Building Services Engineering

After Design, During Construction

Jackie Portman

with website

WILEY Blackwell

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Preface

The purpose of building services engineering systems is to provide a safe environment that is comfortable for building occupants and/or suitable for any processes happening within buildings: their remit may also extend to areas outside buildings in places where a controlled environment is required. I have come across very many situations where a finished building does not perform as building services engineers had intended: there is a performance gap; for example, the end users are not comfortable in their environment, the building operator is not happy with the maintainability, flexibility or energy consumption of the finished building, or the building does not satisfactorily support the processes happening within. In a worst case scenario, a completed building may fail to comply with the requirements of an enforcing authority such that the building cannot be occupied and used.

Despite improvements in design procurement methods that encourage more, and earlier, involvement of construction personnel and the advancement of Building Information Management (BIM) as a tool for collaborative working, suboptimal design solutions and a lack of constructability may only become apparent once the construction works start. The consequences of rectifying these go beyond the reworking of the design, extending in some cases to a knock-on effect on interfacing, programme delays and cost overruns, an increase in claims and disputes and, at the end of the process, higher maintenance costs, which are ultimately borne by clients commissioning the building. This situation can reflect badly on building services engineers capability and competency. At best, on a personal level, such 'criticisms' can be mildly disheartening; at worst, they can involve building services engineers in litigation processes, with all the associated disruption, costs and potential effects on reputation. In the middle, they may have to endure requests for call-backs, investigations, revisiting of the basis of design documentation – this may be during construction, at handover or initial occupancy, or may be years later. Whatever the circumstances, such distractions are irritating and are all at a cost and time to individuals and business organisations.

Furthermore, some of the original design information is included in the documentation handed over at completion of a building. This needs to be reliable, accurate and in a suitable format for the lifetime, and ultimate decommissioning and disposal, of a building. Operators and occupiers of a building need to understand the expected 'design' performance so as to help with operation and maintenance. Likewise, any decision-making processes of organisations with respect to capital planning (new construction and renovation) programmes may depend on original design; for example, allowances for extending systems for additional electrical power, humidity control, more building management system (BMS) functionality, drainage capacity and so on.

Construction is a multifarious process, with the focus changing as the project progresses. After the design team has completed the bulk of its work, the construction cohort takes the lead; however, building services engineers have strong incentives to support the continuity, quality, and intent of the design. By being properly involved they can better manage and limit the potential risks, such as defects and client complaints, and achieve recognition for the quality of their design work.

This book aims to give practical and relevant information to those involved with the design of building services engineering systems. In particular, it recognises the idiosyncrasies and distinct features of building services engineering that are not specifically covered in general texts on construction management issues. This book follows on from *Building Services Design Management* (Portman, 2014), which recognises the particular planning and management techniques to progress the design of the building services engineering system to ensure that the design deliverables are suitable for onward use in the construction phase. The intended audience includes:

- Building services engineering students and their tutors: to forewarn them what to expect during the construction phases of projects.
- Other students in construction-related disciplines and their tutors: to educate them on the particular issues associated with building services engineering during construction.
- Practicing building services engineers frustrated that all their efforts to deliver the best design are subsequently scuppered.
- Construction project managers who want a better understanding of the particular characteristics of building services engineering during construction.
- Clients who want to understand what measures they should take to ensure that their aspirations for a safe, comfortable and appropriate environment are translated into reality.
- Other built environment practitioners who are not qualified or expert in building services engineering but who wish to develop a greater understanding of the implications of the increasingly important building services sector.

Part One of the book sets the scene by describing the stakeholders involved in the construction phase who are involved with translating the building services engineering design into the finished installation.

Part Two focuses specifically on the potential processes and duties building services engineers may be involved with during construction and the initial post-construction period.

Throughout, two types of boxed text are included to provide some light relief from the main text: one is used give further explanations or useful background information while the other comprises worked examples. Feedback questions are included at the end of most chapters to help with the learning process. The responses for these are discussed in the book's companion web site (www.wiley.com/go/portman/buildingservicesengineering). On this website you will also find Scenario Questions with detailed explanatory answers for many of the chapters; these will help to test your understanding of the issues covered in the book.

Whilst the book is biased towards the UK market in terms of references to terminology, legislation and working practices, the approaches and methodologies are applicable to other regions.

Reference

Portman, J. (2014) *Building Services Design Management*. John Wiley & Sons Ltd, Chichester, UK.

About the Author

Dr Jackie Portman DBEnv, MSc, BEng(Hons), ACGI, CEng, FCIBSE, FIET, MCIOB, is a highly accomplished building services engineering project manager with an enviable track record of delivering complex multi-million pound infrastructure and construction projects within budget and operational standards. She graduated in electrical engineering from Imperial College, University of London, and took her first steps into the construction industry. She was attracted by the exciting, challenging, ever-changing and all-encompassing nature of the construction industry, where there are always new challenges and areas of interest, and has never looked back. She has worked in consultancy, main contracting, building services subcontracting, project management and client organisations in Europe, Africa, Asia and the Middle East.

She has led the project management process of a range of projects in terms of complexity, size and uses: university complexes (libraries, archive buildings, state-of-the-art education and research facilities), healthcare projects (wards, laboratories, clinical areas), single and mixed use commercial office complexes, residential developments and schools.

She has always been keen to enthuse and motivate students and trainees and has used her 'hands-on' perspective to support full-time academics and teachers. She has been a visiting lecturer at the University of the West of England and the City of Bristol College, also contributing to the development of the syllabuses, in particular, ensuring the relevance to current industry trends and requirements.

She obtained her doctorate from the University of the West of England, researching into ways and means of improving the contribution of building services engineers to the building design process: looking at how they are perceived by the rest of the construction industry and what tools and processes would help improve their performances.

Introduction

Building services engineers are responsible for developing and delivering information that describes the design intent for the building services engineering services for specific building projects. It is part of the design continuum (Figure 0.1).

The design information needs to be sufficient for the purpose of informing those responsible for the construction about what is required for the physical works and provides a starting point for determining how long it may take and how much it may cost.

However, the building services engineers' contribution to successful building projects should not stop when these design deliverables are 'complete'.

Building services engineers may be colloquially referred to as building engineers, architectural engineers, environmental engineers or mechanical and electrical (M&E) or mechanical, electrical and public health (MEP) engineers. The individuals and organisations involved as engineers are sometimes referred to as consultants or designers. For consistency this book uses the term 'building services engineers' throughout.

Building services engineering design is delivered by an entity that may be 'stand alone' or integrated with other entities. This integration may be on a vertical or horizontal basis (Figure 0.2). In a vertical integration arrangement, building services engineering entities may be part of a subcontractor or main contractor organisation, or a client organisation. In a horizontal integration arrangement, building services engineering entities may be part of a multidisciplinary organisation with other design-related disciplines: civil and structural engineering, architectural or quantity surveying services.

The material values of the building services installation is typically in the order of 30–60% (Hawkins, 2011) of the total value of the construction of a building project. This can be even higher for buildings heavily reliant on close control of the internal environment, such as data centres, laboratories and specialist healthcare areas including operating theatres. Furthermore, the importance of the building services engineering

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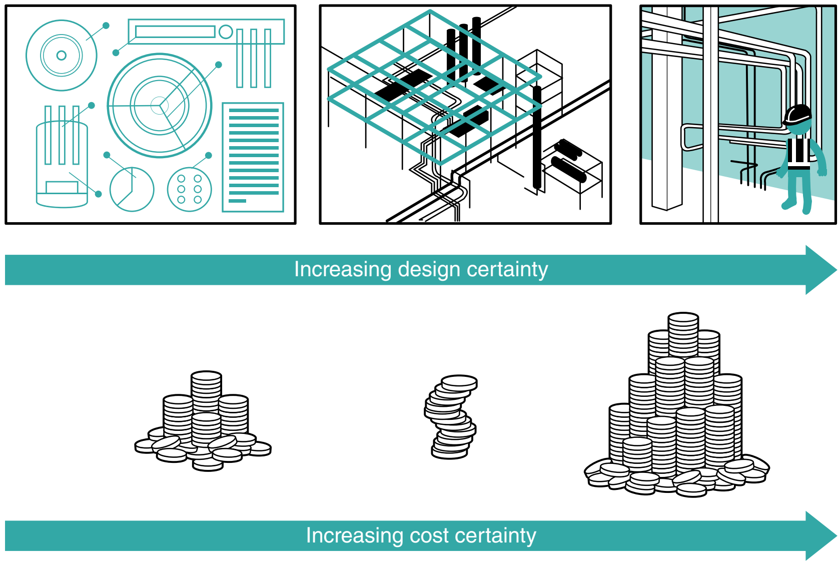

