CONSTRUCTION MANAGEMENT STRATEGIES

A THEORY OF CONSTRUCTION MANAGEMENT

MILAN RADOSAVLJEVIC
JOHN BENNETT

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The book's companion website at
www.wiley.com/go/constructionmanagementstrategies
offers invaluable resources for students and lecturers as well as for practising construction managers:

- end-of-chapter exercises + outline answers
- Gantt charts to accompany examples in the book
- PowerPoint slides for each chapter
- ideas for discussion topics
- links to useful websites

Construction Management Strategies

A Theory of Construction Management

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Contents

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Dr Milan Radosavljevic is a lecturer in Construction Management, Director of Postgraduate Programmes and Director of the prestigious MSc Project Management in the School of Construction Management and Engineering of the University of Reading.

Dr Radosavljevic currently serves as a committee member of the Association of Researchers in Construction Management (ARCOM), he sits on the Board of the International Council for Research and Innovation in Building and Construction (CIB), and represents the University of Reading in the UK Construction Industry Research and Information Association (CIRIA) and Constructing Excellence in the Built Environment (CEBE). He is also a Visiting Professor at the University of Ljubljana in Slovenia.

Before joining the University of Reading Dr Radosavljevic worked as a Production Director in the medium size off-site construction company in Central Europe from 1997 to 2001, as a Research Assistant at the Construction Information Technology Centre (CITC) of the University of Maribor in Slovenia where he administered the EU funded ITC Euromaster programme between 2001 and 2002, and as a Demonstration Projects Coordinator for Scotland on behalf of the Communities Scotland and Constructing Excellence between 2003 and 2006.

He has made contributions on various courses at institutions around the world, including the Norwegian School of Management, Tallinn University of Technology in Estonia, University of Ljubljana in Slovenia, Shandong University in China, and has developed and run executive courses in Project Management in the United Kingdom and abroad.

He was a Principal Investigator in the KanBIM project. This was an international project involving researchers from the University of Reading and Technion in Israel aimed at developing a Building Information Modelling (BIM) based lean production management system for construction jointly funded by the Innovative Construction Research Centre (ICRC) of the University of Reading and Tekla Oy, a major BIM software vendor from Finland. The initial year-long project culminated in a paper published by *Automation in Construction* journal where it has soon become the second most popular and downloaded research paper.

Apart from BIM and digital technologies in their broadest sense, his current research interests include programme and project management, and computational simulation of construction organizations as heterogeneous and evolving networks.

Key publications

Cus Babic, N., Rebolj, D., Magdic, A., and Radosavljevic, M (2003) MC as a means for supporting information flow in construction processes. *Concurrent Engineering: Research and Applications*, 11(1), 37–46.

Radosavljevic, M. (2008) Autopoiesis vs. social autopoiesis: critical evaluation and implications for understanding firms as autopoietic social systems. *International Journal of General Systems*, 37(2), 215–30.

Radosavljevic, M. and Horner, R.M.W (2002) The evidence of complex variability in construction labour productivity. *Construction Management and Economics*, 20(1), 3–12.

Radosavljevic, M. and Horner, R.M.W (2007) Process planning methodology: dynamic short-term planning for off-site construction in Slovenia. *Construction Management and Economics*, 25(2), 143–56.

Sacks, R., Radosavljevic, M. and Barak, R. (2010) Requirements for building information modeling based lean production management systems for construction. *Automation in Construction*, 19(5), 641–55.

Sergeeva, N. and Radosavljevic, M. (2011) Towards a Theoretical Framework for Creative Participation: How Personal Characteristics Influence Employees' Willingness to Contribute Ideas. In A. Mesquita, (ed.) *Technology for Creativity and Innovation: Tools, Techniques and Applications*. IGI Global.

Professor John Bennett, DSc, FRICS

John Bennett is Professor Emeritus of The University of Reading where he was Professor in the Department of Construction Management & Engineering from 1975 to 2001. He was the United Kingdom's first Professor of Quantity Surveying following a successful career in both the public and private sectors. This included being Senior Quantity Surveyor in the CLASP Development Group which pioneered the use of industrialised building and subsequently Chief Quantity Surveyor at Hampshire County Council.

Professor Bennett was Director of the Centre for Strategic Studies in Construction from 1986 to 1997 where he took the lead in publishing reports based on rigorous academic research that influenced practice. Important examples include *Building Britain 2001* and *Investing in Building 2001* which provide an action plan for UK construction endorsed by the then Prime Minister, Margaret Thatcher.

Professor Bennett's research provided the basis for the UK construction industry's approach to partnering. This is reflected in his influential publications: *Trusting the Team*, *The Seven Pillars of Partnering* and most recently *Partnering in the Construction Industry; Code of Practice for Strategic Collaborative Working*.

In 1991 Professor Bennett was employed as Professor in the Research Centre for Advanced Science and Technology (RCAST) at the University of Tokyo where he continued research, begun in 1985, into the management methods of the 'big five' Japanese contractors. In 2002 he was an international visitor providing strategic advice to the Australian Cooperative Research Centre for Construction Innovation based at the Queensland University of Technology in Brisbane.

