

MODERN CONSTRUCTION MANAGEMENT

Eighth edition



Frank Harris
Ronald McCaffer
Andrew Baldwin
Francis Edum-Fotwe



WILEY Blackwell

Modern Construction Management

The book's companion website is at www.wiley.com/go/MCM8 and offers invaluable resources for both students and lecturers:

- **Solutions to the self-learning exercises**
- **PowerPoint slides with discussion topics**
- **Journal and web references**
- **Questions directory**

Modern Construction Management

Eighth Edition

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Andrew Baldwin BSc, MSc, PhD, FICE, has extensive construction industry and academic experience. Following an extended career in industry, he began an academic career at Loughborough University UK where he is now an Emeritus Professor in Construction Management. He is also a Distinguished Visiting Professor at Chongqing University, China and Co-Director of the National Centre for International Research of Low Carbon and Green Buildings.

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Preface to the eighth edition

This book is intended for students and graduates of civil engineering, construction management, building and quantity surveying who wish to extend their knowledge and obtain a better understanding of **site, business and the corporate management** of construction companies.

Since its first edition, *Modern Construction Management* has successfully provided a background to how construction companies operate, the management techniques involved, their decision making and how these decisions are successfully implemented. Over the decades since the first edition, the structure of the industry, techniques adopted and the processes have changed. While the parties to a construction project have remained the same their responsibilities have changed. New materials, technologies and processes have been introduced. However, the young construction manager still needs to be a competent technologist to successfully complete construction work as well as possess the skills of knowledge management and an understanding of business processes. This is the basis of career enhancement to executive and board level. This remains the aim of *Modern Construction Management*.

This new edition builds on previous editions in giving future managers the basic understanding they will need to deliver a crisis-free, efficient and cost-effective construction industry. This requires managers who are people-orientated, socially responsible, innovative and involved in carbon reduction. These objectives have become more acute given recent issues regarding the quality of construction work. The Chartered Institute of Building (CIOB) has recognised that Quality is one of the most prominent issues facing the construction industry today. *Modern Construction Management* begins by emphasising the important role of total quality management and safe working that pervades every aspect of the construction industry. The subsequent sections are: 'project production management' describing the management techniques employed on site; 'business management' which addresses the relevant commercial aspects; and 'administration and company management' covering corporate activities including information management.

The eighth edition of *Modern Construction Management* recognises a changing construction industry and includes the processes essential for meeting performance indicators and delivering continuous improvement. Also featured are the principles of lean construction, construction industry productivity, environmental management and sustainability. Innovations such as procurement standards, contractual legislation, early /optimised contractor involvement, framework processes stakeholder management and corporate social responsibility are reviewed.

Information management within all industries is rapidly changing and set to change further with the introduction of 5G technologies. Worldwide, the continuing emergence of Building Information Management (BIM) is leading to new ways of working. This book recognises how BIM is changing construction and how new technologies will change not only processes but also how the industry operates.

The final section of the book includes a comprehensive selection of worked examples designed to assist the reader consolidate learning and includes many tutorial exercises invaluable for analysing the facets of construction management featured in the contents.

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Companion website



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- Solutions to the self-learning exercises
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Chapter 1

Introduction

Modern management in construction addresses four principal areas of the industry:

- Management of the physical production phase or site construction management;
- Management of the various functions that make up and contribute to the delivery of projects, or total project and programme management;
- Management of the corporate establishments involved in the delivery of the constructed facilities and services or organisational management;
- Management of the industry to create an enabling commercial, regulatory, and conducive socio-economic environment, or sector management.

Construction Management addresses the effective planning, organisation, application, coordination, monitoring, control, and reporting of the core business processes of marketing, procurement, production, administration, accounts, and finance necessary to achieve economic success and/or profitability for an enterprise or organisation engaged in the provision of construction facilities. The functions may be performed by a client, contracting company, consultant firm, public body or a combination of such stakeholders contracted to bring a project or series of projects to safe completion on time, to budget, to the set quality and expected innovative, aesthetic, socially responsible, and environmental impact.

