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.

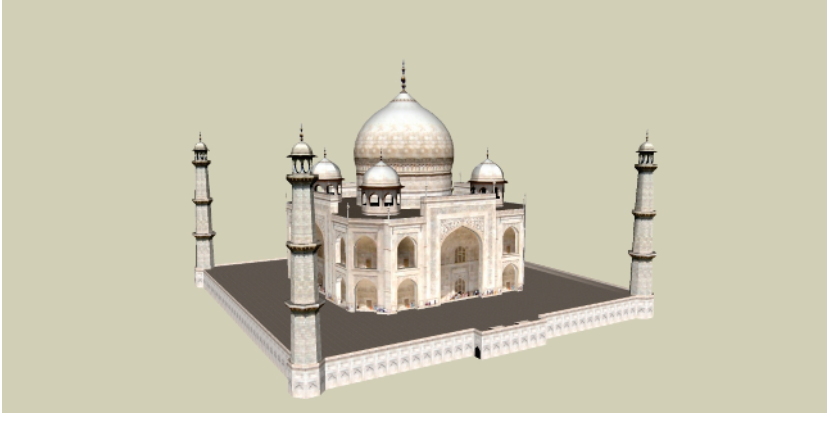

Figure 1.2 Computer Model of the Taj Mahal.

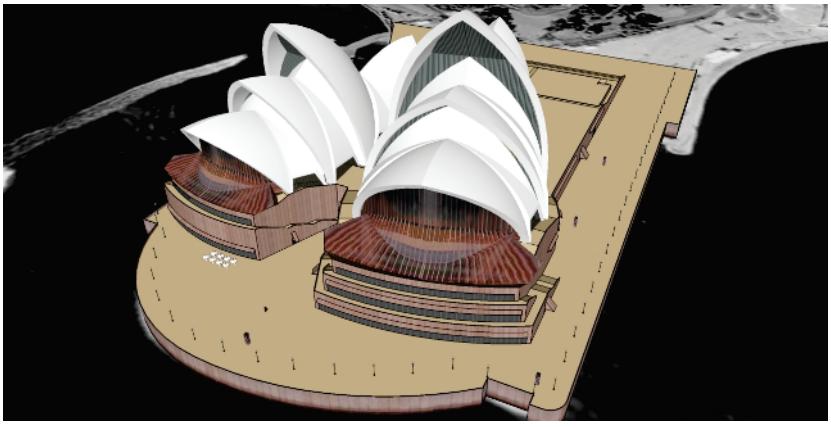

Figure 1.3 Computer Model of Sydney Opera House.

Figure 1.4 Computer Model of a Residential Area in Dubai.

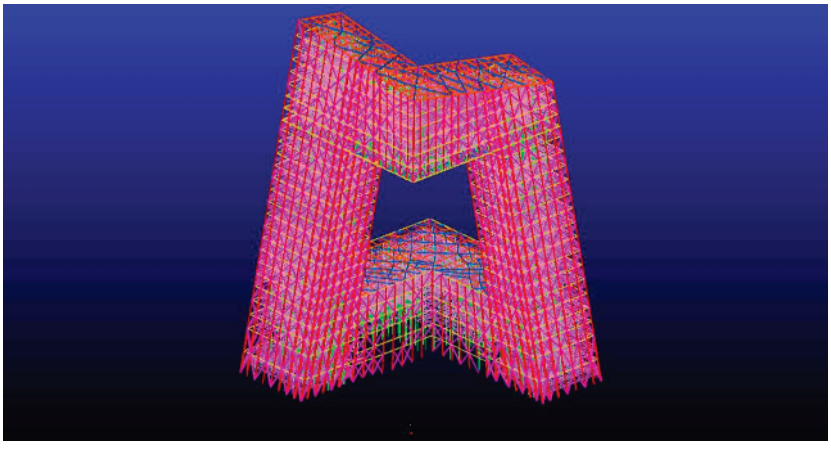

Figure 1.5 Computer Model of the CCTV Tower in Beijing. *Source*: Tekla Oy, Building Information Modelling software vendor

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

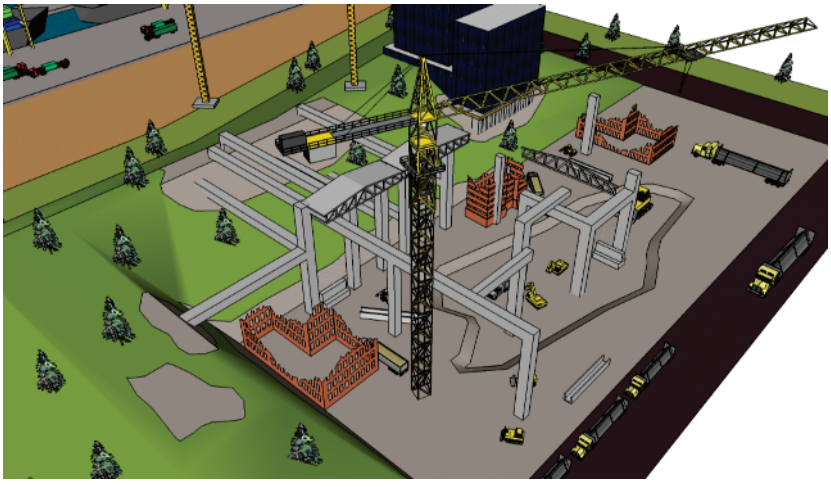

Figure 1.6 Construction in Progress.

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,

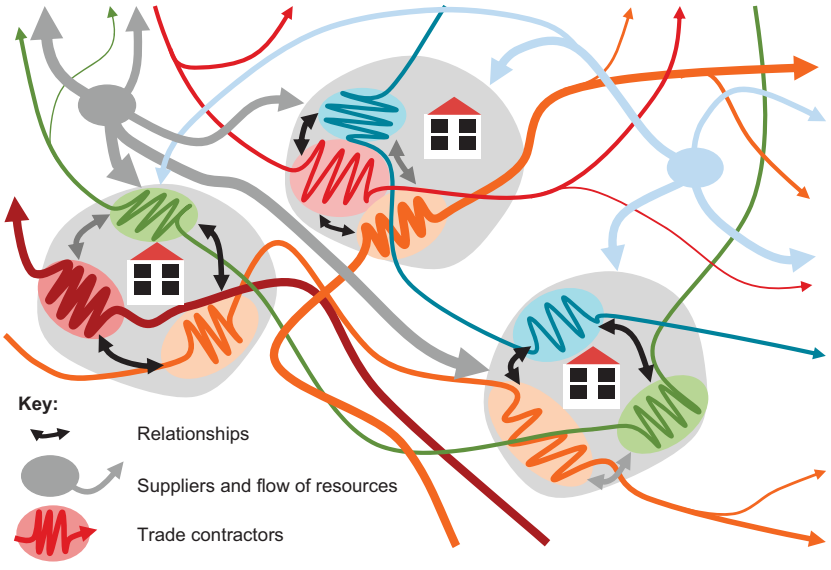

Figure 1.7 Construction Project at the Hub of a Complex Pattern of Supply Chains.