Figure 0.1 The design continuum

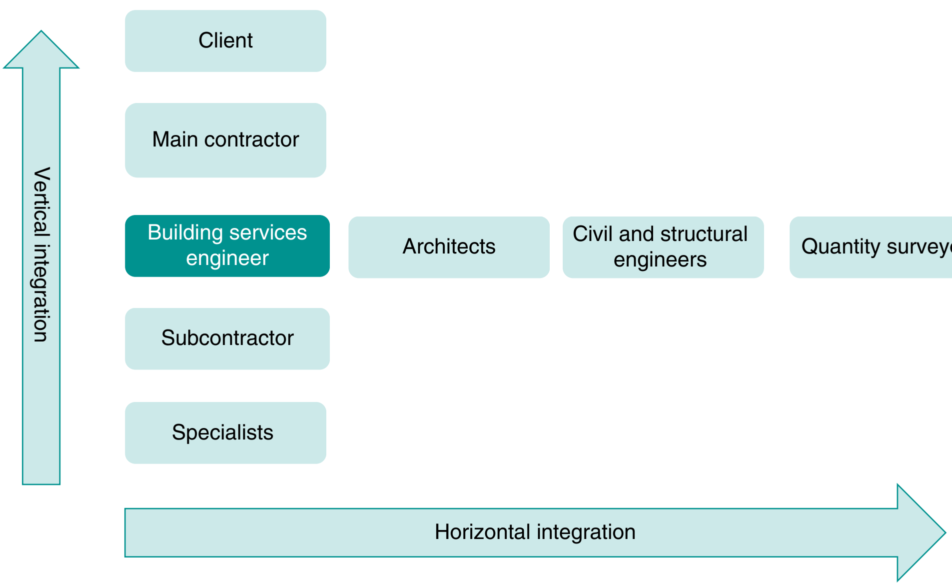

Figure 0.2 Vertical and horizontal integration

systems of any building is now considerable and growing in terms of both economic and commercial value to the end-user; for example, without functioning heating, ventilation, air conditioning, fire and life safety systems, lighting, security systems and electrical services the building may not be fit for purpose.

The nature of the design information that is delivered will depend on the particular contract and the options taken within that contract. This may be a standard form of contract, such as:

- The Royal Institute of British Architect's (RIBA) Plan of Work, which is the most commonly accepted model of the whole construction process.
- The Association of Consulting Engineers (ACE) Schedule of Services – Part G(g).
- The New Engineering Contract (NEC) Professional Services Contract.

Alternatively, some clients issue bespoke contracts that include their own specific requirements for deliverables. Different forms of contract use their own terminology and set out their own expectations with respect to requirements for the deliverables at defined stages. With the agreement of both parties, the schedule of deliverables can be amended to suit particular building projects.

It is not necessarily for the same entity to provide a service at each stage; different entities may handover the responsibility and contribute to the design, cost and procurement at different stages. The design works cannot be considered to be complete until the installation is complete and commissioned to prove the design criteria established. At this point the final account can be settled and final payments made.

Along this continuum the building services engineers' original design intents can be altered or compromised, particularly during the construction phase, so as to alter the nearness and trueness of the final scheme to that intended at the outset … and not necessarily in a good way. Reasons why the original design intents may be compromised are:

- ***Poor workmanship*** meaning that the criteria aspired to in the design are not achieved, which coupled with poor handover procedures mean that the performance of well-designed systems are compromised.

  Figure 0.3 illustrates the consequences of either poor quality welding on a solid pipe system or a screwed pipe system not fitted properly.
- ***Coordination issues*** where, despite what might be shown on the design drawings, the installation on site is not quite the same, such that building services engineering systems fail to coordinate with themselves, as illustrated in Figure 0.4 for the case of a CCTV installation.

  Additionally, installed building services installations may not coordinate with other building services engineering systems or a building fabric and structure.

Figure 0.3 Poor workmanship and handover

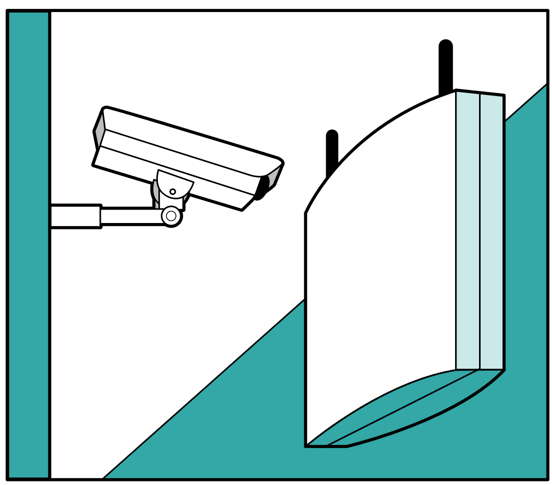

Figure 0.4 Poor coordination

On the other hand, however, there also may be errors in base design that go unnoticed at the time, only becoming apparent after the installation is in progress. Figure 0.5 illustrates the case of an error in a calculation, which was not detected in any review process, resulting in the wrong pipe size being included within the design deliverables … and in due course being installed incorrectly.

These situations can affect the integrity of the building services engineering systems performance, the programme and their final cost. As such, it is beneficial that building services engineers' involvement

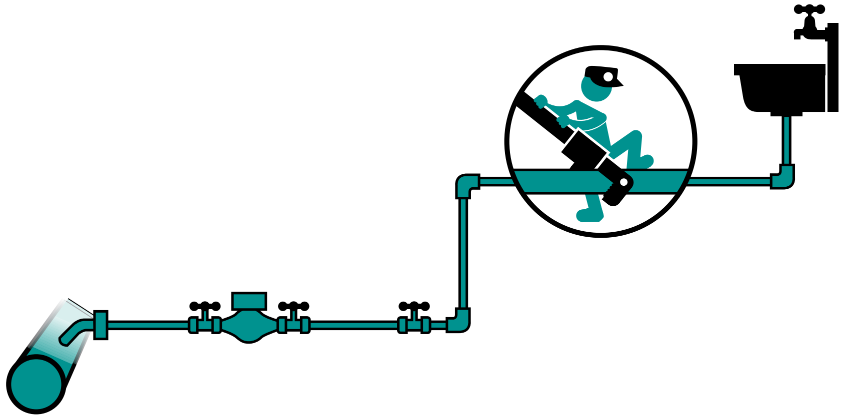

Figure 0.5 Unchecked error in design calculation

does not stop once their design information has been completed. They also have a duty of care to clients and end-users. Their continued involvement should lessen project risks by identifying and resolving issuing arising during construction.

Design finalisation

From whatever point in the design continuum that the design is delivered by one design entity, further design work may be required. Reasons include:

- *Discharging residual design responsibilities* – Some procurement routes are such that the design is only partially developed at the point of appointing a construction team; thereafter, the design still needs to be completed. In the case of refurbishment or extension projects, the level and accuracy of information available relating to the base building may affect the quality of the design information. As more information becomes available during the construction phase, building services engineers may need to revisit and modify their designs.
- *Rectifying errors in the original design* – Preparing a successful design requires a unique combination of scientific and technical expertise, and accomplishing it in a perfect manner is difficult, if not impossible. Any discrepancies or shortcomings at the design stage, left unchallenged/unaddressed may be magnified at the construction phase. Even using the very best designers and implementing seemingly the most robust review and checking processes will not guarantee that there may be shortcomings in the original design that do not become apparent until the construction phase and even after handover.

- ***Addressing new design requirements*** – The need to make changes on any construction project is a matter of practical reality. Even the most thoughtfully planned project may necessitate modifications due to client changes, changes in legislation which are enforceable, differing site conditions, specified methods of construction becoming unfeasible and new developments in technology.

To ensure that the building services engineers' intents are correctly interpreted by the construction team, it is sensible for them to be available to respond to queries and to examine the construction information. Furthermore, building services engineers' presence on site will help guard clients against defects and deficiencies in the physical installation. However, the examination of the physical installation generally considers the static installation, it is not until the commissioning when, firstly, the safety and, secondly, the functionality of the building services engineering systems are tested that there is confirmation that the original design intents have been achieved.