Construction Project Management focuses on the delivery of a specific solution by contracting with stakeholders who undertake combinations of the following indicative sub-processes relating to a specific project:

- Scoping and budgeting the project;
- Design coordination/management;
- Establishing the management structure of the management team;
- Marketing and procurement;
- Defining roles and responsibilities;
- Estimating and tendering;
- Stakeholder management;
- Project and construction methods planning, coordination, and control;
- Value and risk management;
- Organising, leading, and implementing controls;
- Production and productivity management;
- Management of labour resources, temporary works provision, equipment, plant, subcontractors, and suppliers;

- Time and subcontractor interface management;
- Cost and budgetary control, including cash flow forecasting;
- Quality management;
- Contract and progress payments administration;
- Legal issues;
- Information and communications technology (ICT) management;
- Health and Safety management, education, training and welfare provision;
- Corporate Social Responsibility (CSR);
- Management of the potential environmental impacts of construction;
- Commissioning, auditing, and recording of the project(s).

The Chartered Institute of Buildings, CIOB, provide a comprehensive set of definitions of Construction (Project) Management (CIOB 2014).

Significantly, as recent Constructing Excellence (CE) and government reports emphasise, the marked shift towards modern forms of contracting, rapid technological change, and greater environmental, social and economic accountability of construction pose ever-growing competition in a world of intensified global trading – not least the Corporate Social Responsibility notion of ‘doing well by doing good’ to enhance competitive advantage. Hence, an intelligent client will increasingly need to focus on achieving value at the operational and business levels through the appointment of a robust integrated ‘best in class’ supply chain of stakeholders, able to deliver the listed project services with the fresh, practicable, robust, measurable and auditable core competences and management processes.

Structure of the book

This book covers the principal responsibilities of Construction Management divided into four main sections; in addition, Chapters 1 and 2, which do not form part of the main sections, give specific consideration at the outset to the philosophy of the book as a means of explaining the succeeding chapters.

In particular, Chapter 2, *Quality management in construction* provides the platform for the succeeding chapters and describes the evolution of quality management from quality control through quality assurance to total quality management (TQM), as well as the current standards employed by construction organisations. It illustrates how quality is intertwined as a thread running through all subsequent sections and explores the emerging strategic role of quality as a driver for competitive advantage in construction. Looking at quality from the project perspective, it advocates a concerted effort by both client and contractor to make any quality agenda a reality, and explores a systems approach to attaining such an agenda. It concludes with a look at initiatives by the professional bodies associated with the construction to support and promote quality attainment and management.

- Section I deals with techniques relating to project production management.
- Section II covers the business aspects of management at both project and company levels, including environmental management and legislation guidelines.
- Section III addresses the executive management responsibilities for overall corporate control.

- Section IV brings together a selection of self-learning problems complemented with complete worked solutions for use in the classroom environment, tutorial exercises and seminar discussions, which are provided on the companion website.

The reasons for this particular presentation are:

- (1) Successful construction industry executives have distinct phases in their careers: the initial period is spent on site, followed by middle-management duties at the project level, culminating in a career with executive head-office activities. The sections are intended to cater for these phases.
- (2) The construction industry is inherently uncertain as a result of the nature of the industry itself – the competitive tendering process, the company's turnover, site production rates and the weather are all features that are characterised by variability and a degree of uncertainty. To be able to cope with such uncertainty, construction executives need to be acquainted with the relevant knowledge and tools for addressing these features. The management techniques described in this book help reduce variability and thus provide the basis for sound and effective decisions by aspiring executives. For example, with proper planning, the duration of a project is not just an experienced guess. The inevitable residual variability in even the best-run company needs to be controlled by:
 - (a) Planning and setting targets;
 - (b) Choosing methods to achieve such plans and targets;
 - (c) Monitoring progress;
 - (d) Taking corrective action when necessary.