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

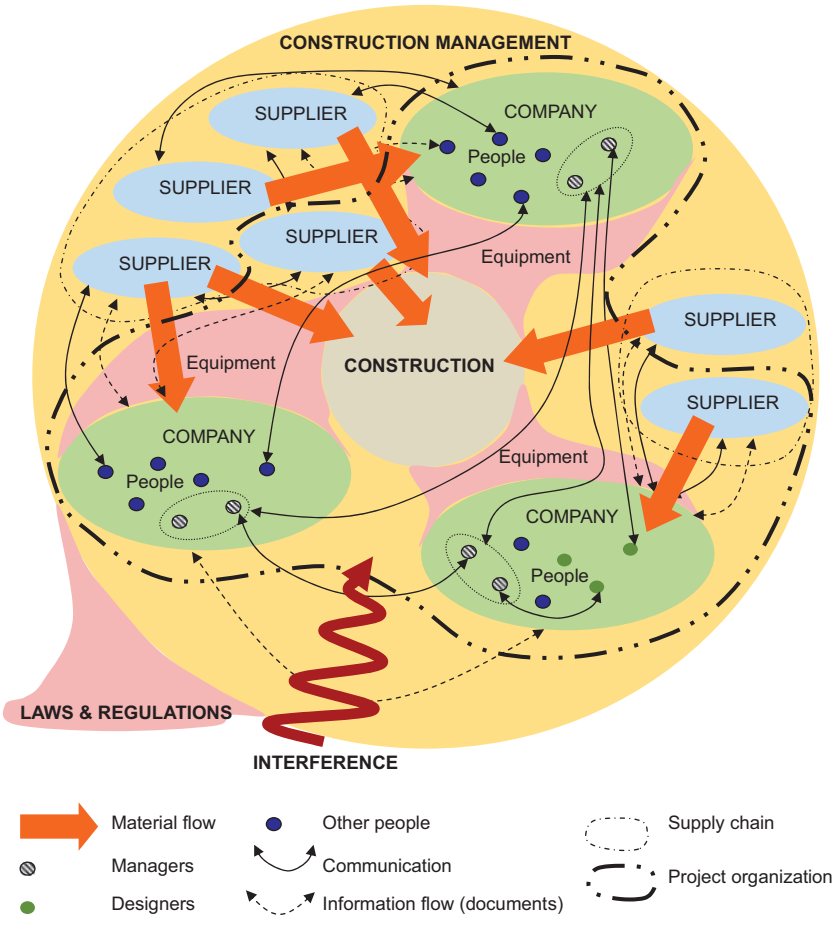

Figure 1.8 The Complexity Faced by Construction Management.

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.

1.3 Why a theory of construction management is needed

Construction management is needed to ensure the specialist actions needed to produce modern buildings and all the parts of our incredibly complex physical infrastructure can be undertaken efficiently. As described earlier in this chapter, construction projects require a bewildering range of resources, knowledge and skills. They require finance, creativity, science, technology, architecture, engineering, factories, craftsmen, labourers and distribution systems aided by almost every type of machine. The number of construction companies directly involved in major projects runs into hundreds; while the supply chains which provide all the necessary materials, components and systems involve literally thousands.

Modern buildings and infrastructure are the most complex things produced by humans. Professions, trades and crafts have developed to play distinct parts in the challenging work of producing them. Some specialised construction knowledge and skills, such as that used by architects, bricklayers and carpenters, have existed for centuries and are widely recognised and respected. Others are very new. Indeed, it is the case that every decade sees the emergence of new disciplines to meet challenging new demands from society and individual customers.

Construction management emerged in the second half of the twentieth century as a distinct discipline. It exists to ensure that construction projects are completed efficiently. This is a demanding task because the sheer complexity of modern construction and the potential for project environments to interfere with even the most careful plans make construction inherently difficult. Construction management seeks to minimise this inherent difficulty in ways which allow projects to be completed efficiently.

Initially the new profession concentrated on providing effective management for individual construction projects. This reflected the project focus of the established construction professions. Construction's historical project focus results from the practical characteristics of construction. It produces buildings and parts of the overall infrastructure which are fixed in one location in response to the needs of individual customers. In total, additions and alterations to the built environment may be required almost anywhere on Earth. This means construction is faced with an endless stream of new situations and new challenges. Each construction site is unique, and each customer has distinct needs and demands. These fundamental characteristics have tended to dominate the thinking of those involved in the industry and this gives traditional construction practice a strong project bias.

The focus on individual projects has influenced the development of distinct professions, working methods and much construction research. This has led to a steady improvement in construction's efficiency and the quality of buildings and other construction products. However, in recent years it has become apparent that the focus on project management has limited construction's performance.

World class progress and development requires the construction industry's understanding of project management to be married to an equal focus on company management. Construction companies need to think and plan long term if construction is to become a truly modern industry able to meet the demands of the twenty-first century. Construction management is at the centre of both company and project management. This new understanding is vital for

the construction industry's prospects. In simple terms, it is beginning to be recognised that construction projects can be undertaken efficiently and predictably only by well run construction companies.

Recognising the equal needs of projects and companies represents a major step forward in construction management thinking. In the past too much emphasis has been given to projects in the education, training and work of all the construction professions. This bias largely came from the practical need to focus on satisfying the needs of individual construction customers. However, many of construction's major customers are leading the way in demanding a long-term approach to the difficult task of producing major buildings and infrastructure. The leading edge of construction practice is already responding to these new and more challenging demands.

The emerging knowledge driving this leading edge are described in this book in theoretical terms because the most robust way of capturing human knowledge is to express it as a rigorous theory. This provides a tool kit of concepts and relationships which enable practitioners to analyse individual situations and select appropriate actions which fit their individual needs. In this way the theory provides a robust basis for everyone involved in construction to make decisions which improve their efficiency and the quality of construction products. A central assumption of the theory is that projects need to be well managed and companies need to be equally well managed.

The concepts needed by the theory of construction management are described in Chapter 3. This provides the basis for the theory to be stated in Chapter 4. The theory is then used in Chapters 5 to 9 to describe all the well established ways of managing construction projects. These chapters provide the background for Chapter 10 which describes the practical implications of the theory for current best practice and suggests future developments. Finally Chapter 11 describes how the theory can be tested and developed by research and practice.

The book is a textbook for all levels of students involved in construction. The theory helps all entrants to the construction industry understand the situations and challenges they find as they begin their own careers. Beyond that, the concepts and relationships described in the book provide a robust basis for understanding and developing best practice in all the construction professions.

