.015
17	0.844	0.776	0.714	0.657	0.605	0.557	0.513	0.436	0.371	0.317	0.270	0.231	0.198	0.170	0.146	0.125	0.108	0.093	0.045	0.023	0.012
18	0.836	0.765	0.700	0.641	0.587	0.538	0.494	0.416	0.350	0.296	0.250	0.212	0.180	0.153	0.130	0.111	0.095	0.081	0.038	0.018	0.009
19	0.828	0.754	0.686	0.626	0.570	0.520	0.475	0.396	0.331	0.277	0.232	0.194	0.164	0.138	0.116	0.098	0.083	0.070	0.031	0.014	0.007
20	0.820	0.742	0.673	0.610	0.554	0.503	0.456	0.377	0.312	0.258	0.215	0.178	0.149	0.124	0.104	0.087	0.073	0.061	0.026	0.012	0.005
21	0.811	0.731	0.660	0.595	0.538	0.486	0.439	0.359	0.294	0.242	0.199	0.164	0.135	0.112	0.093	0.077	0.064	0.053	0.022	0.009	0.004
22	0.803	0.721	0.647	0.581	0.522	0.469	0.422	0.342	0.278	0.226	0.184	0.150	0.123	0.101	0.083	0.068	0.056	0.046	0.018	0.007	0.003
23	0.795	0.710	0.634	0.567	0.507	0.453	0.406	0.326	0.262	0.211	0.170	0.138	0.112	0.091	0.074	0.060	0.049	0.040	0.015	0.006	0.002
24	0.788	0.700	0.622	0.553	0.492	0.438	0.390	0.310	0.247	0.197	0.158	0.126	0.102	0.082	0.066	0.053	0.043	0.035	0.013	0.005	0.002
25	0.780	0.689	0.610	0.539	0.478	0.423	0.375	0.295	0.233	0.184	0.146	0.116	0.092	0.074	0.059	0.047	0.038	0.030	0.010	0.004	0.001

26	0.772	0.679	0.598	0.526	0.464	0.409	0.361	0.281	0.220	0.172	0.135	0.106	0.084	0.066	0.053	0.042	0.033	0.026	0.009	0.003	0.001
27	0.764	0.669	0.586	0.513	0.450	0.395	0.347	0.268	0.207	0.161	0.125	0.098	0.076	0.060	0.047	0.037	0.029	0.023	0.007	0.002	0.001
28	0.757	0.659	0.574	0.501	0.437	0.382	0.333	0.255	0.196	0.150	0.116	0.090	0.069	0.054	0.042	0.033	0.026	0.020	0.006	0.002	0.001
29	0.749	0.649	0.563	0.489	0.424	0.369	0.321	0.243	0.185	0.141	0.107	0.082	0.063	0.048	0.037	0.029	0.022	0.017	0.005	0.002	0.000
30	0.742	0.640	0.552	0.477	0.412	0.356	0.308	0.231	0.174	0.131	0.099	0.075	0.057	0.044	0.033	0.026	0.020	0.015	0.004	0.001	0.000
31	0.735	0.630	0.541	0.465	0.400	0.344	0.296	0.220	0.164	0.123	0.092	0.069	0.052	0.039	0.030	0.023	0.017	0.013	0.004	0.001	0.000
32	0.727	0.621	0.531	0.454	0.388	0.333	0.285	0.210	0.155	0.115	0.085	0.063	0.047	0.035	0.027	0.020	0.015	0.011	0.003	0.001	0.000
33	0.720	0.612	0.520	0.443	0.377	0.321	0.274	0.200	0.146	0.107	0.079	0.058	0.043	0.032	0.024	0.018	0.013	0.010	0.002	0.001	0.000
34	0.713	0.603	0.510	0.432	0.366	0.310	0.264	0.190	0.138	0.100	0.073	0.053	0.039	0.029	0.021	0.016	0.012	0.009	0.002	0.001	0.000
35	0.706	0.594	0.500	0.421	0.355	0.300	0.253	0.181	0.130	0.094	0.068	0.049	0.036	0.026	0.019	0.014	0.010	0.008	0.002	0.000	0.000
36	0.699	0.585	0.490	0.411	0.345	0.290	0.244	0.173	0.123	0.088	0.063	0.045	0.032	0.023	0.017	0.012	0.009	0.007	0.001	0.000	0.000
37	0.692	0.576	0.481	0.401	0.335	0.280	0.234	0.164	0.116	0.082	0.058	0.041	0.029	0.021	0.015	0.011	0.008	0.006	0.001	0.000	0.000
38	0.685	0.568	0.471	0.391	0.325	0.271	0.225	0.157	0.109	0.076	0.054	0.038	0.027	0.019	0.013	0.010	0.007	0.005	0.001	0.000	0.000
39	0.678	0.560	0.462	0.382	0.316	0.261	0.217	0.149	0.103	0.071	0.050	0.035	0.024	0.017	0.012	0.009	0.006	0.004	0.001	0.000	0.000
40	0.672	0.551	0.453	0.372	0.307	0.253	0.208	0.142	0.097	0.067	0.046	0.032	0.022	0.015	0.011	0.008	0.005	0.004	0.001	0.000	0.000

Table A.4 Present Value of £1 payable at regular intervals ('year's purchase'). Present Value of £1 payable (or receivable) at the end of any period (i.e. weekly, monthly, annually) discounted at interest rates from 1% to 30% per period.