Cost finalisation

The cost continuum starts with cost estimating, where construction entities determine what their direct costs would be to undertake the works. This provides a 'bottom line' cost below which it would not be economical for them to carry out the work.

Thereafter, the cost estimate is developed based on the particular information available at the time. With reference to Figure 0.6, the design information relating to building services engineering installation comes from a variety of sources, each of whom may be working on different time scales. As the design develops the cost estimate becomes more certain. A final cost estimate prepared from complete plans and specifications should be within +/−5–10% of the actual final cost.

The final cost estimate provides a benchmark for the actual final cost of the installation. The process for reaching the actual final cost may, at one extreme, involve a formal tender with an evaluation and adjudication process taking place, while, at the other extreme, the works may proceed with estimated costs being substituted for actual costs as they become known. Otherwise a process involving both elements may be used.

At handover building projects enter a defects liability period, where it is occupied and used, but the construction team may still be involved with putting right any identified defects. At the end of the defects liability period (typically one year after completion) the final account particulars can be settled. This may include adjustments due to allowances for prime costs and provisional sums, and for variations (either adding or subtracting costs) associated with changes in scope and programme. When all outstanding defects have been rectified, outstanding payment are made and the final certificate issued.

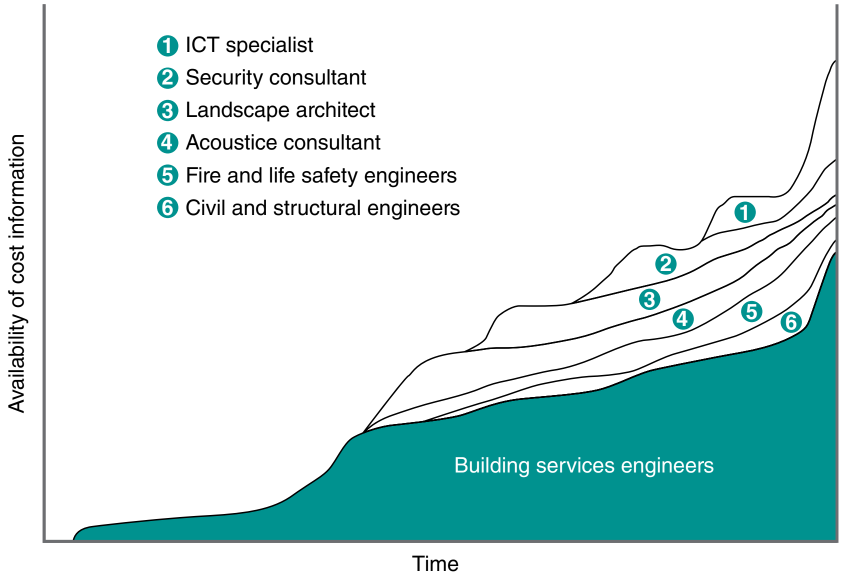

Figure 0.6 The cost certainty continuum

Programme finalisation

The design information provides a starting point for planning how the work will be done. The planning continuum often starts with a desired end date, often driven by end-user needs: for example, a new school year, planned (and advertised) sporting fixture, seasonal shopping peaks or else just the desire for the earliest revenue stream.

It is often left to the construction team to do the detailed scheduling of activities and analysis of the implications of these activities in order to select the most appropriate plan in order to confirm that the clients programme can be achieved.

Post-construction involvement

Once completed building projects are handed back to clients, there may be questions arising regarding the building services engineering installation and its operation. Building services engineers may be called upon to provide information and support on matters and to investigate any problems. Care is required to ensure that building services engineers respond on issues relating to their original design intent and are not drawn into matters arising due to issues with the installation. Also, building services engineers should be interested is ascertaining any lessons learnt, to feed forward into future designs.

Advisory roles

Building services engineers may be involved with buildings projects during or after construction, when they were not the original designers; for example as auditors for another entities design deliverables, litigation support (typically advising on claims for monies and/or extension of time), expert witnesses and forensic investigators. They may be commissioned by legal, insurance or other construction organisations to undertake these duties.

Summary

Building services engineers' deliverables provide information that contributes to the process that finishes with completed building projects. Whilst building services engineers are responsible for producing complete, precise and coordinated design and contract documents, nothing built is ever perfect, nor does the law require a perfect design. The building services engineers are involved during the design phase and have a significant role during the construction phase to ensure that the installed building services engineering systems comply with legal requirements and perform so as to provide a safe and appropriate environment for the end-users and the processes happening within the building.

Feedback question

1 Discuss the effect of projects where the fee for building services engineers design is inadequate. If the fee available is limited, what options might clients consider with respect to ensuring the design is adequate?

Reference

Hawkins, G. (2011) *BSRIA, Rules of Thumb, Guide for Building Services*, 5th edn. UK: BSRIA, p. 80.

Part One Stakeholders and procedures during construction

Although the intention at the outset of almost all building projects is to complete the construction, this may not be the case in practice. Construction may be stopped or delayed (Figure P1.1).

Once construction has been given the green light, the focus switches from office-based activities to activities associated with the physical project site. To deliver a finished building project requires planning, procurement, putting in place, setting to work, testing and commissioning of materials and components in accordance with the design requirements.

The construction period starts with mobilisation, when the construction team prepares for the necessary movement of personnel, equipment, supplies and incidentals for the impending physical activities on the project site. The end of the construction period is more difficult to quantify. There will be demobilisation activities and an official handover date; thereafter, there will still be short- and long-term legacy issues to deal with.

Part One of this book describes the stakeholders as they are involved during the construction phase; specifically, how building services engineering design is affected by the specific roles and responsibilities of a range of interested parties. These stakeholders can express needs and expectations and may have rights and interests in imposing requirements on building projects and the associated environment they occupy. For any particular building project, there will be mostly unique, temporary, multidisciplinary, distributed teams whose membership and focus change during the construction phase and which are often disbanded thereafter. Even when building projects are procured using entities that are listed in a client's framework agreement, the individuals involved may be different for different projects.

Figure P1.2 illustrates a stakeholder map for different entities that engage with the construction team and interact with building services engineers in connection with the construction works. These are broadly categorised as the client team, design team, enforcing authorities and utility services providers; each has different objectives for a building project.

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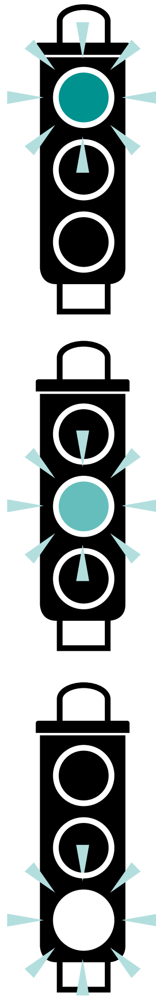


STOPPED: The requirements set out in the business case developed at the outset cannot be fulfilled or have changed. These may be related to cost or programme, which only become apparent once the design has developed.
or
External drivers over which clients have no control mean that projects become unfeasible:; for example, changes in legislation due to changes in political leadership or policy changes.