1.4 Who can manage construction?

The various construction professions have strengths and weakness and once again our visitors from space can take an objective view of the character of key roles in construction. As they learn more about construction, the visitors may well discuss who should play the leading role in managing projects. They are likely to imagine various possible scenarios for construction management, some of which will be similar to those found in practice but others which are unlikely. In creating their scenarios our visitors will need to recognise that constructing a new facility, at the most generic level, comprises three distinct phases.

1. Preparation for construction on site (In this preliminary phase the facility has to be envisaged by a customer who orders the new facility. They employ various construction professionals who design the facility and manage the whole project.)

2. Construction in factories and on site (This phase is dominated by the actions of construction companies who usually have a formal contractual relationship with the customer. As a result many are called contractors. They arrange the supply of materials and components, and build the facility. This complex process normally requires managers to ensure it is completed efficiently.)
3. After construction is complete (Once the construction companies have finished their work, the customers, occupiers and facilities managers take over and use their new facility.)

Thinking about each of these challenging tasks will lead the visitors from space into discussing various possible scenarios for construction management. The following possibilities serve to illustrate the character of one of the key roles in construction projects.

1. Construction may be managed by designers (possible justification: customers require designers to envisage the overall facility and all its detailed features; so designers could well have the most profound understanding of the new facility).
2. Construction may be managed by customers themselves (Possible justification: customers have an obvious incentive to ensure their construction is well managed because they have to finance it and their organization will have to live with the resulting new facility. This should ensure they display the greatest dedication to the task of delivering the facility efficiently.)
3. Construction may be managed by contractors (possible justification: contractors are likely to have a high level of practical knowledge about all the actions needed to construct the required new facility).
4. Construction may be managed by facilities managers (possible justification: the constructed facility will be operated for many years so it is of paramount importance that the facility is simple to operate and maintain).
5. Construction may be managed by independent project managers (possible justification: project managers have a good overview of the whole life cycle of the project and so may be best placed to ensure customers get the greatest overall value from their new facility and its subsequent use).
6. Construction may be managed by independent construction managers (possible justification: by managing all construction actions efficiently, construction managers may be best placed to ensure customers get the greatest overall value from their new facility).

Identifying the advantages and disadvantages of each of these scenarios will help understand each of these six key roles.

1.5 Construction managed by designers

Designers work closely with their customers in deciding exactly what kind of facility is needed. They design the new facility and therefore provide an obvious choice to manage the whole project. However, their knowledge tends to be focussed on the performance and use of the facility itself. Indeed the designer's task is distinctly different from the challenges posed by manufacturing and production. The specialist knowledge they call on is very different from that needed for the direct physical actions required to produce the new facility.

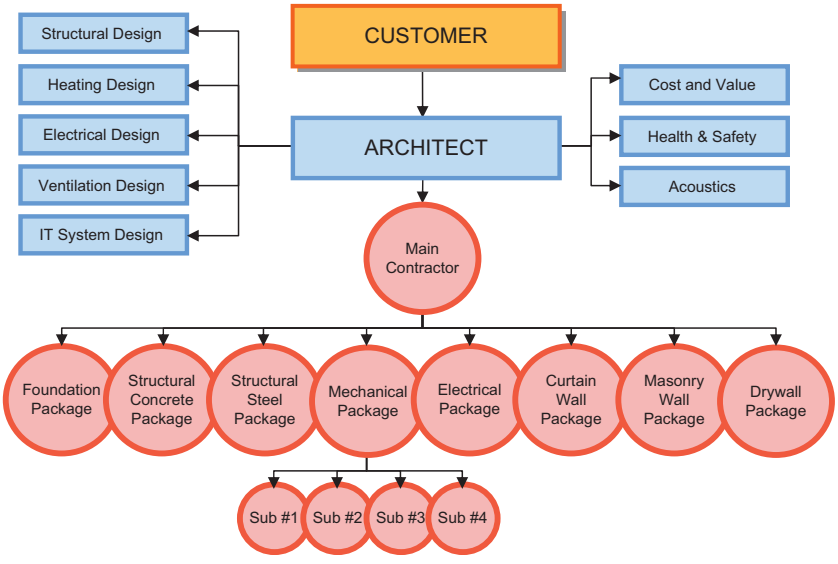

Figure 1.9 Designer-Led Construction Management.

Their lack of operational experience in organizing construction sites and all the supply chains which provide the materials and components could well lead designers into selecting inappropriate construction methods resulting in an inefficient use of resources. In this first scenario designers will need to go beyond their natural design task and extend their knowledge to the manufacturing and production processes. More importantly they need to establish effective relationships with all the construction companies that form the supply chains for materials and components and undertake the direct production of the new facility. They will need to do this and maintain effective relationships with the companies which provide specialist design advice. Figure 1.9 shows the general form of a designer led project organization.

Advantages	Disadvantages
Single point of contact for the customer	Contractors involved too late to ensure the design takes account of the need for efficient manufacturing and production
Manufacturing and production guided by complete design information	Designer may select contractors with an inadequate track record
Designers being involved in all stages of the project may help ensure a high quality facility	Problems caused by the design may create tensions between designers and contractors
	Designers lack of knowledge of manufacturing and production processes may cause inefficiencies
	The project may well be subject to regular design changes which interrupt efficient manufacturing and production

1.6 Construction managed by customers

Customers are normally the most committed party in the construction process. They will own and often use the new facility once it is complete. This means they have serious incentives to ensure the right type of facility is constructed at the right time, for the right budget. Their main weakness is they are in a different type of business from construction. While they may show high levels of dedication to managing their project, their inadequate knowledge of construction technology, resources, materials and components are major barriers to them being successful. This is compounded in most cases by a complete lack of established relationships with the construction supply chain. This can be a serious barrier because the construction of many facilities requires the close involvement of specialist teams in creatively discussing highly developed knowledge and working methods based on many years successful experience. Most customers do not have direct access to such expert, integrated teams. This is not surprising because many customers need only one new facility in several decades so there is no sensible reason for them to maintain teams that have sufficient knowledge to be able to directly manage the construction of a new facility. However, some customers do require several new facilities each year and may well decide it is justified to employ construction management capabilities in-house. They may recognise that having a deep understanding of the construction process is of crucial importance for improving their own products or services. In such cases customers may well have their own construction management teams. This situation is used to illustrate customer-led construction management and the general form of the resulting project organization is shown in Figure 1.10.