He was the principle academic member of the consortium, led by W S Atkins International, which produced the Strategic Study on the Construction Sectors for the Commission of the European Union. He was one of two main authors of the Final Report, *Strategies for the European Construction Sector*, published in 1994 to provide a factual and theoretical basis for the EU's strategy towards construction.

He was Chairman of the SMM Development Unit that drafted SMM7 and the first Chairman of the joint ACE/BEC/RIBA/RICS Building Project Information Committee set up to run the UK's co-ordinated conventions for production information for building projects.

He was founding editor of the leading international refereed journal *Construction Management and Economics*, and remained in this role from 1982–91. His main theoretical publications are *International Construction Project Management*, which provides a contingency theory of construction project management based on practice in the United States, Japan and the United Kingdom and *Construction – The Third Way*, which describes construction organizations in terms of self organizing networks of teams guided by open information and feedback.

Publications

Atkins, W. S. and consultants including the Centre for Strategic Studies in Construction (1993) *Secteur, Strategic Study on the Construction Sector: Final report: strategies for the construction sector*. W.S. Atkins International.

Bennett, J. (1991) *International Construction Project Management: General theory and practice*. Butterworth Heinemann.

Bennett, J. (2000) *Construction – The Third Way: Managing Cooperation and Competition in Construction*. Butterworth.

Bennett, J., Croome, D. and Atkin, B. (1989) *Investing in Building 2001*. Centre for Strategic Studies in Construction.

Bennett, J., Flanagan, R., Lansley, P.R., Gray, C., Atkin, B.L. and Norman, G. (1988) *Building Britain 2001*. Centre for Strategic Studies in Construction.

Bennett, J. and Jayes, S.J. (1995) *Trusting the Team: The Best Practice Guide to Partnering in Construction*. Thomas Telford.

Bennett, J. and Jayes, S.L. (1998) *The Seven Pillars of Partnering: A Guide to Second Generation Partnering*. Thomas Telford.

Bennett, J., and Peace, S. (2006) *Partnering in the Construction Industry; Code of Practice for Strategic Collaborative Working*. Elsevier.

With an ambition to multiply its customers' potential to think and achieve big, Tekla provides a BIM (Building Information Modeling) software environment that can be shared by contractors, structural engineers, steel detailers and fabricators, as well as concrete detailers and manufacturers.

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Preface

Construction management involves unique challenges. It has features which are similar to the systematic improvement of products and production processes which characterise manufacturing but it also has features more usually associated with the controlled innovation and creativity which characterise project based industries, such as software development. The distinctive characteristics of construction result from buildings and our physical infrastructure involving many different technologies. Some are based on very local industries, some depend on companies which operate nationally but an increasing number of construction technologies depend on global networks of organizations often with widely different approaches to business. All this is further complicated by construction projects having individual locations which inevitably throw up at least a few surprises.

This combination of challenges is not comprehended by general management theories. Yet historically these provided the basis of most construction management courses. The inevitable result is young construction managers quickly discover the ideas they have been taught do not fit the practical situations they face. They find it difficult to make sense of bewildering mixes of terms, responsibilities and roles. Eventually most learn from experience in one sector of construction how to work reasonably effectively but that provides a poor basis for working in other sectors.

Similar limitations characterise construction management research. Too much of what is published distorts the realities of construction to make it fit theories developed in other industries. Inevitably the results appear remote from practice which has created a gulf between researchers and practitioners. The subject needs a new foundation which is firmly grounded in the characteristics of construction. This book attempts to provide that foundation by proposing a theory of construction management which identifies the actions which help construction projects and companies to be efficient.

The theory and the practical guidance which flows from it draw on knowledge and experience from two generations of construction management. The authors between them have been involved with the leading edge of construction management from the earliest days of its emergence as a distinct profession and academic subject through to contemporary best practice. When Milan Radosavljevic and John Bennett met in 2008 they rapidly found common ground in understanding the need for construction management to have a robust theoretical basis. They both recognised the absence of this essential foundation results in too much practice and far too much research being based on individual ideas and isolated initiatives. As a result good ideas are lost; systems to ensure year-on-year improvements in performance are weak or non-existent and progress in practice and research is painfully slow.

The fundamental aim of this book is to provide a basis for construction management to develop systematically on robust theoretical foundations. Theory is essential for practice and research to make the steady, relentless progress which is the hallmark of all outstanding industries and bodies of knowledge.

Given this high ambition, the book is organized to provide a coherent message for construction managers at all levels. It recognises that students and practitioners have different needs by developing the material in four sections, each designed to match the knowledge and experience of a distinct group of readers. In addition the authors have recognised the needs of the ever growing number of international students who come from different cultures and are not familiar with English construction terminology. The book therefore carefully defines all the key terms needed to understand the theory of construction management.

