Modern Construction Management

SEVENTH EDITION

Frank Harris and Ronald McCaffer

with Francis Edum-Fotwe

WILEY-BLACKWELL

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The book's companion website is at **www.wiley.com/go/MCM7** and offers invaluable resources for both students and lecturers:

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

Modern Construction Management

Seventh Edition

Frank Harris
Emeritus Professor of Construction Science
University of Wolverhampton

and

Ronald McCaffer
Emeritus Professor of Construction Management
Loughborough University

with

Francis Edum-Fotwe
Lecturer in Construction Management
Loughborough University

WILEY-BLACKWELL
A John Wiley & Sons, Ltd., Publication

This edition first published 2013 John Wiley & Sons, Ltd

Blackwell Publishing was acquired by John Wiley & Sons in February 2007. Blackwell's publishing program has been merged with Wiley's global Scientific, Technical and Medical business to form Wiley-Blackwell.

Registered office:
John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial offices:
9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
2121 State Avenue, Ames, Iowa 50014-8300, USA

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Library of Congress Cataloging-in-Publication Data
Harris, Frank, 1944–
Modern construction management / Frank Harris and Ronald McCaffer with Francis Edum-Fotwe. – 7th ed.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-470-67217-4 (pbk. : alk. paper) 1. Construction industry–Management.
I. McCaffer, Ronald. II. Edum-Fotwe, Francis. III. Title.
HD9715.A2H35 2012
624.068–dc23
2012023206

A catalogue record for this book is available from the British Library.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Cover image: courtesy of Shutterstock.com.
Cover design by Meaden Creative.

Set in 10 on 12 pt Minion by Toppan Best-set Premedia Limited, Hong Kong

1 2013

Contents

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Preface to the sixth edition

The book is intended for students and graduates of civil engineering, construction management, building and quantity surveying, and is arranged to reflect site, business and corporate responsibilities embraced by the S/NVQ supervisory and management levels of career development. This approach acknowledges that the modern successful construction engineer, builder or quantity surveyor needs to be a competent technologist possessing complementary skills and knowledge in management as well as understanding the business processes. Armed with such expertise the young construction trainee will be better prepared for decision-making and undertaking executive responsibilities.

The new edition has been guided by the drive for improvement in construction industry performance stimulated through the *Rethinking Construction* and *Construction Best Practice* programmes.

Recently restated under the *Accelerating Change* initiative as committed leadership, client satisfaction, integrated processes and teams, quality management and social responsibility, the opening overview sets out the key points which are subsequently interweaved throughout the text. The construction engineer, builder or quantity surveyor is thereby better positioned to understand and implement modern strategies needed in providing value for money for the client and society.

The book begins by emphasising the important role of total quality management and safe working that now pervades every aspect of construction activity. The subsequent sections are: 'project production management' describing the management techniques employed on site; 'business management', which addresses the relevant commercial aspects; and finally 'administration and company management' covering corporate activities including IT systems and international work.

The processes essential in delivering continuous improvement and meeting performance indicators are especially featured, while the principles of lean construction, concurrent engineering, supply networks, re-engineering, value and risk management are given prominence. The latest contractual innovations, notably design and build, PFI/PPP, term, prime, managing agent, early contractor involvement, framework agreements and alliances, are evaluated, with reverse auctions contrasted with negotiated contracts and detailed pre-selection. Issues for business development and business models, business process outsourcing, matrix management, incentives and plant hire are also treated. In addition, topical concerns on construction productivity, relationship marketing, environment and sustainability, the 'Kyoto' protocol, corporate social responsibility, corporate governance, data protection, international construction contracts, investment monitoring and regulation, RFID tagging, health, safety and training are brought to the reader's attention.

Finally, the comprehensive selection ofworked examples, designed to help the reader consolidate learning, is augmented in this edition by 25 new tutorial exercises dealing with the Operational Research methods, invaluable for analysing the many challenging facets of construction management featured in the contents.