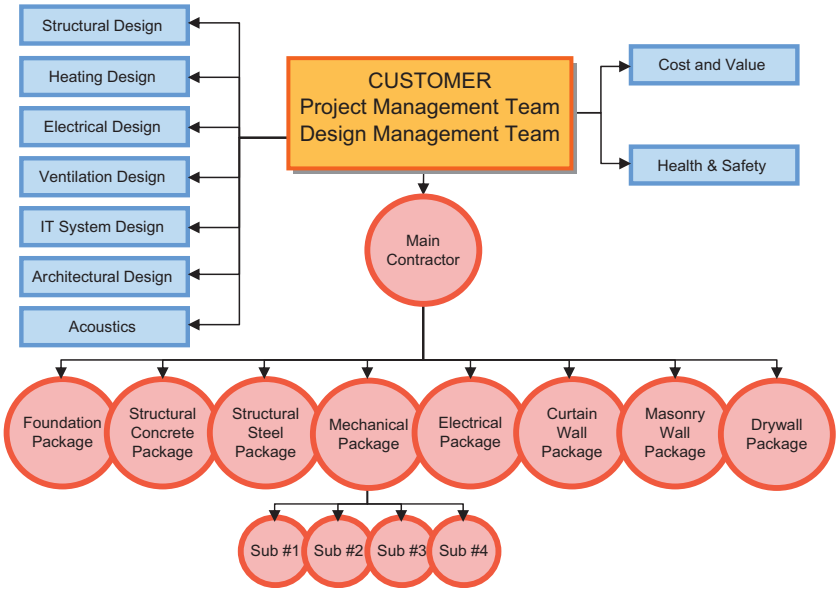

Figure 1.10 Customer-Led Construction Management.

Advantages	Disadvantages
Customer's dedication and involvement in the project should ensure the facility provides good value Internal teams responsible for managing contracted organizations can ensure the customer's needs remain paramount Early involvement of contractors may ensure designs take account of manufacturing and production issues	Customer's business priorities may clash with the needs of construction and cause misunderstandings Lack of experience in working with contractors may create an inefficient project organization A hands-on approach by the customer may result in clashes with contractors especially if they are employed on the basis of fixed-price contracts

1.7 Construction managed by contractors

Contractors undertake the direct physical production of the facility; they understand the direct physical construction process in detail and consistently work with specialist supply chains. This suggests they could provide excellent management for projects but contractors without design capabilities may face difficulties when trying to convert the facility envisaged by the customer into reality. Also contractors that undertake major projects are normally not involved in the operation and maintenance of the built facility which may limit their ability to produce a facility of the highest possible value to the client. For this scenario to work contractors either need a strong in-house design team or they have to subcontract design to an external organization they can work with effectively. Subcontracting provides a major obstacle to the success of this scenario. If a main contractor subcontracts the design and major work packages then their role is reduced to contract management which gives them very little power to ensure the efficiency of the construction process. Nevertheless, some global contracting organizations have build up strong in-house capabilities with large in-house design, specialist production and facilities management teams. Such companies subcontract only a few minor work packages and have competent in-house teams able to undertake all the major construction actions. This is one of the most appropriate construction management approaches. Figure 1.11 shows the main features of a contractor led project organization.

Advantages	Disadvantages
Single point of contact for the customer Potential for minimising the number of teams in the project organization	Only large contractors have adequate competencies and capabilities to avoid extensive subcontracting Where the main contractor subcontracts major packages and design, the project organization is fragmented which tends to cause difficulties

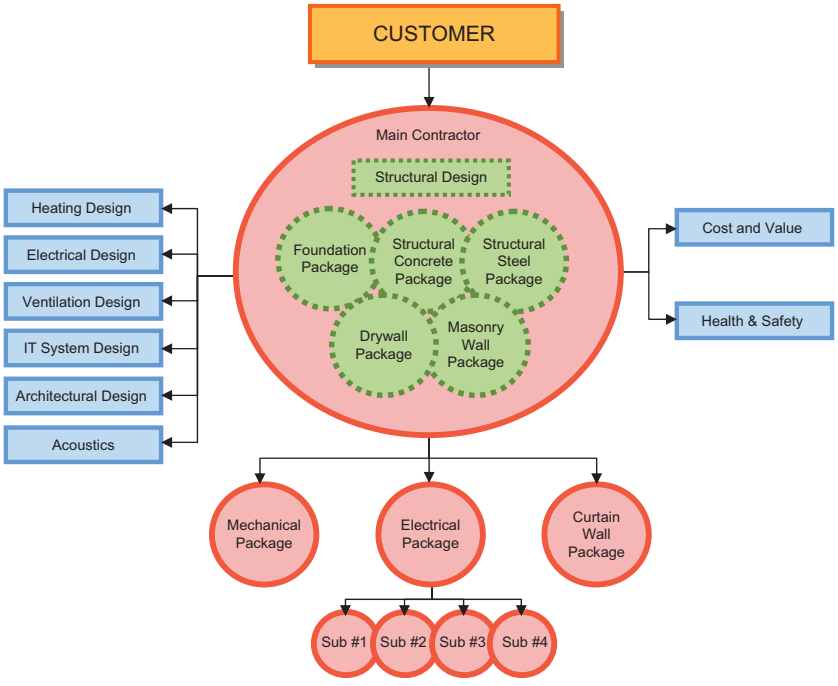

Figure 1.11 Contractor-Led Construction Management.

Advantages	Disadvantages
Experienced management of construction teams Established relationships within the supply chain	

1.8 Construction managed by facilities managers

Operation and maintenance account for a bigger proportion of the whole life costs of constructed facilities than does the initial construction. It is therefore not surprising that whole life costs are increasingly given considerable attention by customers and construction companies. In part this is driven by increasingly stringent legislation aimed at ensuring construction is sustainable. Surging energy prices are adding to the importance of constructed facilities being operated and maintained efficiently. One significant result is customers are involving facilities managers in the construction process as they are best placed to determine the most appropriate type of technology and construction methods to achieve minimum operational and maintenance costs. This expert focus on minimising the costs of operation and maintenance often produces high quality facilities. However, going further and requiring the facilities

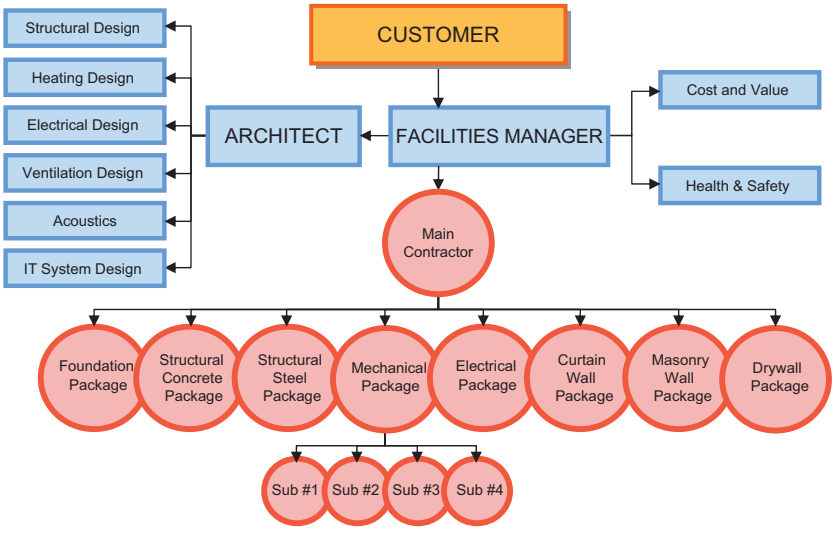

Figure 1.12 Facilities-Management-Led Construction Management.

manager to undertake the construction management role is likely to raise problems. Facilities managers lack direct experience of the whole construction process. They are likely to have little understanding of the design, manufacturing and production processes on major projects. Furthermore, the nature of their task does not allow them to develop effective relationships with specialist contractors. These weaknesses mean this scenario is unlikely to be a viable option for efficient construction management. It is more likely that facilities managers will continue increasing their involvement in construction projects but only during the inception, design and commissioning stages. Nevertheless, it is instructive to consider how facilities-led construction management might work (Figure 1.12).