This continual monitoring and revision is ultimately the only way to cope with uncertainty and variability.

Objectives and contents

Each chapter deals with a specific topic (which could, if exhaustively treated, form the basis of a whole book; suggestions for further reading appear at the end of each chapter, while references appear in the bibliography at the end of the book).

The level of detail aimed at is that which will provide the reader with a basic working knowledge of the topic, rather than with specialist expertise. For example, the planning section of the book explains the major techniques available for planning both repetitive and non-repetitive works in sufficient detail to allow intelligent engineers to apply them, providing sufficient comprehension for them to converse sensibly with a specialist support group such as a planning department. Engineers and builders need enough knowledge to understand, appreciate and, where necessary, question the work of specialist support staff such as accountants, cost clerks, planners, and plant managers. A grasp of the techniques described in the sections should help in achieving this skill. Specialists must not be allowed to hide safely in their own specialisms. Participation in the exercises in Section IV covering the numerical-based aspects of these techniques provides a deeper and better understanding of the implications of the various approaches to decision making.

The contents of each section are now discussed briefly below.

Section I

Section I relates specifically to project production management, including planning techniques, production process improvement, estimating and tendering, workforce motivation and cost control.

- Chapter 3: *Production process improvement* provides a foundation to the efficient delivery for the operational aspects of construction. The basis for evaluating such efficiency has shifted to include energy use, productivity, and national productivity reports, Building Information modelling (BIM), quality management, lean construction, benchmarking, digital technologies, waste management, asset management, Six Sigma, production measurement and sampling. The chapter also provides examples of the application of the production measurement.
- Chapter 4: *Planning techniques and methods* considers who plans, when, and the methods and techniques that may be adopted. The chapter describes techniques including bar charts, linked bar charts, network analysis and space-diagrams together with methods such as, Last Planner, Critical Chain Project Management and ADePT that provide specialist approaches to the management of both design and construction. Also included is guidance for planning for waste management, Health Safety and Environment in construction. A new section considers modern construction planning including developing the time model, schedule design and structure, monitoring progress and managing the time model. Consideration is given to the impact of emerging information technologies including 4D CAD and BIM.
- Chapter 5: *Workforce motivation* links the use of incentive schemes to motivation theory, which is complimented with a coverage of Theory Z. It also presents the various payment systems for non-financial, semi-financial, and purely financial incentives that can be employed to enhance worker motivation. The introduction of a new audit system for workforce motivation offers a new insight for project and senior executives.
- Chapter 6: *Project cost control* gives guidance on the various cost-control methods available, including profit-related control systems, unit- and standard-costing approaches, cost monitoring of subcontractors, and cost management of carbon emissions.
- Chapter 7: *Management of equipment* considers the financing of plant and gives guidance on plant selection and control of gaseous emissions. Calculating a hire rate and maintenance procedures are also covered. The chapter also addresses an important and emerging aspect on plant management – the need for more human-centred approaches to the management of plant within construction.

Section II

Section II presents business management topics and is intended to assist project-based staff to understand and appreciate the company's attitudes and activities, easing the transition from site to general management. The topics described relate to procurement, bidding, budgets and cash flow, economic assessment and plant management.

- Chapter 8: *Project procurement* introduces the role of project and programme management, stakeholder management, design coordination, and reviews various forms of contract including regulations for public contracts. The latest developments for procuring construction and engineering embraced in the ISO and BS Procurement standards and codes

of practice, design and build, early and optimised contractor involvement, modern PFI, partnering and associated funding mechanisms are also explained. The risk exposure of each of the parties involved in different procurement arrangement is also addressed.