Preface to the seventh edition

The book is intended for students and graduates of civil engineering, construction management, building and quantity surveying, and arranged to reflect site, business and corporate responsibilities embraced by the latest national vocational qualifications available for supervisory and management levels of career development. This approach acknowledges that the modern successful construction engineer, builder, commercial manager or quantity surveyor needs to be a competent technologist who possesses complementary skills and knowledge in management as well as understanding the business processes. Armed with such expertise, the young construction trainee will be better prepared for decision making and undertaking executive responsibilities.

Importantly, the new edition directs attention towards achieving a socially responsible, innovative, carbon-reducing, manager-involved, people-oriented, crisis-free, efficient and cost-effective construction industry that competes in an information-enabled environment.

Guided by the drive for improvement in performance stimulated through the *Rethinking Construction*; *Construction Best Practice*; and *Accelerating Change* reports, and more recently by the UK government agenda to achieve Building Information Modelling (BIM) for delivering projects, the key recommendations concerning leadership, client satisfaction, integrated processes and teams, quality management, environmental and social responsibility, cloud operations, and BIM are thus interwoven throughout the text.

The construction engineer, builder, commercial manager or quantity surveyor may thereby better understand and implement the modern strategies needed in providing value for money for the client and society. Particularly, alternative solutions for achieving adequacy in cash flow through invoice financing are provided. Equally, inefficient practices relating to investment decision making, standards and regulation complexity, stakeholder responsibilities, supply chain management, contractual-risk allocation, cost and asset condition data provision as highlighted in the recent *Infrastructure UK cost review* of delivering construction projects are covered.

The book begins by emphasising the important role of total quality management and safe working that now pervades every aspect of construction activity. The subsequent sections are:

'project production management' describing the management techniques employed on site;
'business management' which addresses the relevant commercial aspects;
'administration and company management' covering corporate activities including ICT systems and international work.

The processes essential for delivering continuous improvement and meeting performance indicators are especially featured, while the principles of lean construction, construction industry productivity, environmental management and sustainability are given prominence.

The latest innovations, notably procurement standards and contractual legislation, early/optimised contractor involvement, framework agreements, PFI funding, Building Information

Modelling, Stakeholder Management, Corporate Social Responsibility, and the carbon footprint are also treated. Additionally, topical concerns on education and training, energy conservation and productivity, investment monitoring and banking regulation, occupational health and social welfare provision in the workplace, incentive payments for executives and senior managers, design coordination, web-based marketing, smart phone and tablet computer applications, working in a cloud-enabled construction industry, waste management, and the latest conditions of contract are brought to attention.

Finally, the comprehensive selection of worked examples designed to help the reader consolidate learning, is augmented in this edition by fifteen new tutorial exercises dealing with the Six Sigma process, invaluable for analysing the many challenging facets of construction management featured in the contents.

Frank Harris
Ronald McCaffer
Francis Edum-Fotwe

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, organising, 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 function may be performed by a client, contracting company, consultant firm, public body or 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;

Modern Construction Management, Seventh Edition. Frank Harris and Ronald McCaffer with Francis Edum-Fotwe.

- 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;
- ICT management;
- Health and Safety management, education, training and welfare provision;
- Corporate Social Responsibility;
- Management of the potential environmental impacts of construction;
- Commissioning, auditing and recording of the project(s).

Also see CIOB definitions of Construction (Project) Management.

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 (CSR) 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 described and explained in this seventh edition of *Modern Construction Management*.

Structure of the book

The 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, which covers quality management in construction, is used to illustrate how quality is intertwined as a thread running through all the subsequent sections. It also explores the emerging strategic role of quality as a driver for competitive advantage in construction.

- Section 1 deals with techniques relating to project production management, including environmental legislation guidelines.
- Section 2 treats the business aspects of management at both project and company levels.
- Section 3 addresses the executive management responsibilities for overall corporate control.
- Section 4 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 chapters).

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 4 provides a deeper and better understanding of the implications of the various techniques. Section 4 largely covers the numerical-based aspects of these techniques.