Advantages	Disadvantages
The facility is likely to be efficient in terms of its whole-life costs	Lack of experience in working with designers and specialist contractors may well result in an inefficient project organization
Contractors involved in the construction process may subsequently be involved in the operation and maintenance of the facility	Contractors involved too late to ensure the design takes account of the need for efficient manufacturing and production

1.9 Construction managed by independent project managers

Independent project management organizations are often employed to manage complex projects through many stages in which construction is only a

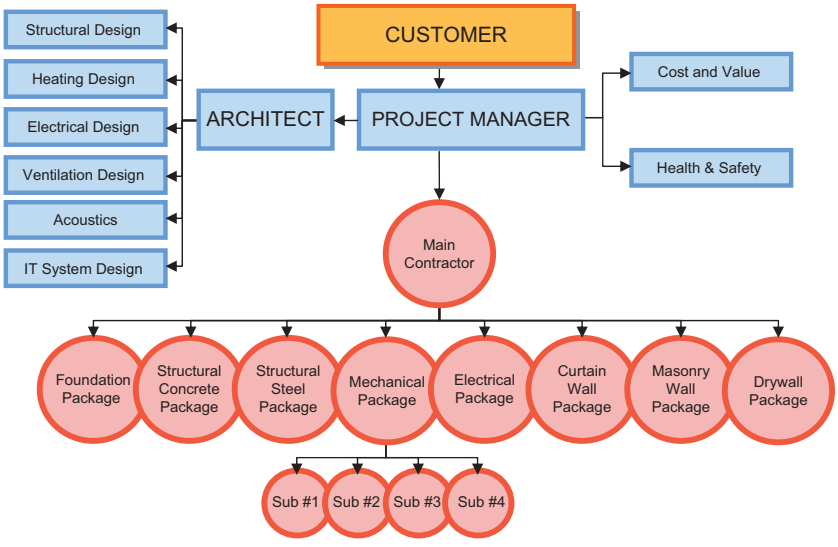

Figure 1.13 Project-Management-Led Construction Management.

relatively small part. Many of these organizations are generalists relying on huge supply chains which give them diverse knowledge. This is likely to give them a good overview of the issues and potential benefits which persuaded a customer to invest in a new constructed facility. However, if they were to undertake the management of a construction project, their wide ranging knowledge could all too easily leave the project with widely conflicting objectives. Similarly an over reliance on contractual relationships may limit the development of the construction project organization because of the project management organization's reliance on rudimentary contract management rather than much more effective relationship-based management. A generalist project management organization may also lack the specialist knowledge needed to give adequate consideration to appropriate construction methods and an effective focus on construction supply chain management. There are project management organizations which specialise in managing construction projects and understand the need for well informed management. The existence of these specialist organizations are taken into account in illustrating this scenario (Figure 1.13).

Advantages	Disadvantages
Management by project managers with experience of diverse temporary project organizations Project managers provide a range of views based on their close relationships with a number of large customer organizations	Project managers may employ subcontractors to provide at least some of the essential knowledge and skills leading to an over-reliance on contractual relationships Project managers may be oblivious to design issues because their normal role requires a wider and more generalist approach

Advantages	Disadvantages
Project managers experience of all the stages of large, complex projects may enable them to generate greater value for customers	Only large and established project management companies have adequate experience of manufacturing and production processes
Specialist construction project managers can provide effective and highly focussed management	Contractors involved too late to ensure the design takes account of the need for efficient manufacturing and production

1.10 Construction managed by independent construction managers

Many experienced customers rely on professional construction management organizations to manage their construction projects. In this scenario construction management organizations do not undertake any direct construction actions and all the designers and specialist contractors have contracts directly with the customer. The construction manager concentrates on managing the construction project organization on behalf of the customer. Solid relationships built up through many projects and possibly over many years are of vital importance for the success of this scenario because all the relationships between specialist teams are based on contracts. Construction management organizations of this type have very good knowledge of the construction process based on long experience and extensive experience in developing effective relationships. This scenario offers one of the best construction management approaches when it is based on solid long-term relationships. Even with this advantage, construction managers need to remain closely involved throughout their projects. It is all too easy for any problems not dealt with quickly to fester and lead to inefficient and dispute-ridden attitudes and behaviour. Construction managers need to concentrate relentlessly on ensuring everyone involved actively fosters effective relationships. Figure 1.14 shows the general form of a project organization led by an independent construction manager.

Advantages	Disadvantages
The construction manager's influence on design provides a robust basis for manufacturing and production	Design may be compromised by an over emphasis on manufacturing and production issues
Construction manager is likely to have long-term relationships with highly effective contractors	Over-reliance on contracts since every specialist contractor has a contract with the customer and this may lead to problems and disputes
Efficient manufacturing and production processes	

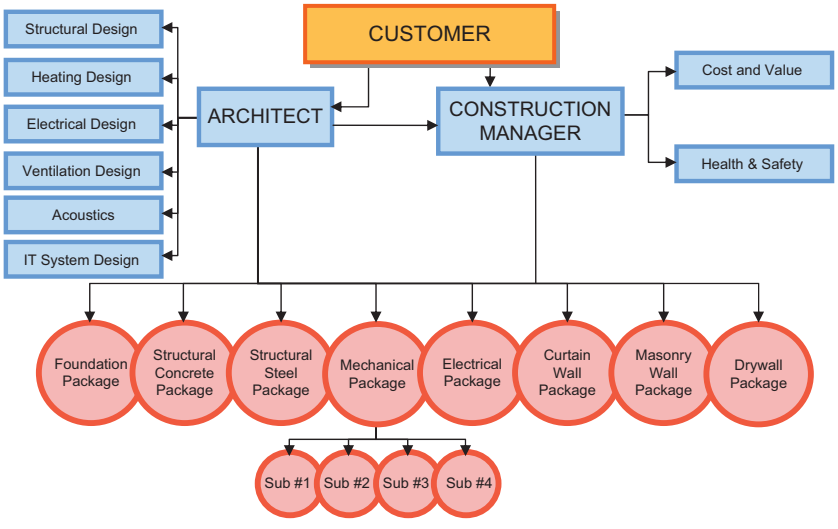

Figure 1.14 Construction-Manager-Led Construction Management.