The book begins with a basic introduction to construction processes and products. This is in Chapters 1 and 2 and is suitable for first year undergraduate students in courses for all the professions involved in modern construction. The next section of the book describes the theory of construction management. It begins in Chapter 3 which defines the basic concepts of the subject. This is necessary because the construction management literature lacks consistent definitions of commonly used terms like *built environment*, *construction*, *design*, and so forth. Throughout the existing literature different terms are used for the same or similar concepts and the same terms are used for obviously different concepts. For example, a plethora of muddled and overlapping role titles are currently used in construction which makes it difficult to establish how projects are actually managed and by whom. Chapter 3 provides a set of clear and consistent definitions of the basic concepts needed to understand construction management.

The resulting set of fundamental definitions is used in Chapter 4 to describe the theory of construction management. This provides a rigorous way of understanding the factors which determine the performance of construction projects and companies. In a distinct break with most existing construction management literature, project and company management are treated as an integrated whole. This is vital in enabling the theory to take account of the major influence company managers have on projects, and the impact of project managers on companies. Chapter 4 also describes how the complexity and uncertainty endemic in construction can be expressed in mathematical terms to provide effective indicators of the inherent difficulty of the tasks facing construction managers in practice. The website linked to this book, www.wiley.com/go/constructionmanagementstrategies, includes a basic guide for readers not familiar with mathematical terms. The mathematics introduced in Chapter 4 is straightforward but nevertheless provides a powerful tool to guide decisions about appropriate strategies for construction projects and companies. The theoretical material in Chapters 3 and 4 is designed for undergraduate students in their final years as they become familiar with construction.

Chapters 5 to 9 describe the practical implications of the theory in the major construction management approaches currently used in practice. These include traditional approaches, the various management-based approaches as well as recent developments designed to foster cooperation including partnering and strategic cooperation. The book goes further in describing a totally integrated approach capable of delivering, in the right circumstances, outstanding

performance. Each major approach has its own chapter which describes the main roles and actions and relates them to the theory of construction management. This rich mixture of theory and practice is designed for final year undergraduate students.

The first nine chapters are ideal for postgraduate students who have not studied the subject at undergraduate level. They provide a coherent and rigorous description of construction management in theoretical and practical terms. The subject matter is expressed in clear descriptions, diagrams and mathematics to make it accessible to the widest possible range of postgraduate students.

The first nine chapters provide an essential introduction to the fourth section which comprises Chapters 10 and 11. Chapter 10 describes how the theory of construction management benefits practice by providing 25 propositions about construction management actions which improve the efficiency of projects and companies. These are set out and explained in Chapter 4. The propositions provide a checklist of best practice. Practitioners who decide to act on any of the propositions will find a mass of useful advice and guidance on the strength and application of each of the propositions in the body of the book. As they consider using any of the major approaches to construction management, they will find the chapter which describes it helps ensure they are making a good choice and provides direct advice on using it effectively. All this is brought together in Chapter 10.

Chapter 11 describes the implications of the theory of construction management for future research. It then uses this analysis to propose a radical new basis for construction management research. It explains how this can be set up and developed by the construction management research community in a manner which enables individual projects and companies to use the best available knowledge and research. At present too much practice and research is isolated so that knowledge remains fragmented and lacks a robust basis for making progress with any confidence. Chapter 11 is intended to change this by proposing a major step forward for the subject. This important development is supported by the website linked to this book, www.wiley.com/go/constructionmanagementstrategies, which demonstrates the use of the proposed new knowledge base for construction management.

The book is based on the authors' very diverse knowledge and experience. It also takes account of the best of the construction management literature by including in each chapter a list of *Further Reading*. This lists the most significant books and papers which are relevant to the chapter. This approach has been adopted to avoid interrupting the text with detailed references to the sources of particular ideas. The authors fully understand why references are essential in research reports but the book is a textbook for students and a guide and checklist of best practice for construction managers. The needs of these readers are best served by guiding them towards the most outstanding construction management literature not by interrupting their focus on understanding the subject with a multitude of references.

Milan Radosavljevic
John Bennett
The University of Reading, UK

Chapter One
Introduction and Background

Construction provides many of humanity's greatest achievements: Salisbury Cathedral (Figure 1.1); the Taj Mahal (Figure 1.2); Sydney Opera House (Figure 1.3); high rise buildings in Dubai (Figure 1.4); and incredible buildings in modern China (Figure 1.5). Construction gives us places to live, eat, sleep, work, play, entertain, worship and be cared for. It provides the basis for transport systems and sophisticated services which make modern living comfortable and efficient.

Buildings and infrastructure involve virtually every human technology which makes them the most complex of products. They include technologies like brickwork and carpentry, which have their origins in ancient times, technologies based on heavy machinery, many of which developed during the first industrial revolution, right through to highly advanced, modern technologies including the most sophisticated communication systems and intelligent materials. Ensuring this diversity of technologies is used effectively and efficiently requires highly skilled management.