- Chapter 9: *Estimating and tendering* is an important function in all construction companies that must be conducted with a clear understanding of the resources required and risks involved. The chapter describes the parties involved in the estimating and tendering process, and the four types of cost estimates that may be produced. It outlines the process, decisions, and calculations involved within the traditional estimating practice and the variations adopted for other types of procurement such as Management Contracting, Design and Build, together with cost planning, cost management, whole-life costing and the private finance initiative. The last section of the chapter reviews how BIM contributes to better construction estimating.
- Chapter 10: *Competitive bidding* examines the effect of estimating accuracy, which implies the need for more resources in the estimating department, reviews how to interpret the various available items of data relating to competitors' behaviour and comments on improving estimating accuracy. It also covers electronic bidding and fundamental information on bid evaluation.
- Chapter 11: *Company budgetary control* deals with the preparation of budgets and controlling costs for a company or enterprise, including budgeting for the carbon footprint.
- Chapter 12: *Cash flow and interim valuations* illustrates company cash-flow forecasting and provides guidance on how to do this type of forecasting, the use of computers in cash-flow calculations, the process of interim valuations and the relationship between interim valuations and cash flow. It introduces the concept of invoice financing as a means for achieving positive cash flow for the construction company.
- Chapter 13: *Economic assessments* describes the principles employed in economic comparisons and in measuring rates of return, life-cycle costing, cost-benefit analysis and financial modelling. It also provides an introduction to the use of multi-criteria analysis for appraising projects.

Section III

Section III presents the executive management responsibilities largely concerning head-office activities, including organisation, business development, global construction, and the emerging role of information as a major construction resource and finance.

- Chapter 14: *Company organisation* contains a description and explanation of company structure, organisation and managerial responsibilities, training and vocational qualifications, R&D, environmental management and international agreements. The chapter also covers working in an age of connectedness.
- Chapter 15: *Market planning and business development* describes a marketing approach to construction and the benefits likely to be derived and methods of selling including green/low-carbon marketing, modern web blogging and social networking.
- Chapter 16: *International construction and logistics* risks provides an overview of the problems in globalisation of trade, raising finance, dealing with unfamiliar conditions of contract and legal systems, transport of goods, payment procedures and local labour, resources and security.

- Chapter 17: *Towards BIM and digital construction* considers the changing role of information in construction, the adoption of information technologies, information management including information strategy options, and outlines principles for investing in information systems, their implementation and management. The importance of information security and data protections is stressed. Full consideration is given to the emergence of BIM, BIM-maturity levels, and the future of BIM. The chapter ends with a review of digital construction including digitisation, artificial intelligence and the use of drones and other new technologies.
- Chapter 18: *Financial management* describes the workings of the national economy, company types and formation, banking and money, sources and means of acquiring capital funds and the use of balance sheets, profit-and-loss accounts, ratio analysis and financial regulation.

Section IV

This section presents tutorial examples with complete worked solutions for students in construction disciplines. It is separated into three chapters, with the first, Chapter 19, covering the worked examples from Chapters 3 to 18. Chapter 20 provides worked examples on operational research techniques. Chapter 21 similarly introduces Six Sigma statistical examples supportive of Lean Sigma application to productivity improvement analysis.

Students learn by reading texts and attending lectures. However, they need to test their new-found knowledge or skill by attempting to work through example problems, and several textbooks are available that offer such examples, either with or without answers. Where an answer is provided, the student's own answer is frequently at variance and they are then faced by a dilemma: is the textbook in error or has the author made different, but valid, assumptions? In this book, a complete worked solution to each example is given so that the student has full guidance through the analysis.

The topics covered in Section IV are those aspects of construction management that may be treated numerically:

- Production analysis;
- Planning;
- Estimating;
- Motivation schemes;
- Control of project costs;
- Budgetary control;
- Cash-flow forecasting;
- Discounted cash flow;
- Investment analysis;
- Plant management;
- Setting of plant-hire rates;
- Financial management;
- Development economics;
- Construction methods;
- Operational research;
- Six Sigma for construction.