1.11 How the construction industry works

The six scenarios which our visitors from another galaxy may have discussed provide opportunities to think about how some of the main roles in construction interact. It is now time to consider the approaches which do in fact dominate established practice.

All the leading national construction industries have developed over centuries. Distinct methods and procedures have grown up to serve the interests of customers, industry and the wider society more or less well. The main drivers for change are new technologies, new demands from customers or regulators and construction companies seeking more effective and profitable ways of working. Changes initiated by construction companies tend to be responses to economic crises or changes in market demand. Individual construction companies invest in research and development usually with financial support from government but it often takes decades for even the most useful industry-based innovations to be adopted widely.

As a result of these various factors, construction is organized in a number of distinct ways which produce significant differences in established national approaches to construction. These provide distinct strengths and in particular situations have various weaknesses. The leading edge in most national construction industries is dominated by large customers and construction companies. They lead negotiations with government about regulations and the way the public sector employs construction companies. Outside the leading edge are other more or less informal ways in which construction companies deal with their customers and work together on projects. However, the established national approaches are of most direct interest at this point in the book.

The next three sections describe the significant features of three influential approaches which provide an immediate introduction to the diversity of

practice. Each is shaped by the interests of a different one of the main construction professions.

1.12 Designer-led practice

Traditional practice in the United Kingdom construction industry influenced practice in many countries as British methods and procedures were introduced during the days of the Empire. The traditional United Kingdom approach is dominated by designers. This is most evident in the building industry where architects have historically determined the methods and procedures used by customers and the other members of project organizations. Within this approach the customer for a new building employs an architect to help determine what is needed and then design it. As the design is developed, the architect recommends the customer employs engineers and other specialist designers who assist the architect in completing the design. The professional architects and engineers normally negotiate a fee with the customer taking account of the requirements of the project and their particular skills, experience and costs.

The resulting design team produce detailed drawings and specifications which provide the basis for selecting a contractor to take responsibility for the production work. The selection process normally involves competitive bidding and some negotiation over the precise terms of the contract. It is usual to appoint the contractor submitting the lowest price who enters into a contract with the customer to complete the work in accordance with the drawings and specifications by a specified date for an agreed sum of money. Quality is assured by requiring the contractor to be supervised by the architect. It is usual for the contractor to employ specialist subcontractors to undertake the production.

Most contractors have established working relationships with groups of subcontractors competent in the technologies normally involved in the projects they undertake. In selecting a subcontractor for each distinct technology, they may simply negotiate with one of their established subcontractors or invite prices from three or four and select the one submitting the lowest price. The architect's dominant role complicates these arrangements in various ways. Most significantly, it is likely that at least some members of the design team are companies whose main business is undertaking production in accordance with their own design information. These typically include companies specialising in structural frames, external cladding, internal partition systems and all the services required in modern buildings. Various arrangements exist to ensure the firms involved in the design are employed by the contractor or at least that they are considered for the work. This can lead to the contractor having to employ a company they have never worked with before; or even worse, employing a company they are in dispute with on another project.

The most significant of the distinct arrangements which have developed to facilitate the architect's detailed involvement in all stages of building projects is the creation of the profession of quantity surveying. The role of quantity surveyors is to prepare bills of quantities. These are detailed schedules of the work required to turn the architect's design into the finished building. Bills of quantities incorporate the design specifications and are sent with the main design drawings to contractors invited to bid for the work. Priced bills of quantities provided by the successful contractor form part of their contract with the customer. The unit

rates in the priced bills of quantities are used to value changes to the design ordered by the architect as the work proceeds. This provides an administratively simple way of valuing changes which is reasonably equitable to customer and contractor provided the changes are relatively minor. Large changes lead to disputes, negotiations and occasionally result in litigation.

Quantity surveyors now use their knowledge of detailed building prices to provide cost advice to customers and designers during the design stages of projects. This helps ensure designs are likely to be capable of being constructed within the customer's budget. This constraint on design freedom is resented by architects and engineers who claim financial constraints prevent them producing great architecture.

Partly as a result of the complex and bureaucratic procedures which characterise traditional practice in the United Kingdom building industry, production work on site is unpredictable. Changes may be imposed at any time by architects who insist that every detail warrants careful design and if better answers can be identified, re-design. As a result work on site is planned on a day-to-day basis. It is characterised by delays and muddle which create inefficiency, uncertainty and disputes.

The focus on individual design limits the development of companies. Project organizations have to be assembled to undertake the particular set of actions required to realise each new design. Everyone involved faces new situations. Flexibility is crucial to survival and there is no advantage in companies growing big. Small companies struggle to find sufficient work which they are more or less competent to undertake. As a result the United Kingdom design-led approach gives little attention to company management which means long-term issues are neglected. The most serious effects are inadequate investment in training, research, development and marketing. This failure inevitably produces a weak industry. Many projects are completed late and over budget. Quality is generally acceptable but minor items of work are often incomplete when buildings are handed over to customers. The approach provides some of the world's finest architecture but it is just as likely to result in mediocre designs. United Kingdom urban areas are a strange mixture of high quality and great architecture surrounded by much that is mediocre and dull.

Overall the United Kingdom's design-led approach produces variable results in a largely unpredictable manner which customers increasingly find unacceptable. This has led in recent decades to many initiatives aimed at improving the industry's performance. The best seek to retain design quality but manage it in ways which deliver greater efficiency and certainty for customers. Many of the most effective ideas have their origins in the influential approaches described in the next two sections.

1.13 Manager-led practice

The most distinctive approach to construction in the United States is used by developers who undertake major building projects which they see as financial investments first and architecture second. Their approach relies on market forces allied to efficient management. At the start of a new project, major developers employ a design team and a construction management team. Some developers select these key teams on the basis of competitive bids. Others, particularly if they need their new facility completed as quickly as possible,

negotiate tough terms with designers and managers they have successfully employed on earlier projects.

The two teams work together to establish the customer's requirements and produce a design and construction plan. This can be achieved very quickly, once the necessary formal approvals have been obtained. Design teams comprise architects and engineers who aim to produce the best possible design within the money and time allowed by the developer. Architects understand how useable floor areas, rental values, building costs and financial markets interact to constrain design. They concentrate on the 'feel and face' of their buildings as viewed by users and the general public. The structure and services are designed by engineering consultants who understand the requirements of local authorities and developers. They rely on their local knowledge in defining the required performance of the main elements and systems but leave detailed design decisions to the specialist contractors.