This book provides a rigorous guide to the situations and decisions which face construction managers. It is based on extensive research into the most effective ways of managing construction. Much of this research has been undertaken by the authors but the book also draws on published research into all aspects of construction management. The most important sources are listed at the end of each chapter as further reading.

Practice and research have identified fundamental concepts and relationships which guide effective and efficient construction management. These are described in this book in the form of a theory of construction management because this allows the ideas to be applied to every kind of construction project. More than this a rigorous theory allows the ideas to be developed by practitioners as new situations arise and robust ways of managing them are developed. It also allows the ideas to be tested by academic research and confirmed or replaced by better management ideas.

A fundamental theory of construction management needs to be based on a generic description which answers the question: What is construction? A useful way of providing such a description is to envisage visitors from another galaxy looking at Earth. This allows the description to be based on direct observation which is not influenced by preconceptions about construction.

Construction Management Strategies: A Theory of Construction Management, First Edition. Milan Radosavljevic and John Bennett.

Figure 1.1 Computer Model of Salisbury Cathedral.

1.1 Construction viewed from space

As they circle Earth in their spacecraft the visitors from another galaxy see a planet covered by great expanses of blue water interrupted by land masses dominated by rocks and vegetation. The gleaming white polar ice caps attract their attention for a while. Looking closer at the land areas, the visitors see concentrations of buildings and infrastructure. In places these stretch for hundreds of miles forming mega-cities but most construction is arranged in smaller clusters which form cities, towns and villages. At night, the visitors see the Earth dominated by the lights of urban areas. They are fascinated by the erratic patterns of fixed and moving lights. They notice strings of lights connecting many of the cities, towns and villages.

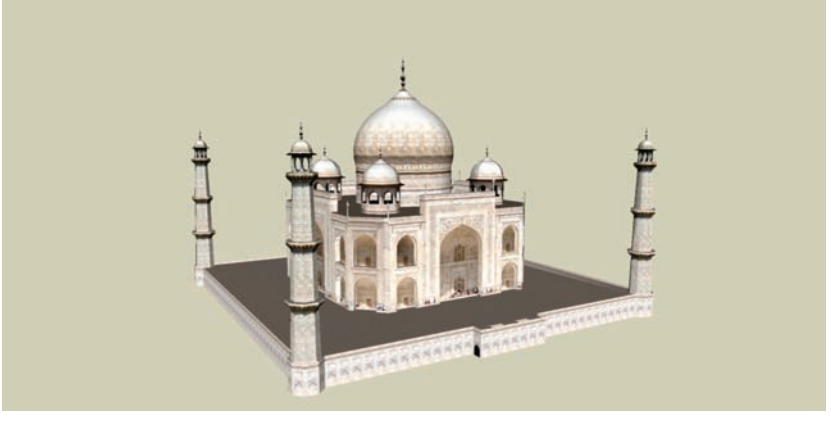

Figure 1.2 Computer Model of the Taj Mahal.

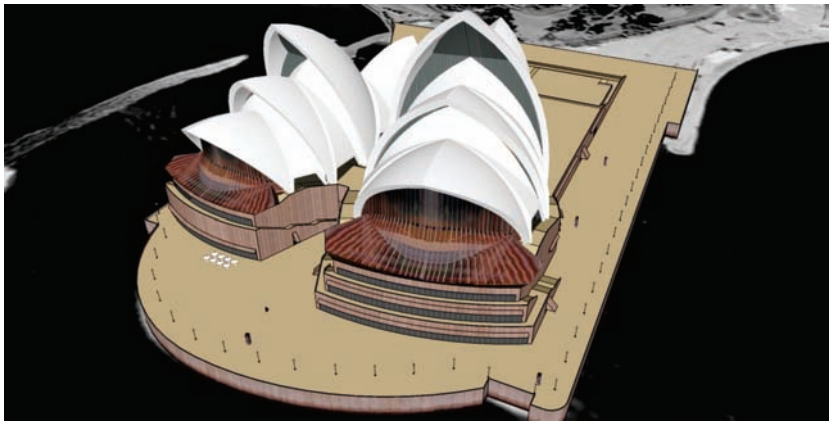

Figure 1.3 Computer Model of Sydney Opera House.

Figure 1.4 Computer Model of a Residential Area in Dubai.