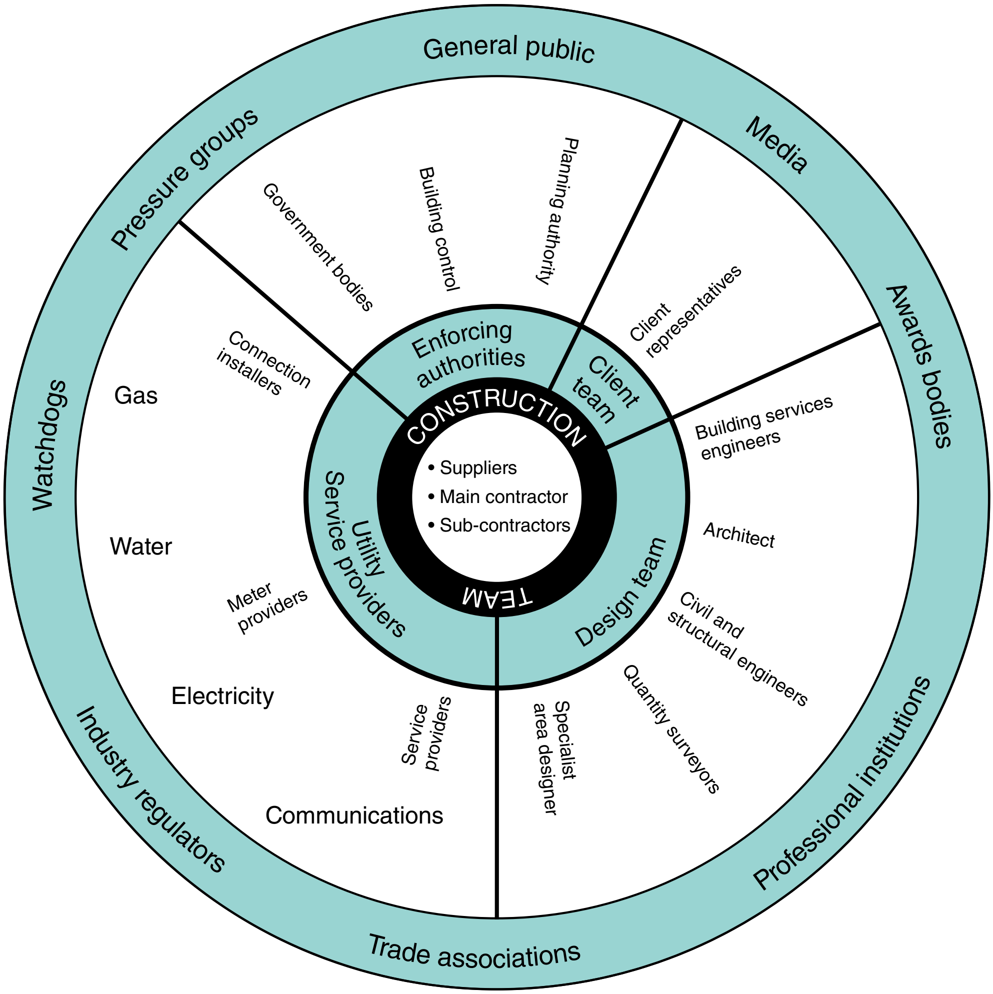
DELAYED: After the design work is complete the start of construction may be delayed or put on-hold. This may be due to the client's decision -making processes and procedures, sourcing of funding or pending statutory authority approvals.

START: Construction phase ready to start.

P1.1 Status of construction after design delivery

There are also other 'third-party' stakeholders who have no contractual link to a building project but may have influences that affect the progress and nature of the construction works. The particular stakeholder make-up and the contractual arrangements between the stakeholders vary according to the particular project. In some cases the function will not be required or more than one function may be undertaken by the same person; for example, the architect may also be the landscape architect.

Figure P1.2 shows the design and construction teams as separated entities. The concept of separating design and construction has been challenged in the last few decades. This has led to new procurement methods and attitudes towards working relationships amongst the parties in the design and construction teams. It has meant that the roles of



P1.2 Construction phase stakeholder map

building professionals in the structure of a project team have been changed. In particular, this means that building services engineers (and the other members of the design team) may still be discharging some their duties during the construction phase.

The diversity of stakeholders makes for a multidisciplinary culture and complex issues with multiple and overlapping influences that are legally only limited by formal contractual lines. This lack of direct contractual relationships makes the lines of authority subtle and may be a factor in creating a less than optimum team performance: formal contractual rules may bring about and legitimise behaviours and strategies at odds with common sense perceptions as to how trustworthy and cooperative exchange stakeholders should act.

Every team member has particular functions and obligations to a project. The obligations can be moral or legal. Moral obligations are duties that are owed, and which ought to be performed, but to which the member is not legally bound. On the other hand, legal obligations are a legal tie between two entities which is recognised and enforceable by law by a court of law. These obligations are associated with the legal object of performance, which is a definite action or inaction, delivery of a specific thing or payment of a specific amount of money.

Feedback questions

1 Discuss and describe situations where prospective construction projects have stopped during or at the end of the design stage. What were the reasons and drivers behind this?
2 If a project is greatly delayed between completion of the design and starting on site, discuss the risks to the integrity of the design once the project starts?

1 The client team

Clients are not unitary bodies but need to be considered as a team comprising (in-house or out-sourced) individuals, internal departments and external entities organised to deliver clients liabilities and obligations. Client teams have a collective goal of determining a need (normally encapsulated in a business plan), arranging finance and organising the processes that result in the delivery of building projects to satisfy their requirements. There are many different ways of categorising client types according to the particular nature of the building project. Figure 1.1 describes these based on their financial motivation and the beneficiary of their efforts.

The performance of client teams affects the quality, cost and progress of the construction on site. Client teams need to establish structures and protocols to deliver their responsibilities and obligations with respect to legal, contractual and financial matters, facilities management, and project management to support and interface with the construction team.

By the time construction starts clients will have determined the procurement route that informed the nature of the design work, method of selection of construction team, established how work is authorised, financed, programmed and commissioned. They should also have planned for the ultimate disposal of finished building projects once their need for them has expired – this may be by demolition or sale. At any stage, and certainly at the key decision point prior to starting construction, clients should review their business case plans before deciding whether to proceed as is, proceed with modifications or to stop a project.

1.1 Client team functions

Client team functions comprise:

- ***Legal***: As well as operating their entity within the law with respect to employment of staff, taxation and disclosure of information, clients have to fulfil certain legal requirements to take reasonable steps to

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Figure 1.1 Types of clients

ensure that arrangements related to health and safety matters for all building projects they procure are in place and properly managed;

- ***Contractual***: These can be categorised as either non-contentious or contentious. Non-contentious roles cover the legal aspects of setting up equitable contracts, contract administration and dealing with claims; for example, dealing with claims relating to delays to the completion of a project or requests for additional payments. Contract law becomes 'contentious' when something goes awry; for example, projects run late, over budget or terms of the contract have been broken and resolution cannot be mutually agreed. However, the contracts, when drawn-up, should set out how any disputes should be dealt with, and usually (in an effort to minimise costs and to promote better relationships) the preferred route to resolution is through conciliation, or arbitration if necessary, rather than via the courts;
- ***Financial***: This involves developing financial models and sourcing the necessary finance. This may be by self-investment, borrowing on a repayment basis, accessing grant funds, or by means of special purpose vehicles (SPVs). It also involves ensuring the finance is available, at the right time, and distributed in accordance with the terms of contracts;

- ***Facilities management***: This includes the operation and maintenance all the building services engineering systems, including the information communications technology (ICT) infrastructure systems. Ideally, this involves client participation during the design phase to impart information regarding the operation and maintenance of the existing facilities and to recommend improvements. During the construction phase the facilities management function should continue to be involved, particularly during commissioning, where the building services engineering systems are set up in readiness for building occupation. It also includes ensuring that the information generated during the construction phases is appropriate for the occupants, business operational needs and asset management of the completed building project.
- ***Project management***: Client teams need to interface with the construction team to provide information and make decisions concerning residual design issues, programming matters, quality assurance requirements, risk management and value management. Client team representation needs to be organised to articulate its particular desires and wishes as required such that they can be understood and addressed in a useable way by the construction team. There may be more than one group of end-users that needs to be represented; for example, in a healthcare environment there are different types of patients, staff and visitors that must all to be considered as end-users.

There may be a single point of contact (SPOC) between the client's team and the construction team. The SPOC may, depending on the particular contract, be called the clients' representative, client project coordinator or even just project manager; despite the name, on larger projects the SPOC role may be allocated to more than one individual. This book uses the term client-side project manager. Depending on the client's skill set and capabilities, this role may be undertaken using in-house staff or out-sourced to an independent project management organisation, a design or quantity surveying entity (with in-house project management capabilities) or a combination of these. Some procurement routes are such that the contractor also effectively acts as the client-side project manager.

Client-side project managers are primarily concerned with ensuring that the project delivers the benefits set out in the business case and should be mindful and react to any circumstances that necessitate a change to the business case. When building projects are active on-site part of this role may be taken up by a clerk of works, who acts as the client's representative on site – either on a full-time or visiting basis.

1.2 Client's liabilities and obligations

Client teams need to establish a structure and protocols to deliver their responsibilities and obligations.

Health and safety

Clients have a legal obligation to ensure that any contractors appointed by them have the necessary competencies and resources to carry out the construction work safely. Clients must provide relevant pre-construction information to those undertaking or affected by the construction works and make the required statutory appointments for advisors in respect of construction health and safety risk management matters.