Construction managers aim to ensure the building is completed on time, within the developer's budget. During the design stages they establish an overall strategy for the actions on site which aims to ensure the design can be realised by an efficient production process. The details of individual specialist contractor's supply chains and production methods are left for them to determine. The construction management team concentrates on establishing a management framework which coordinates the work of designers and specialist contractors.

The specialist contractors selected to form project organizations are those offering the lowest price for a work package which produces an element or system of the end product. Once appointed, the specialist contractors undertake detail design, manufacturing or organizing the supply of materials and components, and producing a distinct element or system of the building. They are expected to ensure their decisions fit in with the work of all the other specialist contractors.

This approach provides a very fast way of working which depends on each local construction industry having well- established technologies understood by designers and specialist contractors. This ensures, for each work package, there are many specialist contractors with well-developed design details and production methods which meet the requirements of local designers. It also ensures there are standardised components readily available from local builder's merchants which meet the needs of locally established technologies. These are supported by excellent product information and technical advice which is readily available over the internet. This well-developed and standardised approach allows competitive bids for work packages to be based on the design teams' generic descriptions of the required product. It also guarantees fierce competition for the work packages on major projects.

The design team coordinates the design work of the specialist contractors to ensure the overall design concept is realised. The construction management team coordinates the manufacturing and production actions of the specialist contractors to ensure the customer's budget and completion date are achieved. A vital weapon in this is a programme of key decision points agreed by each company when they are selected to undertake work on the project. The key decision points typically link the completion of a defined set of information or a distinct stage of the production work to a specific date. The start of each new stage is marked by what is often called a 'kick-off' meeting. It brings together everyone involved in the stage to ensure they understand the scope and objectives of the stage and their individual responsibilities. Projects are

driven towards these key decision points by coordination meetings attended by managers from all the companies directly involved in the current stage of the project. The meetings are organized and run by construction managers and concentrate on checking progress and solving major problems. A positive, 'can-do' attitude builds team spirit and energises everyone to strive to meet the agreed objectives.

It is inevitable that problems arise given the market driven, fast-track approach insisted on by major American developers. The relentless focus on time and cost combined with having at least forty or fifty major specialist contractors involved makes it inevitable that clashes and incompatibilities between individual design details will emerge as the production work proceeds. Workers directly involved in the problem on site are expected to cooperate in finding a mutually acceptable answer. They are expected to do this immediately the problem is identified so work is not delayed and no additional costs are incurred. It is only problems which cannot be solved by the workers directly involved which are dealt with at project coordination meetings. This dual level management system enables most projects to be driven to a reasonably satisfactory completion.

The relative certainty provided by locally standardised design and construction methods mean companies know broadly what to expect from any new project. This means they can afford to develop systems which improve their efficiency and invest in marketing to ensure reasonably stable workloads. As a result some companies grow big enough to shape developers' demands, influence local standards and have a beneficial influence on the industry's performance. The most successful operate across the United States and internationally. The management of such companies balance their own long-term interests with those of individual projects.

The overall results are that the American management -based approach produces buildings quickly, usually on time and within budget. They look stylish but rarely provide great architecture. Superficial the quality looks fine but many details, especially those hidden behind the glossy claddings, are completed in the quickest and cheapest manner with no regard for their appearance. The buildings lack any real depth of quality but broadly they satisfy the demands of major developers. The visual sterility of many urban areas in America is the social cost of efficient standardisation. The approach is like a highly developed machine which performs specific tasks efficiently.

However, machines struggle when faced with work which is different from that they were designed to undertake. Similarly, the American, management-based approach depends absolutely on sticking to established designs. Faced with innovative designs, the approach struggles. Irregular shapes, unusual details or new materials take specialist contractors beyond their well-established competence. Problems arise and the relentless focus on speed and economy obstructs attempts to find well thought out solutions. Dangerous compromises have resulted in building collapses, time overruns, higher costs, everyone blaming everyone else for the failure and litigation. Allowing these things to happen is a failure of construction management.

1.14 Contractor-led practice

Traditional practice in Japan is dominated by major contractors who have adapted the methods employed by Japan's great manufacturing companies.

This involves taking responsibility for every aspect of the construction projects they undertake. As a result leading construction companies deliver excellent buildings and infrastructure totally reliably. The companies are dominated by engineers recruited from university and trained over many years in the company's way of working. Some engineers specialise in architecture and undertake the design of buildings. The companies have world-class research and development departments which concentrate on producing new design ideas and new technologies which enable them to steadily improve the buildings and infrastructure they produce for their customers.

Japanese major contractors have established long-term relationships with major customers based on delivering exactly what these customers demand. This is all achieved exactly on time and at the agreed price. Customers know what they can reasonably demand because reliable and detailed information about the performance, timescales and costs of new buildings and infrastructure is published widely in Japan.

The major contractors have developed wide-ranging competence in all aspects of design and construction management. As a consequence, when they receive a new order from one of their established customers, they immediately set up a project committee. Its members are drawn from all parts of the company likely to suggest improvements to the customer's requirements, the design or construction methods. They often involve the company's research and development department in searching for the best answers.

Once the broad nature of the project is agreed, a project manager is appointed. Typically this is an engineer who has worked in the company for at least fifteen years and fully understands how the company works. He ensures that every aspect of the project is considered, re-considered and agreed before work begins on site.

The major contractors have long-term relationships with specialist subcontractors who undertake the production work. Typically these specialist contractors have worked for the major contractor for decades, even centuries. They know the type of designs the contractor produces and are competent in undertaking the required production actions safely, to reliable quality standards, exactly on time for the normal price.

When work on site begins, the design is complete and the construction plan is very detailed. This is facilitated by the use of extremely detailed national standards which specify every aspect of established construction technologies. For example, national standards include comprehensive sets of structural steelwork connection details. This allows project drawings to be relatively simple and specifications to be brief since they deal only with unusual design details. The wide use of standards means subcontractors do not face new or unusual tasks. The project manager can be sure they will be able to work effectively and so it makes sense to plan for all the production actions before work begins on site. The plan is extremely detailed. It defines each day's work in detail. For example, it establishes a precise time and date for the delivery of all the required materials and components.

Work on site is controlled by a small project management team led by the project manager appointed at the start of the project. Work begins at 8.00 a.m. five days a week with a meeting of everyone working on site that day. The subcontractor teams line up in order and are addressed by the project manager who describes the day's work. He highlights the required outcomes, any major deliveries and any safety issues which need attention. By 8.15 a.m. all the

workers are in their work places where each construction team holds a brief meeting to agree exactly how they will complete the planned day's work. Well before 8.30 a.m. purposeful work begins.