The intention is for the students to test their knowledge by trying the examples and comparing the solutions with those offered in the book. Any differences between the student's solutions and those presented here may be discussed with the tutor and, in this way, tutorial discussions may be used advantageously for resolving difficulties rather than for routine learning. It should be remembered that these are tutorial examples and that each one deals with a limited number of variables and principles, sometimes making simplifying assumptions. Thus, students may test their understanding of the principles and ability to manipulate the variables.

Chapter 2

Quality management

Summary

Quality control, quality assurance, total quality management, and systems quality in construction.

Introduction

Quality management has seen a transition from reacting to the outcome of site production activities to become a strategic business function accounting for the *raison d'être* of construction companies. Unless a construction company can guarantee its clients a quality product, it can no longer compete effectively in the modern construction market. Crucial to the delivery of such quality products is the quality of processes that produce the product. 'Quality' now stands alongside 'price' as a major factor of differentiation in contractor selection by the client as well as determining the efficiency of processes that the contractor adopts for site operations. To be competitive and sustain good business prospects, construction companies need a more strategic orientation for the quality systems they deploy.

This chapter focuses on the transitions in quality management for construction companies culminating in a systems outlook for managing quality in construction. Quality management must provide the environment within which the tools, techniques, and procedures presented in the other chapters can be effectively deployed leading to operational success for the company. The role of the quality management for a construction company is not an isolated activity, but intertwined with all the operational and managerial processes of the company. This chapter reviews various *concepts* associated with the quality and then considers the contributions of quality control, quality assurance (QA) and total quality management (TQM) to the quality of construction. It also addresses the growing use of quality management systems for achieving superior performance in construction. It highlights the fact that quality in construction can be achieved only through the direct effort of all stakeholders of the project.

Notions of quality

The management of quality in construction is an area of specialisation that has been growing over the past three to four decades to embrace aspects of the project and company activities that are often seen as remote from the physical product. Figure 2.1 shows a number of concepts

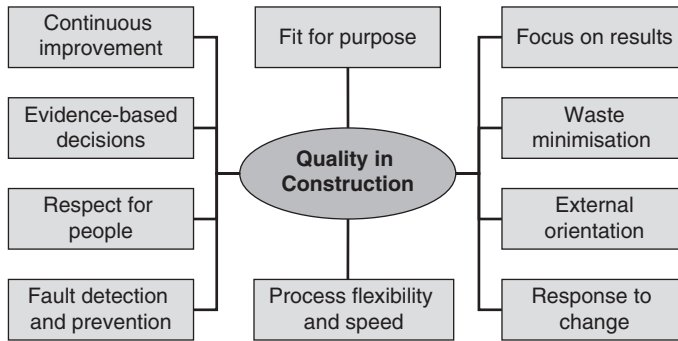


Fig. 2.1 Aspects of construction quality.

considered to have an influence on the quality of the product and which have become associated with quality in construction.

The various areas that contribute to quality in construction in Figure 2.1 reflect the product features, the processes of production and organisation, as well as wider company and industry/business issues. In particular, the management of quality in construction has been embracing considerations that address more of the pre-production processes and organisation/industry issues. For example, a company's quality status is not just seen in isolation, but increasingly from the perspective of industry-wide standards and against that of its competitors.

Quality in transition

The modern concept of quality is considered to have evolved through major transition stages over many years. These stages are described below:

(1) Quality control and inspection

Inspection is the process of checking that what is produced is what is required. Quality control introduced inspection to stages in the development of goods and services to ensure that they are undertaken to specified requirements. Usually quality control is done on a sampling basis dictated by statistical methods. Sampling concrete by making cubes is the most common and best-known example in construction.

(2) Quality assurance

This has developed to ensure that specifications are consistently met. '*Fit for purpose*' and '*right first time*' are the principles of quality assurance and the frame of reference for quality assurance is the International Quality Standard ISO 9000 family of standards. In particular, ISO 9001 is seen as the de facto standard for addressing quality in the construction sector. To be certified as operating to the ISO 9001 standard is now virtually seen as essential in today's construction industry. Many clients simply will not do business with companies not certified to ISO 9001.