Achieving statutory health and safety requirements may include responsibilities for notifying the relevant authorities of impending building projects, contributing to and producing the required relevant documentation and, via the construction team, ensuring that the appropriate project management arrangements are in place and being correctly maintained. Although the responsibility for health and safety on site is transferred to contractors, clients may still have responsibilities, which will be dependent upon:

- The proximity of the construction works to the client's employees and business operations that is if it is remote or completely isolated it poses no threat.
- If it is vital for clients to keep business operations live during the construction works, which may expose the contractor to risk.
- If clients have determined how contractors undertake particular aspects of the works.

Depending on their particular ethical and moral stance, possibly incorporated into their Corporate Social Responsibility (CSR) policies, clients may choose to extend their minimum legal obligations beyond those directly responsible for the construction of their building project; that is they may assume obligations to materials and equipment suppliers, the suppliers to materials and equipment suppliers … and so on down the supply chain.

Allied to health and safety is occupational health. This considers the physical and mental well-being of employees in respect of the effect work could have on employees' health, and what effect employees' health may have on work. Some aspects of occupational health, for example medical surveillance concerning dealing with hazardous materials, such as asbestos, lead and compressed air, are mandatory. Other aspects of an occupational health programme, for example advice on healthy eating and back care, free eye tests and blood pressure measurements, are not mandatory but may be made available.

Migrant worker welfare and accommodation

Developing countries may be reliant upon migrant workers to help with their construction programmes. At the same time, these developing countries may not have the same approach to health and safety and occupational welfare as developed countries.

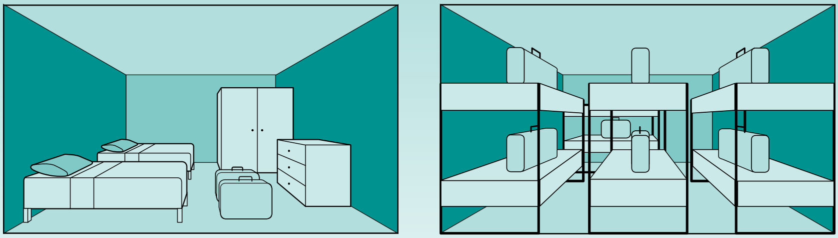


Figure 1.2 Migrant worker accommodation (ideal vs. non-ideal)

An example of extended occupational health and safety responsibility is illustrated in Figure 1.2, where reasonable quality welfare and accommodation are provided for migrant workers although there is no in-country legislation necessarily requiring it.

Awarding the contract for construction

Clients are responsible for formalising the appointment of the construction team in contractual terms to meet their requirements. Depending on the procurement strategy (Chapter 3.2) this may require the appointment of a single entity or a number of separate entities. The construction team contract(s) may include requirements for design, operation and financing of the projects as well as the actual construction. This reflects clients' attitude to quality, time, costs and risks, as well as their scope of control and funding for a project.

Clients require contractors to provide performance bonds to provide themselves with a third-party guarantee of the construction teams' performance. This protects them with monetary compensation against contractors failing to fulfil contractual obligations for them, for example due to poor performance or bankruptcy.

Handover to contractor of the site

Clients are responsible for handing over possession of the site to the construction team. As well as the actual project site this may also include stores areas, material lay-down areas and designated parking areas. Clients will need to advise any working restrictions for the site area; for example, working hours' and noise criteria.

With respect to utility services within the site area, clients are responsible for undertaking isolations, disconnections or removals of equipment, and providing the record information to confirm this. Besides the gas, water and electricity services, this may include medical gases, telecommunications, TV aerials, fire alarm cables and condensate lines. Notwithstanding this, contractors should verify all information claimed to confirm either the absence of or the location and status of any utility services; for example, there may still be unidentified services that are still live, which either need to be worked around, isolated or isolated and removed.

If clients are providing utility services (typically electricity and water) to the site for use in the construction process, then, at handover, meters should be read, or installed if not already in place, and a tariff agreed for repayment.

In the case of refurbishment projects, issues related to continued occupation of any part of the existing building, for example health and safety, impact of noise, site lighting, dust and access for personnel and vehicles, need to be informed by clients.

Providing information to the construction team

Clients must provide all relevant information already in their possession or reasonably obtainable concerning the site in a timely manner for the construction team. This includes:

- A description of the construction works planned, including important dates such as handover of site to the contractor, time allowed for planning and preparation for construction work before the construction phase, interim and final completion dates.
- Appointments for the design team already in place.
- Information directly relating to the existing site, such as record information of any existing utility services and/or building services engineering systems installed, asbestos and other hazardous materials registers, and all existing health and safety information.
- Information pertaining to the eventual use of the building as a workplace.
- Any site specific hazards and risks identified that will affect those carrying out the construction work.
- Client requirements such as health and safety goals and aspirations, participation in voluntary codes and practices schemes, site rules, emergency procedures.
- Residual design information.
- Disclosure in respect of decisions to change design criteria. Buildings are constructed from a set of client requirements that define client's aspirations. In reality, changes to the clients' original requirements are inevitable. Reasons for changes may be due to changing business requirements, or simply a change of heart, or due to a value engineering process.

It was only a little thing…

Whilst clients are entitled to change their mind, they need to be mindful that even a seemingly innocuous change may have significant impact on an already designed scheme; for example, if a client decides it wants to change from having electric to gas cookers in a new apartment block project (Figure 1.3), there may be a greater impact than just an exchange of equipment. The change may necessitate:

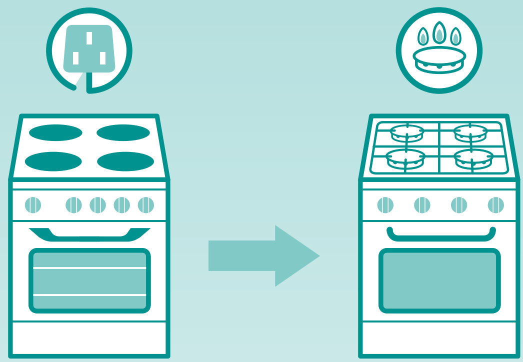


Figure 1.3 Changing from electric to gas cookers

- Omission of electrical distribution system associated with supplying the cookers. The design of the remaining electrical distribution system will need to be reviewed with respect to load analysis, discrimination, allowances for spare capacity, cable and distribution equipment sizes, containment sizes and location of final outlets. This may result in spare space in the building.
- Addition of a larger, or even new, gas supply. The design work will require a load analysis, pipe and equipment sizing, consideration of the distribution of the gas pipework in suitably ventilated routes Also, consideration of interfaces with the fire detection and alarm system with respect to gas shut off valves, gas leak detectors linked to an alarm system.

There will be additional costs associated with the redesign work, not just for building services engineers but also probably for architects, interior designers and quantity surveyors.

Furthermore, the construction team may be due costs and additional time. Even if the new gas distribution system and cookers have not yet been installed there may have been much 'invisible' work associated with the procurement – arranging and appraising quotations, raising the paperwork to place the order for equipment, perhaps effort spent chasing those orders, if it is delivered to site arranging for inspection and receipts, arranging for storage and making final payments.

Whilst it may be possible to get monies back for equipment bought, often this is not the full amount and as described there are further costs borne by the design and construction team which are entitled to be claimed for.

Changing client requirements are one of the principal factors that contribute to delays and budget overruns of building projects and, consequently, result in claims, disputes and construction team dissatisfaction. Contractual claims can be made against clients for extensions of time and money (loss and expense) and for the cost of changes to the works due to such changes or variations. Costs may be associated with finance charges, loss of profits, general disruption and abortive management time.

Change management procedures should be included in the construction contract to ensure that such changes are handled through a properly coordinated and controlled process that is visible, traceable and auditable.

Discharging residual design decisions

There may be residual client decisions and information not available during the design stage required which need to be advised to the construction team.

Final selection of FF&E

Furniture, fixtures and equipment (FF&E) ranges in nature but typically includes ICT/telephony, audio visual equipment, signage, catering appliances and specialty equipment required to support the buildings functions. FF&E may be built into the building fabric or stand alone. Typically, the building services engineering design would have made a notional allowance in terms of the size, location and interface arrangement with the building services engineering systems. Delaying the final selection of FF&E to the construction stages allows clients to choose the most up-to-date equipment, albeit that this may necessitate modifications to the design. During the construction phase it is necessary to consider the actual equipment selected to ensure it coordinates in all respects with the building design.