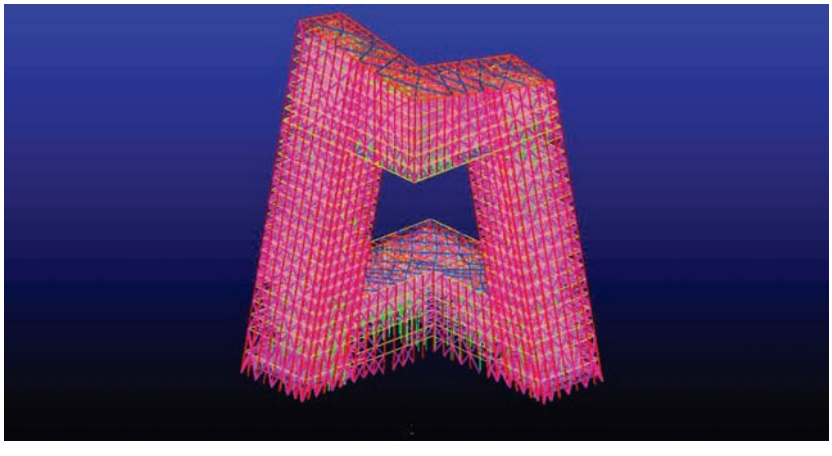

Figure 1.5 Computer Model of the CCTV Tower in Beijing. *Source*: Tekla Oy, Building Information Modelling software vendor

Looking at the same areas in daylight they see roads and railways carrying vehicles and trains. The patterns of movement cause them to notice concentrations of aeroplanes taking off and landing near cities. They see huge ships leaving and arriving at many of the cities near the oceans. Looking ever closer they see people in the urban areas moving in and out of buildings, walking between them and using various forms of transport.

As they focus on the urban areas, their attention is attracted by sites where new structures are apparently growing out of the ground. This growth takes time and involves people and machines in many different actions.

Observing a construction site our visitors see a group of people communicating and performing a complex set of actions that collectively contribute to a growth of a new structure. They are fascinated by huge excavating machines ripping earth and subsoil apart and pushing it into new, unnatural shapes. On other sites they see great tower cranes lifting materials and components into place. Some are forming massive steel frames. Others are lifting prefabricated concrete units to form the structure of a building, bridge or some other brainwave. Yet others are lifting prefabricated cladding panels and internal elements of buildings. Other sites are dominated by reinforced concrete technology as wooden or steel formwork is filled with reinforcement and concrete which is pumped into place from vehicles largely comprising huge, revolving tanks. Looking closer they see that not all construction technologies depend on big machines. There are groups of people who undertake actions which rely on their own physical strength and skills to position and then fix materials and components. In total the visitors see people using a wide variety of tools, equipment and materials.

Our visitors notice people on construction sites work according to day and night intervals; and in many cases they also see a pattern of work stopping for two days at regular seven day intervals. Initially they assume most groups of humans are working at different tasks but they may well see groups undertaking the same activity in different parts of the structure. They may guess these have some extra relationship beyond their involvement on the same site.

As they watch different examples of these fascinating sets of actions (Figure 1.6), the visitors realise they move through stages dominated by distinct types of technology. Before any construction starts the site may be an empty space or it may contain existing structures. The first stage alters or demolishes any existing structures and reshapes the site. This prepares the site for the next stages which create a strong foundation and a basic structure. The visitors can see broad similarities in the function of the foundations and basic structure but as they look more closely it becomes apparent that they have individual characteristics. Many different sizes and shapes are formed from various combinations of concrete, bricks, steel, other metals, timber or various synthetic materials. Some basic structures sit just above ground level or even below it but others provide many floors rising high into the air.

Once the basic structure is complete, the next stages clad it with various materials and components. As this external cladding is completed, further stages begin in the newly created internal spaces. Pipes, ducts and wires are threaded through the basic structure. Sometimes these are installed in large prefabricated units but equally often they are positioned by what appear to be specialists working with hand tools. Further stages form partitions to divide each floor into separate spaces. At the same stage various kinds of access

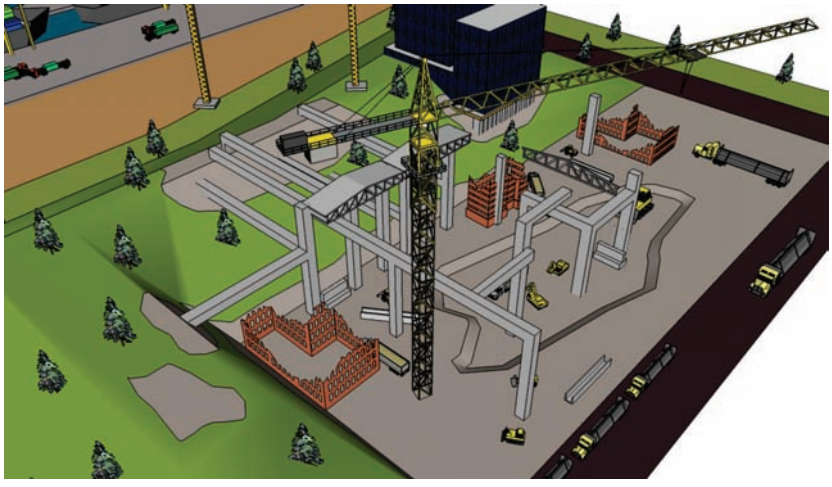

Figure 1.6 Construction in Progress.

between the separate floors are installed. These may be assembled on site from basic materials or involve the installation of complex components. Further stages install major items of plant and equipment which the visitors learn are designed to heat or cool the completed building, provide electricity in a controlled form, supply water, gas and other useful chemicals and dispose of waste material. The visitors see these various services form systems which are tested and re-tested to ensure they work properly. As all these actions are completed, further stages provide internal and external decoration to complete the new building or addition to the infrastructure.