(3) Total quality management (TQM)

This is based on the philosophy of continuously improving goods or services. A TQM approach is now seen as essential to long-term survival in business, including

construction. A key factor is that everyone in the company should be involved and committed from the top to the bottom of the organisation.

The successful total-quality-managed company ensures that their goods and services can meet the following criteria:

- Be fit for purpose on a consistently reliable basis;
- Delight the customer with the service that accompanies the supply of goods;
- Supply a quality of the product that is so much better than that of the competition that customers want it regardless of price.

(4) **Quality management systems**

A quality management system presents a set of processes that ensure the attainment of defined quality standards for the provision of services and products by the project or a construction company. This can be company-specific or project-specific or one of several systems available on the market. The ISO 9001 is the most commonly used international standard that provides a framework for an effective quality management system.

It is now argued that successful construction companies have to meet at least two of these criteria to stay successful. *The pursuit of total quality is seen as a never-ending journey of continuous improvement.* A fuller description and application of each of the stages is set out below.

Quality control and inspection

The earliest and most basic form of quality management is quality control. This is described under the headings of:

- Definition and objectives of quality control;
- Controlling quality;
- Quality control implemented in construction.

Definition and objectives of quality control

The term quality control is defined by an interpretation of its elements: 'quality' and 'control'.

Quality

The term 'quality' is often used to describe prestige products such as Rolex watches and Mercedes Benz motor cars. However, the term 'quality', although applicable to these items, does not necessarily refer to prestigious products but merely to the fitness of the product to the customers' requirements. *Quality* describes the sum of attributes for a product or service that enables it to meet the requirements or specified need of the *customer*. The concept of quality goes hand in hand with *value for money* as perceived by the client.

Control

The concept of being 'in control', or having something 'under control', is readily understood. We mean that we know what we intend to happen, and are confident that we can ensure that it does. Quality control, however, is primarily concerned with defect detection. The

main quality-control techniques are inspections and statistical quality-control techniques (i.e. sampling). Both are aimed at ensuring that the work produced and the materials used are within the tolerances specified. Some of these limits are left to the inspector's *judgement* and this can be a source of difficulty. The major objectives of quality control can be defined as follows:

- To ensure that the completed work meets the specification;
- To reduce customers' or clients' complaints;
- To improve the reliability of products or work produced;
- To increase customers' or clients' confidence;
- To reduce production costs.

Controlling quality

Quality control involves ensuring that every product or service meets a minimum set of defined criteria for acceptance. The central feature to all quality-control systems is that of inspection.

Inspections

To be effective, the construction process requires that work items to be inspected must be catalogued into a quality schedule. Inspection in construction takes two forms: that which is objective and quantifiable, for example, the length of a line, levels of floors or roads, verticality of a wall, and volumetric dimensions of a kitchen pod; and that which is open to the inspector's interpretation, for example, cleanliness, fit, tolerances and visual checks. The latter method of inspection usually involves simple observation, and relies on the experience of the inspector. Objective inspection requires some form of measurement to support the verification of meeting the quality standard. For example, there are some precise quantified inspections involved in the commissioning of plant and machinery, pressure tests in pipework and strength tests on materials such as concrete, each of which involves such physical measurement.

Statistical methods

These methods of quality control are based on the need to sample. In many of the processes of manufacture and construction, the scale of the operation is too large to have 100% inspection and therefore sampling techniques are employed.

The main techniques in statistical quality control are:

- *Acceptance sampling*, based on probability theory, allows the work to continue if the items sampled are within predetermined limits.
- *Control charts* that compare the results of the items sampled with the results expected from a 'normal' situation. Usually, the results are plotted on control charts which indicate the control limits.

In construction, it is the quality of materials that is normally controlled by statistical methods, the most common being that of the cube strength of concrete.