FF&E may require connections to the building services engineering systems, power, air, water, drainage or telecommunications connections. The size, location and interface arrangement allowed for in the notional design may need to be amended; for example, what was envisaged to be a plug and socket arrangement for connecting a piece of electrical equipment may need to be changed to a directly wired fused connection unit. Also, the heat gains derived from the finally selected piece of equipment need to be checked against the notional allowance, as the heating and cooling system designs may need to adjusted.

FF&E may not require connections to the building services engineering systems or utility services, that is stand-alone equipment, but its presence may affect the building services engineering design; for example, the location of cupboards or shelving may impact on the position of socket outlets, grilles, taps, telephones and so on.

Approval of samples and mock-ups

These are provided by the construction team and comprise representative portions of the final specified items that may be necessary to satisfy aesthetic, performance or public relations requirements. They may be physical (with a degree of functionality varying from nothing to fully functioning) or may comprise virtual images and models. The purposes range from reviewing materials, colours and finishes, making final selections from a range of possible items. They may be full size or to scale. In addition, samples and mock-ups may be retained as benchmarks for use in project quality control.

Handback from contractor to client

At the end of projects clients take back responsibility for the buildings and become building operators. This means they assume the responsibility for operation and maintenance, utility services, arranging the necessary insurances and licenses to operate.

Operation and maintenance

To protect the significant capital investments in equipment and systems, the building services engineering systems need to operate and maintain uttermost efficiency, without unplanned outages of service, such that harm and discomfort to the occupants is avoided and the right environment for the processes that occur in the building are provided. During the construction phase, clients should assign appropriate facilities personnel and allow them time to participate in contractor's testing and commissioning activities, including coordination and planning meetings, attending on and off-site demonstrations of operations of systems, and also to receive training in operation and maintenance of building services engineering systems. This may involve ensuring there is adequate in-house staff or procuring appropriate contracted services. If the skills required to support the installed building services engineering system need enhancing, training will need to be provided.

The responsibility for ensuring buildings are used as per the design parameters applied to the building also passes to clients as building operators; for example, this includes:

- Ensuring occupancy rates in spaces is within the range allowed for in the design – otherwise the ventilation and cooling systems will not function as designed, giving rise to poor indoor air quality and overheating of the space.
- Ensuring all portable electrical equipment is tested (Portable Appliance Testing) before being connected to (plugged into) the fixed electrical wiring system causing nuisance tripping out of electrical circuits.

Utility services agreements

Clients will need to arrange for taking over the utility services agreements, agreeing appropriate tariffs and making payments – otherwise the contractor may continue to receive the bills.

Arranging insurances

Clients will need to arrange for the appropriate insurances ready for the occupation of a building. These typically include:

- Buildings insurance against damage to the buildings structure (walls, windows, roof etc.) as well as permanent fixtures and fittings, such as sanitary ware and kitchen fixtures, and contents insurance for loose equipment. Depending on the particular policy this may cover the insured against fire, lightning strike, explosion or earthquake, theft or attempted theft, riots or vandalism, storms or flooding, subsidence, falling trees, moving objects (such as a vehicle impacting the building) and escaping or leaking water, oil or other fluid.
- Employer's liability insurance to cover the cost of compensating employees who are injured at or become ill through work.
- Public liability to cover for accidental injury and property damage by non-employees, for example customers and visitors.

Other insurances that may be required due to the particular nature of an organisation include:

- Professional indemnity insurance against claims of negligence for entities delivering design advice and services.
- Fleet vehicle insurance.

Compensation is often normally for direct material damage only and does not necessarily cover business continuity. The provision of insurance services is nearly always out-sourced. However, in some cases, for example if the client is an insurance entity, clients may decide to self-insure. Historically, government or parastatal body clients self-insure, but this is now changing.

Obtaining licences to operate

Clients are responsible for obtaining any necessary licences and statutory approvals needed for building occupancy and operation. These may be licences and permits associated with the type of business, for example, animal boarding, nursing home or nursery schools, or the operation of specific function, for example, different categories of laboratories, selling alcohol, certain research and testing activities, storage of hazardous materials and handling of controlled materials and goods.

Client's fit-out

After buildings are handed back, clients may arrange for further work to be undertaken to fit-out spaces so they are suitable for occupation by their end-users. This may include extending building services systems into a tenant's areas. This is maybe general office areas or more specialist areas such as restaurant/dining areas, reception areas, spas and so on. This may done in conjunction with the provision of raised floors, ceiling and demountable partitions.

Summary

Clients have business, operational and human requirements that they will want to ensure are manifested in the completed buildings. The performance of client teams affects the quality, cost and progress of the construction on site. Client teams need to establish structures and protocols to deliver their responsibilities and obligations with respect to legal, contractual and financial matters, the operation and (facilities) management of the completed project and client representation to the project management process. Thereafter, the client teams need to discharge their responsibilities with respect to health and safety matters, awarding the contract(s) for the construction works, handing over the site, providing information to the construction team, discharging residual design responsibilities and accepting the finished site back from the construction team. The building project will either be ready for immediate occupation or will require a degree of fitting out.

Feedback questions

1 If a client has no record information relating to the existing underground utility services on a particular site, discuss the risks to the project (in financial, programme and quality terms) and the options available to address the issues.
2 Discuss the particular work-related illnesses (not injuries) that construction workers have a higher risk of developing than non-construction workers? Discuss how these are related to the particular environment and nature of construction sites and what strategies clients may use to manage them.

2 The design team

Design teams comprise the various disciplines which collectively are responsible for translating clients' requirements into information that describes the scale and shape of proposed building projects. These constitute the design deliverables. They describe the requirements and form of building projects, including the materials to be used and the details of the workmanship required. However, the liabilities of the design team do not end upon delivery of the design information, as building projects, when complete, needs to conform to the original design intent – which can only be verified once all the construction has been completed. Building services engineers particular roles limits and definitions during the construction phase being included in their agreements: sometimes using exculpatory language so as to excuse themselves from certain actions.

2.1 Design team members and arrangement

The main design disciplines are usually considered to be architecture and engineering (including building services engineers). However, quantity surveying (the management of costs and contracts) and planning (the management of activities) should also be included. Additionally, there may be any number of other specialists involved; the various types and examples are given in Table 2.1.

The organisational arrangement of an entity delivering building services engineering design may be configured in many different ways according to:

- ***Ownership arrangement*** – for example, private sector (sole traders, partnerships or private or public limited companies), public sector (part of local or national government departments). Alternatively, entities may operate under a licensing arrangement or form joint venture arrangements. They are usually independent of manufacturers, suppliers and installers of building services engineering equipment

Building Services Engineering: After Design, During Construction, First Edition. Jackie Portman.

Companion website: www.wiley.com/go/portman/buildingservicesengineering

Table 2.1 Design team specialists

Specialist type	In-discipline specialists	Cross-discipline specialists	Specialist-area consultants
Feature	Detailed knowledge of a specific aspect of a discipline	Broad knowledge across multiple disciplines	Particular specific knowledge associated with the end-use of a building
Examples	Lighting specialist Steam systems specialist	Fire engineering specialist Acoustics engineering specialist	Catering specialist Equine facilities specialist

and systems. This enables them to offer unbiased opinions, judgments and decisions without any potential conflict of interest;

- ***Scope of building services engineering offered*** – whether they are single (offering services with respect to mechanical, electrical or public health only) or multidisciplinary. Also, whether they offer services for each stage of design (from preparation to handover and operation in use or specialise in certain stages only; for example, just doing feasibility studies and concept design work, or just doing the detailed design stage).
- ***Integration with other entities*** – the building services engineering entity may be stand-alone or (horizontally or vertically) integrated with other entities.
- ***Types of projects undertaken*** – according to building use.
- ***Delivery office arrangements*** – there may be two or more design offices involved; for example, the main delivery office, another near site, the head office and another overseas undertaking outsourced work.

Assignment and novation

Building services engineers may be working on a project to a particular stage under the client's appointment and then transferred (this can either be an assignment or a novation) to the construction team in order to provide continuing design input. This is usually the main contractor but could be a building services engineering subcontractor. For this to happen, the building services engineer must have agreed at the time of their initial appointment – otherwise there is no legal obligation to agree to it latter.