The visitors recognise that on each separate site they are watching a concerted effort by a group of people to construct a new structure until a point in time when all the people involved in construction leave and are replaced by another group of people who use the newly created structure. In its most fundamental form our observers describe the construction actions as a complex interplay of people, tools, equipment and materials coordinated by communication.

As the visitors continue looking at many construction sites, they learn that humans refer to sets of linked actions which have agreed start and end dates as actions and projects.

As the visitors from another galaxy struggle to understand what they have observed they notice the actions on site are not independent. They see lorries and vans delivering materials, components, equipment and machines to the site. As they track the lorries and vans they recognise they are part of complex supply chains which link warehouses, factories, processing plants, mines and many different kinds of transport.

As they attempt to make sense of these wider patterns of actions (Figure 1.7), the visitors notice some of the lorries and vans are decorated with distinctive images which the humans call logos. They see the same types of logos on some of the warehouses, factories and the other parts of individual supply chains. Then following the materials and components onto construction sites they recognise groups of people performing distinct actions wearing clothes some of which carry the same logos. Other groups using different materials,

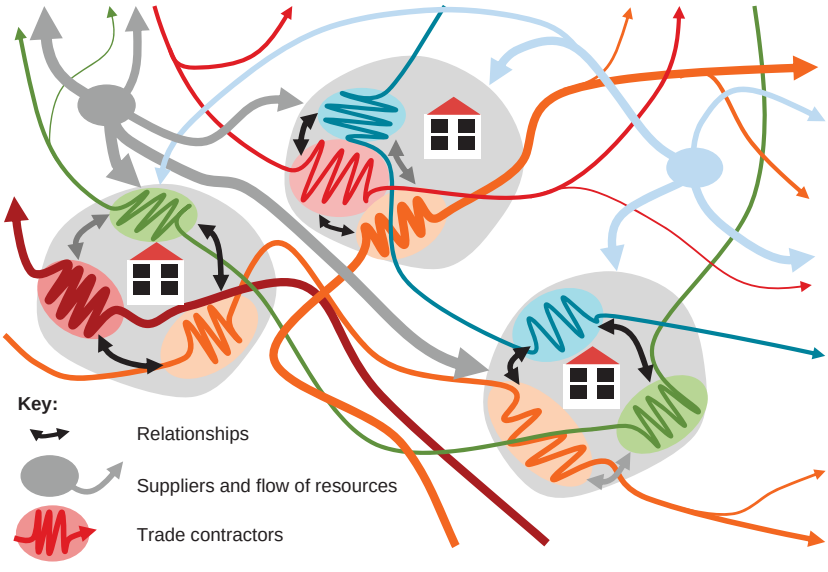

Figure 1.7 Construction Project at the Hub of a Complex Pattern of Supply Chains.

components, tools, equipment and machines are dressed differently and have different logos.

As they watch more sites, the visitors realise there are groups on other sites wearing the same logos. The visitors conclude that the logos serve to identify the existence of distinct organizational entities which humans call companies. As they consider this evidence, the visitors realise companies provide some kind of connection between people and the resources they use which is independent of individual construction projects. The visitors soon work out that individual companies provide the resources needed to carry out a specific type of production work on many different sites. By studying further, they find some companies operate locally or nationally, while others work all over the world.

Looking inside construction companies the visitors see they are permanent organizations intended to continue long-term. They listen to meetings of people called managers as they make decisions about the actions of the company as a whole. The meetings discuss staff training, investments in new plant and equipment, financial issues, developments in the demand for construction and new government legislation. All these issues concern the company as a long-term enterprise and are entirely independent of any individual projects.

Seeing the confidence with which managers in many of the companies deal with broad ranging issues makes the visitors from another galaxy question why the organizations responsible for construction projects are temporary. They have watched project organizations being formed and re-formed as projects progress through their different stages and then once the new building or infrastructure is complete, they cease to exist. The visitors find this puzzling but are unable to work out why people assemble project organizations only to disband them after just one project. It must be more sensible to let a carefully developed and efficient organization undertake more projects.

As they struggle to understand project organizations the visitors realise the sets of actions which make up most construction projects are so complex there

must be a sophisticated system of coordination to ensure the work is undertaken correctly. Watching closely the visitors' attention is attracted by people called foremen who do not perform any production actions but communicate with those who do the work. Then the visitors notice other people, who humans call designers and managers, who communicate with the foremen. In addition to day-to-day, informal communication, there are formal meetings. These bring together various groups of people involved in the project at regular intervals to discuss problems and make decisions. The visitors notice the formal meetings are arranged and run by managers. It soon becomes clear the communication at formal meetings leads to certain work being done. They notice other less formal discussions between managers and foremen and as they get close enough to listen they discover that much of this informal communication is needed to prevent clashes between groups undertaking closely related construction actions. In its purest form the observers would regard these various kinds of communication as management of people, tools, equipment and materials.