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, as well as the current standards employed by construction organisations. It also looks at quality from the project perspective, 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.

The contents of each section are now discussed briefly below.

Section 1

Section 1 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:* covers energy use and the environment, Carbon Reduction Commitment legislation, national productivity reports, quality management, lean construction, benchmarking, stakeholder management, Corporate Social Responsibility, Six Sigma, production measurement and sampling, waste management.
- Chapter 4. *Planning techniques* deals with the principles of the techniques used in planning repetitive or non-repetitive construction work. The chapter describes bar charts, linked bar charts, network analysis and line-of-balance scheduling, PERT, space–time diagrams and The Last Planner. The role and use of computers in planning and the requirements of computer systems in exchanging data are also described. The chapter is updated with pertinent material on managing multiple projects.
- Chapter 5. *Workforce motivation* links the use of incentive schemes to motivation theory. It also presents the various payment systems for non-financial, semi-financial and purely financial incentives that can be employed to enhance worker motivation.
- 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.

Section 2

Section 2 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 management and design coordination, and reviews various forms of contract including EU 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.
- Chapter 9. *Estimating and tendering* describes the current nature of estimating practised by main and work-package contractors. It describes parties involved in the estimating and tendering process for work packages and outlines the process, including the decisions and calculations involved, and the issues in costing materials and subcontractors. It also addresses the use of computers in estimating and the changing role of the estimator in the face of advances in information technology.
- 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 3

Section 3 presents the executive management responsibilities largely concerning head-office activities, including organisation, business development, global construction, 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, including training and vocational qualifications.
- 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 modern web blogging and social networking.
- Chapter 16. *International construction logistics* 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. *Information resources and IT systems* develops an understanding of the strategic role played by information resources in managing both projects and the business for organisations in the construction industry including the cloud resources. It also addresses information systems and its associated technology embracing email, web sites, intranets, on-line information data and transfer, data exchange and integration of systems, as well as an introduction to Building Information Modelling.
- Chapter 18. *Financial management* describes the sources and means of acquiring capital funds and the use of balance sheets and profit-and-loss accounts and financial regulation.

Section 4

This section presents 87 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. The solutions are available on the companion website.

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 4 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 now 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 to 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 has to 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 and total quality management 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

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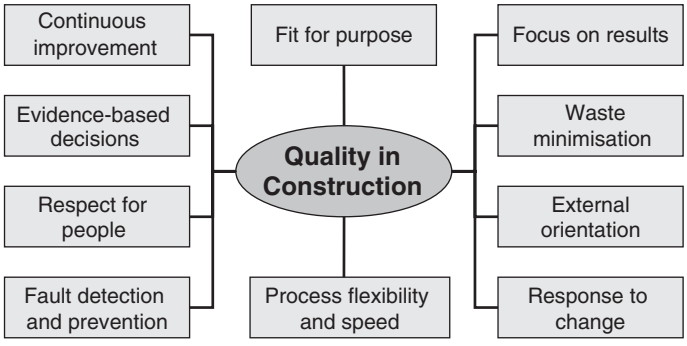

Fig. 2.1 Aspects of construction quality.

that are often seen as remote from the physical product. Fig. 2.1 shows various concepts that are considered to have an influence on the quality of the product and which have come to be associated with quality in construction.

The various areas that contribute to quality in construction in Fig. 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 construc-

tion. 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 that are 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.

Quality control implemented in construction

Traditionally there are two sets of documents that are used to determine the required quality of a construction project. These are the specifications and the contract drawings. The contractor uses these two documents during the site-operations stage of any project to facilitate 'quality' construction.

The process of actual construction is dissimilar to that of a production line in that there are no fixed physical and time boundaries between each operation of the process, hence the positioning and timing of quality inspection cannot be predetermined. In construction, quality checks are undertaken as each operation or sub-operation is completed. The majority of quality checks are undertaken visually. Visual quality checks of each section of construction are undertaken by the contractors' engineers and foremen, and then by the resident engineers and inspectors, to ensure that it complies with the drawings and specification. Quantifiable quality checks are also made during the construction stage. These include testing the strength of concrete cubes, checking alignment of brickwork, and commissioning of services' installations. Fig. 2.2 provides an example of a quality-control sheet for undertaking these inspections. The results of these quality checks are recorded and passed to the resident engineer.