- As illustrated in Figure 2.1, assignment involves the transfer of a building services engineer's scope of works from a client to a contractor or subcontractor. However, the burden, or obligations, under a contract cannot be transferred. In the context of a building contract, this means clients are in a position of being liable for their original contract should the party they have assigned fail to perform its obligations.
- As illustrated in Figure 2.2, novation involves the transfer of a building services engineer's scope of works from a client to a contractor or

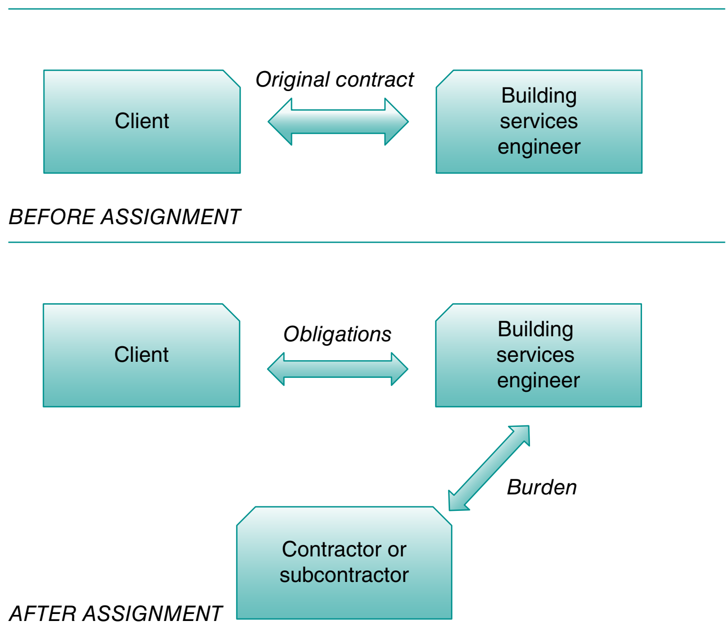


Figure 2.1 Contract assignment

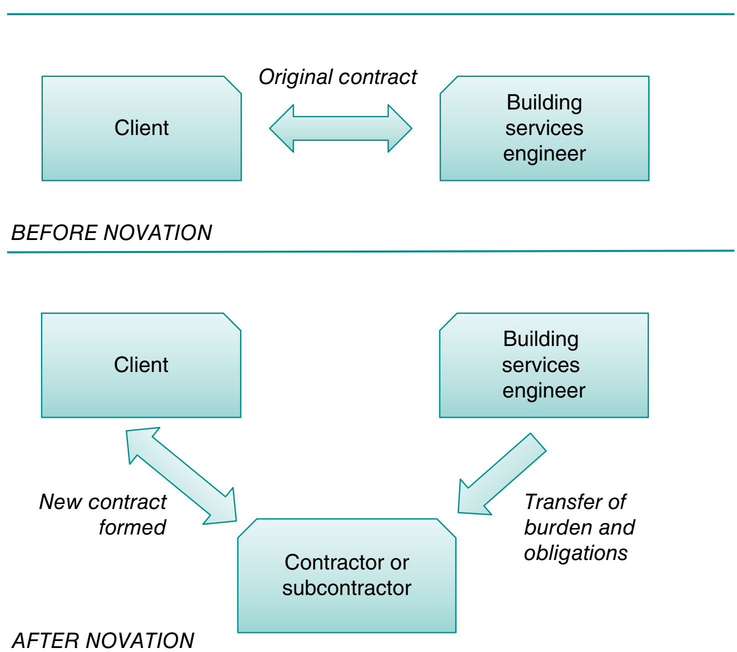


Figure 2.2 Contract novation

> subcontractor. Both the burden, and obligations, under a contract are transferred. In the context of a building contract this means the original contract is terminated and is replaced by a new one in which the contractor (or subcontractor) takes up rights and obligations that duplicate those of one of the original parties to the contract. The client still has the rights and obligations under the original contract.

Building services engineering may give a warranty in respect of services undertaken pre-novation. This provides the contractors (or subcontractors) with protection in the event that it suffers loss due to an error in the design work that is novated.

Blyth and Blyth Ltd v Carillion Construction Ltd [2001] 79 Con LR 142

Blyth and Blyth Ltd (Blyth and Blyth) was novated to Carillion Construction Ltd (Carillion), which was awarded a design and build (D&B) contract for the construction of Fountainbridge Leisure Complex in Edinburgh.

As a D&B contract, Carillion assumed responsibility to the employer for the design of the building and, therefore, for the work of Blyth and Blyth, which had originally been engaged by the employer to produce the design. After the novation agreement, disagreements arose between Blyth and Blyth and Carillion.

Blyth and Blyth was claiming for unpaid fees whilst Carillion was counterclaiming for additional construction costs incurred by them arising from alleged errors and shortcomings; for example, making calculation errors when designing the structure in the information supplied by Blyth and Blyth, initially to the client, and which was included in the contract documentation provided to Carillion. Carillion pleaded that the engineer had breached their duties – where they had been owed to the employer at the tender stage, before Carillion became involved in the main contract and retrospectively assumed responsibility. Those duties were, Carillion argued, deemed to have been owed to it in terms of the novation. It had suffered losses because it had had to do extra work at their cost.

The construction contract was the JCT Standard Form of Building Contract with Contractors Design 1981 Edition, such that Carillion should assume responsibility for the design of the works, whether undertaken before or after the execution of the contract. Carillion's primary position taken in its pleadings, but not pursued at trial, was that the novation agreement was to 're-write' the terms of appointment between the client and Blyth and Blyth, substituting 'contractor' for 'employer'.

Lord Eassie described the issue as follows:

> 'One ought, accordingly, to examine the legally logical position of the defender's analysis to the effect that the Novation Agreement produced an essentially three-sided relationship whereby A (contractor) engages B

(consultant) to perform services for, and give advice to, C (employer). Accepting for the moment that analysis to be correct, the questions which arise are whether the sufficiency of the performance by B (consultant) is to be judged by what is required by the destinee of the services C (the employer) and whether in the event of defective performance the losses or costs for which B (consultant) may be liable in damages are those reflecting the need to put C (employer) in the position of having received satisfactory service, or, as the (contractors) contend, those said to have been suffered by A (contractor).'

Lord Eassie determined that Carillion could not claim for its own losses caused by breaches by Blyth and Blyth prior to the date of novation in relation to the duties then owed by Blyth and Blyth to the client, the losses sought by the Carillion not being losses conceived as having been suffered by the client.

As a consequence, contractors have had to protect themselves with appropriate contractual conditions where they are taking over the responsibility of the design process by way of a novation and may consider entering into appropriately worded collateral warranties with design teams to protect themselves from pre-novation losses.

Duty of care

Building services engineers have a duty of care towards stakeholders, so as not to cause them any unreasonable harm or loss (Figure 2.3). This means that they are required to perform their duties as that of reasonably competent designers, working to current industry standards and good practices and the codes of conduct of their professional bodies. These codes of conduct set out the rules, responsibilities and proper practices that individuals should adhere to. Otherwise, they are subject to sanctions by their professional body.

The meaning of a competent person can be an inexact science at the best of times. For most particular situations there is no legal definition of what a competent person is; different aspects of building services engineers' roles that require certain competencies are. For example, completion of the BS7671 Electrical Installation Certificate is the responsibility of the electrical subcontractor that undertook the installation. However, it requires a 'designer' to sign a section and thus take responsibility for confirming that the design is compliant with the requirements of BS7671. The signatory needs to exercise reasonable skill and care to the best of their knowledge. There are no specific examinations that need to be passed, nor a requirement to achieve membership of the Institute of Engineering and Technology (IET) to 'prove' sufficient competency, but no designer should feel

Figure 2.3 Duty of care

compelled to sign unless they are happy to accept the responsibility should there be any comeback.

Note: this ability to certify design compliance does not necessarily mean that the significant additional trade skills and experience of electricians ensures that the completed installation is acceptable.

Bolam v Friern Hospital Management Committee [1957] 1 WLR 583

Building services engineers cannot guarantee that their design decisions and advice are unequivocally the best single solution, especially when there are alternatives – only that they believe they are the best.