As they watch people on site communicating, the visitors see them referring to various paper-based and electronic documents. They realise many of these documents are not produced on site but arrive from various external sources. They see communication on site becomes most intensive when new documents arrive. These discussions are led by managers who also appear to control the distribution of the documents. The visitors gradually realise the management of the construction actions on site is guided by information provided by the documents.

The visitors also notice most of the documents carry logos similar to those on the workers' clothes. By tracing the documents back to the originating companies they recognise each new building or addition to our infrastructure begins with tentative ideas. These usually originate in organizations which are not construction companies. The visitors see these organizations are primarily involved in some activity other than construction and have decided they need a new building or infrastructure. The visitors are fascinated as they watch how ideas for new construction emerge and change. They see men in smart suits sat around large tables arguing about minor features of a new building. They watch formal meetings of various government bodies debating the merits of a new airport. They see many discussions inside customer organizations as staff try to understand the implications of a new factory or office building. The meetings and informal discussions eventually lead to an agreed description of what the customer organization needs.

The customer organization approaches a construction organization either during their internal discussions or when a decision has been made that a new facility is needed. This triggers design work and a multitude of calculations. The visitors see descriptions of the end product being developed in ever greater detail. Various ideas are discussed and documented before there is agreement on one design. This is developed by people working in many different companies and results in detailed descriptions of all the parts of the new facility. The visitors recognise much of this detailed work is undertaken by companies which form part of the supply chains for construction projects. Other specialists consider how the emerging design can be constructed, how long it will take to complete and what it may cost.

As the visitors watch further, they see the formal meetings, informal communications and documents provide information which helps coordinate the design and management actions. They see managers guiding this coordination

system. They realise the site and supply chain actions they have already studied include a similar system. Indeed they can see many projects managers use a common coordination system for all the actions whether they are based on site or elsewhere.

Looking back at their observations of the coordination systems, the visitors notice that managers spend much of their time on a day-to-day basis dealing with problems. Dramatic examples arise when a construction site is affected by bad weather. The visitors are amazed and amused by the chaos which follows snow, heavy rain, cold weather or high winds. In some parts of the planet, all the actions on construction sites are brought to a shuddering halt for many days by these extreme weather conditions. They watch managers struggling to find ways to protect the partially completed work and ensure an early resumption of effective work.

The visitors also remember being fascinated by construction sites that had became the subject of protests. They had watched people, many carrying banners and shouting, surrounding a site. The visitors witnessed protests which objected to the way the work was being organized and others where the protestors disliked the nature of the new facility. They saw protests provoked by sites working at night, streams of heavy lorries on narrow roads, the construction of a nuclear power station, a prison and a motorway which threatened to destroy the habitat of a spotted toad. They also noticed protests by construction workers about conditions on particular sites or their wages being reduced. Whatever the causes, it is plainly obvious that managers face many difficulties as they struggle to deal with protests and ensure efficient work on site.

As they continued discussing the problems faced by construction managers, the visitors identify a less dramatic but far more common cause. Individual construction actions often overrun their planned end dates. Many reasons and excuses are offered to explain these failures: shortage of materials, absent workers, broken machines, damaged components, work delayed by other people working on the site, an industrial dispute at a factory manufacturing components for the project, and many more. Whatever the causes, delays leave managers to find some way of making up lost time or explaining to the customer organization that their new facility will be completed late.

The visitors from another galaxy decide construction is complex and inherently uncertain. The uncertainty may have its causes inside the project organization or result from interference from external sources. They begin to understand that construction management is difficult and the fact that many constructed facilities are completed on time is a substantial achievement.

Turning their attention to the documents from several projects, the observers see some of the information which guides management contains values in a single or sometimes several currencies. They read that companies undertake work only if these sums of money change hands and humans generalise these transactions into economic principles. They also see the financing of many construction projects can be a complicated business as customer organizations attempt to borrow money from banks and speculators, and seek subsidies or grants from official agencies. They recognise the success of some construction projects depends largely on the terms and conditions accepted by the customer organization in order to obtain the necessary finance.

As they read further the observers discover the transactions are governed by documents called contracts. Looking through contracts, the observers see

various clauses govern the relationships between the separate companies, the flows of information between them, and the work that needs to be completed in order to complete a new facility. They notice that on each individual project the customer organization is a party to a number of the contracts. Our observers read that at the end of projects, the customer organization takes over the new facility. In many cases they see the customer use the new structure to support their own actions but this is not always the case. Some new facilities are used by other organizations and these arrangements give rise to yet more contracts.