The weakness of quality control is the development of the inspection mentality or culture whereby the construction contractors' operatives and engineers set their standards to that which they can 'get past the inspector'. In addition to potentially surrendering the standards of workmanship to an inspector, it exposes the contractor to expensive re-work if the standards of workmanship obtained do not meet with the inspector's approval. It would be much better if the contractors' engineers and operatives had a clear understanding of the quality required and were able to recognise it themselves, achieve it first time or regulate it by self-inspection. This concept, being the basis of quality assurance, potentially reduces the risks of producing unsatisfactory work and being involved in expensive re-work. Notwithstanding the existence of quality assurance and the emergence of total quality management, most clients still engage inspectors through their resident engineers or architects to reassure themselves. However, the impact and importance of the clients' inspectors are much reduced in a quality-assured or total-quality-managed company.

Quality assurance

Quality assurance (QA) emphasises defect prevention, unlike quality control that focuses on defect detection once the item is produced or constructed. Quality assurance concentrates on the production or construction-management methods and procedural approaches to ensure that quality is built into the production system. Quality assurance involves planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements or standard, and to be able to demonstrate any such compliance to that quality standard.

Quality assurance is described under the following headings:

- Evolution of quality assurance from quality control;
- Definition of quality terms;
- Quality assurance standards;
- Developing and implementing a QA system;
- Quality assurance in construction.

Quality Control – RM & Co. Ltd.

Inspection Report

Contract **RMC Installations**
Work Section **Brickwork**
Programme No

Sheet 1 Of 1
Contract No
WS Ref No 0 4 1 1 S 1
Prog. Item No

	SATISFACTORY	UNSATISFACTORY
(1) SETTING OUT		
(a) Check all door and window openings	✓	
(b) Check width of cavity	✓	
(c) Brickwork is plumb (including jambs and corners)	✓	
(d) Check all banding levels and window levels	✓	
(e) Check internal room sizes	✓	
(f) Check all joint sizes	✓	
(2) TECHNICAL ADEQUACY		
(a) Brick ties (number, spacing, insulation clips)	✓	
(b) Insulation (installed and secure)	✓	
(c) DPC (correctly installed)	✓	
(d) Cavity cleaned	✓	
(e) Movement joint (installed correctly)	✓	
(f) Check brickwork support angle	✓	
(g) Check for fire barriers	✓	
(3) APPEARANCE		
(a) Joints and sizes constant	✓	
(b) Faced brick cleaned (free from staining and mortar splashes)	✓	
(c) Bricks level and true	✓	
(d) Overall appearance satisfactory	✓	
(e) Is the work adequately protected	✓	
REMEDIAL ACTION (IF ANY)		
(1)		
(2)		
(3)		
(4)		
(5)		
(6)		
Date of inspection	20/4/99	
In attendance	FCH	
Result of inspection	SATISFACTORY	UNSATISFACTORY

Remedial action (inspected and approval to proceed given)

Signature Date 20/4/99

Prepared by: RM
Date: 23/04/99

Distribution				
	Arch	✓	WS	✓
	Const Eng	✓		

Fig. 2.2 Example of an inspection report sheet for undertaking construction quality control.