At 3.00 p.m. all the foremen currently working on site meet with the project team to review the day's progress. Any problems are described and solved. The meeting is direct and tough. The foremen take the initiative in insisting that any subcontractor failing to complete the day's work must take remedial action. This may mean a team working late, bringing extra workers onto site, or in extreme cases working through the weekend to ensure the week's work is always completed in the week.

As a result of the detailed planning and control, projects are always completed exactly on time. They are fully complete in every detail when they are handed over to the customer. Everything has been checked and tested to ensure every part of the building or new infrastructure works properly. On completion, there is no negotiation over the price; the customer pays what was agreed when they initially placed the order for their new facility.

Everyone involved in these impressive organizations is required to search for better ways of doing their work. This is an essential part of total quality control which is procedures and actions designed to ensure everyone relentlessly searches for better ways of working. Every individual team is required to report twice a year on the improvements to their own performance they have achieved in the preceding six months. Companywide competitions are held annually to identify and reward the best new ideas.

The Japanese government actively fosters and supports the construction industry. They work with the major contractors in determining public policy towards construction. The biggest contractors undertake all the largest and most important public sector projects. Public sector investment is used to offset fluctuations in private sector demand so the major contractors have stable workloads. The most important effect is that construction companies have the confidence to invest in their own future. This valuable outcome is reinforced by the contractors themselves employing large numbers of experienced staff in marketing aimed at winning new orders from private sector customers.

The overall results are high levels of efficiency and remarkably reliable performance. The resulting buildings and infrastructure are produced to high quality standards. Designs tend to be safe, even dull but they broadly suit Japanese culture which requires individuals to fit in. In Japan it is often said "the proud nail is hammered flat." Individually designed buildings are demanded by a few customers and the major contractors can deliver these but they put great strain on their highly tuned systems. The resulting buildings are completed on time to the normal quality standards. This requires extraordinary efforts by everyone involved and often leaves the contractor with a financial loss but no loss of face.

These impressive results are possible because government and industry work together to create the conditions needed for very large construction companies to invest long term in training, research, development and marketing. They recruit graduates from the best universities and provide comprehensive and well-organized training which ensures they are competent in the company's working methods. To ensure their long-term survival, they have large marketing teams of highly experienced, senior engineers working with their long-term and potential customers. Their task is to identify situations where new construction could benefit a customer's business. The research institutes, which are large and well equipped, play a key role in the large companies' success. They continuously

improve tried and tested technologies to ensure the buildings and infrastructure they produce are safe, of reliable quality and function well. They also produce bold concept designs for such things as mile-high buildings and cities under the sea. These are often featured on national television which helps sustain the construction industry's good reputation in Japan.

1.15 Conclusions

This chapter introduces the nature of construction in generic terms; discusses the character of key roles in the construction process; and describes three influential approaches to construction projects which have distinct strengths and weaknesses. This completes the basic introduction to construction's methods and procedures and the role of construction management. The next chapter completes the essential introduction by describing the built environment to establish a common understanding of the purpose of all construction actions.

Exercise

Figure 1.15 shows a simplified example of contractor-led construction management with most of the design, auxiliary services and some of the major mechanical and electrical work packages being subcontracted to specialist designers, consultants and trade contractors.

Some major contractors may comprise several internal specialist teams. Draw different simplified configurations of contractor-led construction

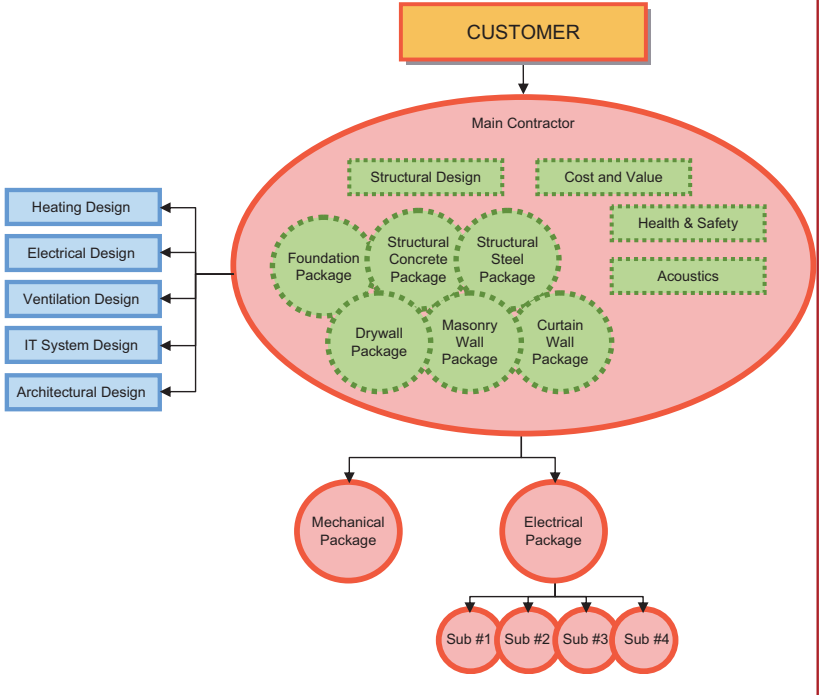

Figure 1.15 A Possible Configuration of Contractor-Led Construction Management.

management. How many different configurations can you draw? Hint: Figure 1.15 shows one such possible configuration.

Take a close look at Figures 1.9–1.14 and draw possible simplified configurations for all the other construction management scenarios. How many can you draw? What does that tell you about construction management?

Further Reading

The following publications are the source of ideas used in this chapter and provide further information for readers.

Bennett, J. (2000) *Construction the Third Way: Managing Cooperation and Competition in Construction*. Butterworth-Heinemann. This book provides a wide-ranging description of key ideas which have shaped construction management practice and theory. It does so by explaining international best practice in managing construction in terms of fundamental ideas drawn from general management theory.

Bertelsen, S., and Sacks, R. (2007) Towards a New Understanding of the Construction Industry and the Nature of its Production. *Proceedings of the 15th Conference of the International Group for Lean Construction*, C. Pasquire and P. Tzortzopoulous (Eds.), Michigan State University, East Lansing, Michigan, 46–56. The paper challenges the current construction management approaches by looking into the nature of the construction industry as a complex network of projects that share the same production system and are therefore highly interdependent.

Cox, A. and Townsend, M. (1998) *Strategic Procurement in Construction*. Thomas Telford Ltd. This book recognises the consequences of the flawed presumption that there is a single approach that can be adopted regardless of the circumstances.

Morledge, R., Smith, A. and Kashiwagi, D. T. (2006) *Building Procurement*. Wiley-Blackwell, 1st edn. This book provides a good overview of the current procurement strategies starting with a concise and well-supported literature review. It defines core procurement principles and looks at its different aspects (e.g. procurement stages, risks, etc.). The book also provides a very good insight into construction procurement across the globe (e.g. Europe, China, and the United States).