Further investigations of contracts and all the associated documents reveal the existence of another kind of documents which influence the actions of those involved in construction projects. These very formal documents are produced by organizations external to any of the companies involved. The visitors discover the external documents are called laws and regulations. They discover they are produced and published by various levels of government and other organizations working for government. In this way they identify that all actions, including construction, are governed by a legal system. One effect which intrigued the visitors is the preliminary stages of many projects are delayed by a need to obtain official approval for the particular type of facility required by the customer organization, the proposed design, particular design details or the planned method of working.

The visitors from another galaxy conclude that construction on Earth takes place in complex environments (Figure 1.8) which may interfere with even the most carefully devised strategies and plans of experienced construction managers.

Returning to their own planet the visitors' report is greeted with astonishment and laughter. Construction on Earth is very different to their own construction methods which allow individuals to make plans, consult with everyone likely to be affected, reach agreement on what should be produced and then place a firm order. The new facility is produced by robots using intelligent materials and never takes more than four weeks to complete. It will be several centuries before construction on Earth achieves this highly developed approach. In the meantime this book provides a guide to current best practice and the immediate future.

1.2 What is construction?

The visitors from another galaxy provide an independent view of construction based on direct observation. This provides the basis for a robust answer to the question: What is construction?

Construction is a series of actions undertaken by construction companies which produce or alter buildings and infrastructure. Individual construction companies become competent at one or more of the actions over many years. They apply their specialised skills and knowledge on construction projects. Each construction project has a start and end date and usually requires a number of construction companies that work together to produce a new or altered building, a group of buildings, or an addition or alteration to the infrastructure.

The actions which form any one construction project are extremely diverse as they take place in widely different locations and may involve practically every technology yet devised by humans. They include design and management

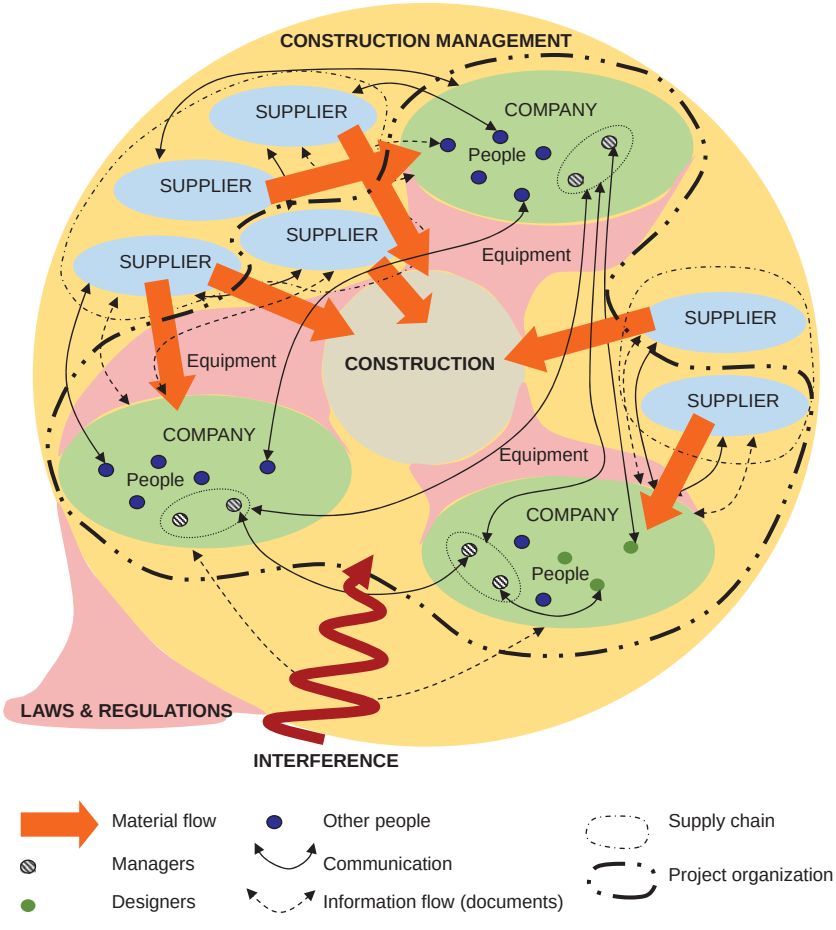

Figure 1.8 The Complexity Faced by Construction Management.

decisions which involve owners and customers in detailed negotiations with construction specialists and a great variety of regulatory, legal and financial organizations. These actions precede the direct physical production of the new facility which takes place on a construction site and in many distinct supply chains.

Ensuring the actions are undertaken effectively, efficiently and on time is construction management. It requires the coordination of a complex interplay of people, materials, components, tools, equipment and machines subject to variable performance in environments likely to interfere with planned progress. This in turn requires effective communication and efficient systems to organize the flow of the documents which provide the information needed by everyone involved in construction.

Construction management is the responsibility of everyone involved in construction companies and projects. It is common within companies and projects for specialists in management to be given responsibility for parts of the overall construction management task. This does not remove responsibility from everyone involved for ensuring that all the actions are undertaken effectively, efficiently and on time.