Period	1% £	1.5% £	2% £	2.5% £	3% £	3.5% £	4% £	5% £	6% £	7% £	8% £	9% £	10% £	11% £	12% £	13% £	14% £	15% £	20% £	25% £	30% £
1	0.99	0.99	0.98	0.97	0.96	0.96	0.95	0.94	0.93	0.93	0.92	0.92	0.91	0.90	0.89	0.89	0.88	0.88	0.87	0.87	0.86
2	1.97	1.96	1.93	1.91	1.89	1.87	1.85	1.83	1.81	1.79	1.77	1.76	1.73	1.72	1.70	1.69	1.67	1.65	1.63	1.62	1.60
3	2.94	2.91	2.86	2.83	2.78	2.75	2.70	2.67	2.63	2.60	2.56	2.53	2.49	2.47	2.43	2.40	2.36	2.34	2.31	2.29	2.25
4	3.90	3.85	3.76	3.72	3.63	3.59	3.51	3.47	3.39	3.36	3.28	3.25	3.18	3.15	3.08	3.05	2.99	2.96	2.91	2.88	2.82
5	4.85	4.78	4.65	4.58	4.46	4.40	4.28	4.22	4.12	4.06	3.96	3.91	3.82	3.77	3.69	3.64	3.56	3.52	3.44	3.40	3.33
6	5.80	5.70	5.51	5.42	5.25	5.17	5.01	4.94	4.80	4.73	4.59	4.53	4.41	4.35	4.23	4.18	4.07	4.02	3.92	3.87	3.78
7	6.73	6.60	6.35	6.24	6.02	5.91	5.71	5.62	5.44	5.35	5.18	5.10	4.95	4.88	4.74	4.67	4.54	4.48	4.36	4.30	4.19
8	7.65	7.49	7.18	7.03	6.76	6.63	6.38	6.26	6.04	5.94	5.74	5.64	5.46	5.37	5.20	5.12	4.97	4.89	4.75	4.68	4.55
9	8.57	8.36	7.98	7.80	7.47	7.31	7.02	6.88	6.61	6.49	6.25	6.14	5.93	5.82	5.63	5.54	5.36	5.27	5.11	5.03	4.89
10	9.47	9.22	8.77	8.55	8.16	7.97	7.63	7.46	7.16	7.01	6.74	6.61	6.36	6.24	6.03	5.92	5.72	5.62	5.44	5.35	5.19
11	10.37	10.07	9.54	9.28	8.82	8.61	8.21	8.02	7.67	7.50	7.19	7.04	6.77	6.64	6.39	6.27	6.05	5.95	5.74	5.65	5.47
12	11.26	10.91	10.29	9.99	9.47	9.22	8.76	8.55	8.15	7.97	7.62	7.46	7.15	7.01	6.73	6.60	6.36	6.24	6.02	5.92	5.72
13	12.13	11.73	11.02	10.68	10.09	9.80	9.30	9.05	8.62	8.41	8.03	7.84	7.51	7.35	7.05	6.91	6.65	6.52	6.28	6.16	5.95
14	13.00	12.54	11.73	11.36	10.69	10.37	9.81	9.54	9.06	8.83	8.41	8.21	7.85	7.67	7.35	7.19	6.91	6.77	6.52	6.39	6.17
15	13.87	13.34	12.43	12.01	11.27	10.92	10.30	10.00	9.47	9.22	8.77	8.55	8.16	7.97	7.63	7.46	7.16	7.01	6.74	6.61	6.36
16	14.72	14.13	13.12	12.65	11.83	11.44	10.77	10.44	9.87	9.60	9.11	8.88	8.46	8.26	7.89	7.71	7.39	7.23	6.94	6.80	6.55
17	15.56	14.91	13.79	13.27	12.37	11.95	11.22	10.87	10.25	9.96	9.44	9.19	8.74	8.52	8.13	7.94	7.60	7.44	7.14	6.99	6.72
18	16.40	15.67	14.44	13.87	12.90	12.44	11.65	11.27	10.61	10.30	9.75	9.48	9.00	8.77	8.36	8.16	7.81	7.63	7.31	7.16	6.88
19	17.23	16.43	15.08	14.46	13.41	12.92	12.06	11.66	10.96	10.63	10.04	9.76	9.25	9.01	8.58	8.37	8.00	7.81	7.48	7.32	7.03
20	18.05	17.17	15.71	15.04	13.90	13.37	12.46	12.04	11.29	10.94	10.32	10.02	9.49	9.24	8.79	8.57	8.17	7.98	7.64	7.47	7.17
21	18.86	17.90	16.32	15.60	14.38	13.81	12.85	12.39	11.61	11.23	10.58	10.27	9.72	9.45	8.98	8.75	8.34	8.14	7.79	7.61	7.30
22	19.66	18.62	16.92	16.14	14.84	14.24	13.22	12.74	11.91	11.52	10.83	10.50	9.93	9.65	9.16	8.92	8.50	8.29	7.93	7.74	7.42
23	20.46	19.33	17.50	16.67	15.29	14.66	13.58	13.07	12.20	11.79	11.07	10.73	10.13	9.84	9.34	9.09	8.65	8.44	8.06	7.87	7.54
24	21.24	20.03	18.08	17.19	15.73	15.05	13.92	13.39	12.48	12.05	11.30	10.95	10.33	10.03	9.50	9.24	8.79	8.57	8.18	7.99	7.65
25	22.02	20.72	18.64	17.70	16.15	15.44	14.25	13.69	12.75	12.29	11.52	11.15	10.51	10.20	9.66	9.39	8.93	8.70	8.30	8.10	7.75