Evolution of QA from quality control

Traditional quality control is the practical implementation of techniques to ensure that the quality of work is satisfactory. There are no standard methods for implementing quality-control techniques hence it is unlikely that there is a consistency of quality between companies claiming to use quality control. The variability of quality control results in the loss of the competitive edge it potentially affords a company in the market place, as customers can not quantify the effectiveness of quality control in any one company. Quality assurance was created to remedy this situation. The ultimate objective of quality assurance is to provide the client with the quality of work required without the need for clients' checking during the process. A customer for a car does not insist on checking the assembly of the car, for example. This objective is achieved by documenting what processes are performed and how they are accomplished, by self-checking that each process is completed correctly and finally by recording that fact. The policy of recording the processes undertaken, together with the checking and recording of procedures, provides the customer with the assurance that the company is aiming to achieve an acceptable standard of quality. Although 'satisfying the client' is the main objective, the essence of QA is primarily to address 'getting it right first time' in order to avoid unnecessary costs to the contractor. Most construction contracts will include a clause requiring contractors to remedy any work that does not meet with the quality requirements of the project. Since this remedial work is undertaken at the contractor's expense, it provides a very strong incentive for the contractor to adopt a QA approach. Oakland (1995) defined both quality control and quality assurance and, in doing so, he also clearly explained their differences.

> *Quality control* is essentially the activities and techniques employed to achieve and maintain the quality of a product, process, or service. It involves a monitoring activity, but also concerns finding and eliminating causes of quality problems so that the requirements of the customer are continually met.

> *Quality assurance* (QA) is broadly the prevention of quality problems through planned and systematic activities (including documentation). These will include: the establishment of a good quality management system, the assessment of its adequacy, the audit of the operation of the system, and the review of the system itself.

Definition of quality terms

There are many quality terms in use for each of which the ISO 9000 family of standards, *Quality Management Systems – Fundamentals and Vocabulary*, provides a specific definition. Below are some salient ones of direct applicability to construction, and for which explanations have been provided. The exact definitions can be obtained from ISO 9000: 2000.

Term	Denotation
Conformity	Satisfying pre-defined requirements of a client in a quality system.
Design review	This is a set of activities whose purpose is to evaluate how well a potential design meets all quality requirements. During the course of this review, problems can be identified to which solutions must be developed.
Design verification	This process involves examining design outputs and the use of objective evidence to confirm that outputs meet input requirements.
Preventive actions	Preventive actions are procedures put in place to ensure the elimination of potential causes of non-conformities or to achieve quality improvements.
Quality	Every entity has specific characteristics, some of which are derived from stated or implied needs. The set of these special characteristics makes up the quality of an entity. For example, the need for dependability is met by designing a dependable product. Dependability then becomes a quality of the product.
Quality assurance	This is a set of activities whose purpose is to demonstrate that an entity meets all quality requirements, and will do so when the product is finished. QA activities are performed in order to inspire the confidence of both customers and managers, that all quality requirements are being met.
Quality audits	These examine the elements of a quality system in order to establish that they comply with quality system requirements. Elements include responsibilities, authorities, relationships, functions, procedures, processes, and resources.
Quality control	This is a set of activities or techniques undertaken to ensure that all quality requirements are being met. In order to achieve this purpose, processes are monitored and performance problems are solved.
Quality management	This includes all the activities that managers perform in an effort to implement their quality policy. These activities include quality planning, quality control, quality assurance, and quality improvement.
Quality manual	A quality manual is a document that states the quality policy and describes the quality system of an organisation or a process. It describes the roles, relationships, functions, processes, procedures, systems, and resources that affect quality. It can be a paper manual or an electronic manual.
Quality planning	Quality planning is defined as a set of activities whose purpose is to describe quality system policies, objectives, and requirements, and to explain how these policies will be applied, how these objectives will be achieved, and how these requirements will be met.
Quality policy	A quality policy statement defines the organisation's commitment to quality.
Quality surveillance	Quality surveillance is a set of activities aimed at monitoring an entity and to review its records in order to prove that quality requirements are being met.
Quality system	This is a network of processes made up of responsibilities, authorities, relationships, functions, plans, policies, procedures, practices, processes, and resources. Its purpose is to satisfy quality management requirements and to assure customers on quality of products and services.
Total quality management	This is a management approach that tries to achieve and sustain long-term organisational success by encouraging employee feedback and participation, satisfying customer needs and expectations, respecting societal values and beliefs, and obeying governmental statutes and regulations.