26	22.80	21.40	19.19	18.19	16.57	15.82	14.57	13.99	13.00	12.53	11.73	11.35	10.69	10.36	9.81	9.53	9.06	8.82	8.41	8.20	7.85
27	23.56	22.07	19.72	18.67	16.96	16.18	14.88	14.27	13.25	12.76	11.93	11.54	10.85	10.52	9.95	9.67	9.18	8.94	8.51	8.30	7.94
28	24.32	22.73	20.25	19.14	17.35	16.53	15.18	14.54	13.48	12.98	12.13	11.71	11.01	10.67	10.08	9.79	9.29	9.04	8.61	8.40	8.02
29	25.07	23.38	20.76	19.60	17.73	16.87	15.47	14.81	13.71	13.19	12.31	11.89	11.17	10.81	10.21	9.91	9.40	9.15	8.71	8.49	8.11
30	25.81	24.02	21.27	20.04	18.09	17.20	15.74	15.06	13.93	13.39	12.49	12.05	11.31	10.95	10.33	10.03	9.51	9.25	8.80	8.57	8.18
31	26.54	24.65	21.76	20.48	18.45	17.52	16.01	15.31	14.14	13.59	12.66	12.21	11.45	11.08	10.45	10.14	9.61	9.34	8.88	8.66	8.26
32	27.27	25.27	22.25	20.90	18.80	17.83	16.27	15.54	14.35	13.77	12.82	12.36	11.58	11.21	10.56	10.24	9.70	9.43	8.97	8.73	8.33
33	27.99	25.88	22.72	21.32	19.13	18.13	16.53	15.77	14.54	13.95	12.98	12.50	11.71	11.32	10.67	10.34	9.79	9.52	9.04	8.81	8.40
34	28.70	26.48	23.18	21.72	19.46	18.42	16.77	15.99	14.73	14.12	13.13	12.64	11.84	11.44	10.77	10.44	9.88	9.60	9.12	8.88	8.46
35	29.41	27.08	23.64	22.12	19.78	18.71	17.01	16.21	14.91	14.29	13.27	12.78	11.95	11.55	10.87	10.53	9.96	9.68	9.19	8.94	8.52
36	30.11	27.66	24.08	22.50	20.09	18.98	17.23	16.41	15.09	14.45	13.41	12.91	12.07	11.65	10.96	10.62	10.04	9.75	9.26	9.01	8.58
37	30.80	28.24	24.52	22.88	20.39	19.25	17.46	16.61	15.26	14.61	13.55	13.03	12.18	11.76	11.05	10.70	10.12	9.82	9.32	9.07	8.64
38	31.48	28.81	24.95	23.25	20.68	19.51	17.67	16.80	15.42	14.76	13.68	13.15	12.28	11.85	11.14	10.79	10.19	9.89	9.38	9.13	8.69
39	32.16	29.36	25.37	23.61	20.97	19.76	17.88	16.99	15.58	14.90	13.80	13.26	12.38	11.95	11.23	10.86	10.26	9.96	9.44	9.18	8.75
40	32.83	29.92	25.78	23.96	21.25	20.00	18.08	17.17	15.73	15.04	13.92	13.37	12.48	12.04	11.31	10.94	10.33	10.02	9.50	9.24	8.79

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Ferry and Brandon’s Cost Planning of Buildings, Ninth Edition. Richard Kirkham.

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