This is equivalent to the duty of care in negligence in medicine, which was captured in the Bolam test. This centred on a patient who had mental illness issues and was treated with electroconvulsive therapy. The doctor did not give any relaxant drugs and the patient suffered a serious fracture. There was divided opinion amongst medical professionals as to whether relaxant drugs should be given. If they are given some, there is a very small risk of death; if they did not give some, there is a small risk of fractures. The patient argued that the doctor was in breach of duty by not using the relaxant drug. The court determined that the doctor was not in breach of duty and, subsequently, the UK House of Lords formulated the Bolam test:

> 'a medical professional is not guilty of negligence if he has acted in accordance with a practice accepted as proper by a responsible body of medical men skilled in that particular art. Putting it the other way round, a man is not negligent if he is acting in accordance with such a practice, merely because there is a body of opinion who would take a contrary view.'

Building services engineers' obligations are not normally 'absolute' obligations – which would be unconditional. They are actually conditional obligations requiring them to provide a satisfactory result using reasonable skill and care as expected by a competent person in the provision of the design. This means that they are not necessarily liable for design defects – even when they are the root cause of the error, unless they are proved to be negligent. If building services engineers are initially justified in thinking that the design was adequate and suitable for their clients' needs and purposes, then they could not be held liable for negligent design. However, they have a duty in such circumstances to take steps to correct the defective design. This means that building services engineers' duty of care is continuous and carries on through into the construction phase, even if they have no further contracted duties.

Statutory requirements and codes and standards will change overtime: what was correct at the time of design may be out-of-date when construction commences. Building services engineers are, however, not judged with hindsight. If the codes of practice and general literature available at the time of the design would not have reflected the inadequacies of such design, then the building services engineer would not be held liable in negligence if such design should subsequently prove to be inadequate.

199 Knightsbridge Development Ltd v WSP UK Ltd [2014] EWHC 43 (TCC)

The property developers, 199 Knightsbridge Development Ltd (Knightsbridge), for a high-end residential block of flats with communal facilities, and building services design engineers WSP UK Ltd (WSP) were involved in a case which centred on duty of care and professional negligence.

A partial drain-down of part of the domestic cold water system meant there was a reduction in the available pressure in the pipework, which producing a cataclysmic pressure surge that shattered pipe joints and pipework causing severe flooding.

Knightsbridge sued WSP for losses claiming negligence in the design of the domestic cold water system and for not addressing the likelihood of damage caused by a loss of water.

The court determined that Knightsbridge was unable to prove that WSP had breached its duty of care. Mr Justice Edwards-Stuart judged that WSP had fulfilled the terms of its contract in that it had used 'a reasonable level of care and skill as [was to be] expected of a qualified Consultant in the same profession, experienced and competent in carrying out work of similar size, scope and complexity to the Project'. This duty equates to the standard of care and skill the law ordinarily imposes on professionals.

This case drew attention to the difference between the existence of a responsible body of professional opinion and industry standard practice. It was noted that WSP's contemporaries were also not foreseeing the particular scenario of partial water drain-down and the need to provide surge arrester valves in the cold water risers which could avert disaster due to pressure surges.

However, even after the incident, Knightsbridge still did not fit surge arrestors, suggesting that even if WSP had recommended this measure at the outset, it would still not have been done; hence, WSP had not been negligent.

Professional liability (also called professional indemnity) insurance provides a way for building services engineers to protect themselves from financial loss arising out of actual or alleged breach of their professional duty of care. The claim types are not normally specific in the particular policy and, therefore, can include, errors and omissions that cause personal injury, property damage or financial loss. This does not cover intentional misrepresentations, fraud and breaches of warranty or guarantees.

Professional liability insurance should not be confused with public liability insurance. Under common law everyone has a duty not do any damage to another person or their property or cause them to suffer a financial loss. As a professional this duty can be separated into one of two types – a 'general' duty and a 'professional' duty. The general duty of care covers everyone and is insured under public liability insurance. The professional duty of care arises as a result of academic training and practice such that professional advice is relied upon by the general public and commissioned clients.

Copyright

Building services engineering design is categorised in the quaternary sector of the economy where the output is based on its intellectual capital. This is the possession of knowledge and experience, lore, ideals and innovation, professional knowledge and skill, good relationships, and technological capacities. Building services engineers rely on copyright law to protect their intellectual property rights (Figure 2.4). They may also register patents if they have developed a solution to a particular technical problem.

Design deliverables can be copyrighted as an artistic (as opposed to literary) work. The drawings (and specifications, schedules and other documents) are copyright protected but the actual design idea cannot be copyrighted (Figure 2.5): the idea and the expression of the ideal need to be considered separately. This gives building services engineers' entities the absolute legal right to control how they reproduce, publish, sell, or distribute their design deliverables.

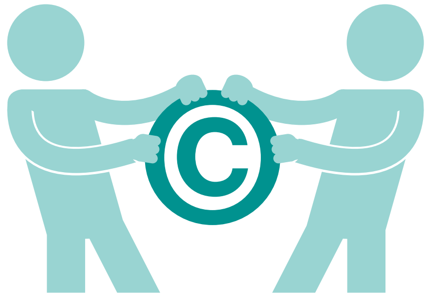


Figure 2.4 Who owns the copyright?

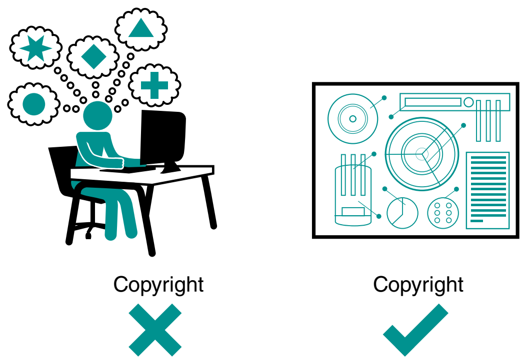


Figure 2.5 Copyright explained

Although clients pay for the design deliverables, building services engineers still own the copyright. Effectively clients use the design information 'under licence'. This arrangement constitutes a non-exclusive licence, which means that the copyright owners authorise others to use the information on the basis of the constraints, typically time included in the licence. An exclusive licence would be when a copyright owner does not authorise any other party to use the design deliverables. If the design's exclusivity is important to clients they may wish to insist that its license be exclusive or buy the copyright. Circumstances for this might be:

- For a unique design; for example, the design of a bespoke luminaire that represents a client's particular brand image. This would prevent the building services engineers using the designs for other clients and other building projects.
- Clients may want to use designs on a repetitive basis and no longer believe they need the original designers. Clients with multiple outlets may want a prototypical design; for example, cafés, garages, or other retail building types – although it will still be necessary to review and adapt the plans to suit local site conditions, orientation issues, code requirements, and other related design considerations.

In another scenario, it may be that building services engineers decide to sell an element of their design for a one-off payment, for purely commercial business reasons: they need to money now.

In these situations clients or contractors need to ensure that the design contracts contain a written assignment of all copyrights and other intellectual property that building services engineers own in the plans; this is to ensure that building services engineers do not retain any intellectual property rights in the design that could create issues latter. Also, clients or contractors should obtain written permission from the original building services engineers before reusing previously purchased plans on other projects.

Site presence

Building services engineers may, despite robust QA/QC procedures, make mistakes in their designs. Moreover, not all problems can be foreseen when pen meets paper. With any building project, the familiar caution holds true: Expect the unexpected. Unanticipated problems – and opportunities – will arise during the course of construction.

Building services engineers may, as part of their contract, be required to either visit or reside on site, full-time or part-time, to resolve design problems and be involved with the testing and commissioning. There are benefits to clients, construction teams and the building services engineers themselves:

- From the client's perspective, it may be comforting knowing that building services engineers are still available during the construction phase to provide informed reports of the project's progress, a trained eye toward quality control and protection against work that is not according to plan. Furthermore, with their knowledge of client's requirements and their history, building services engineers can be a valuable asset in identifying new opportunities that are consistent with clients design objectives.
- Building services engineers who have been involved with the design will have the best mental picture of how a project's components relate to each other and be able to identify problems and deviations, to the construction team, early on, before they can become too expensive or difficult to correct. The more they are on site, the more likely it will be possible to address issues quickly and reduce the overall amount of paperwork.
- From their own perspective, it is useful to be on-hand when the design included assumptions about existing site condition; for example, the locations and state of underground utility services or when the details of the existing building services engineering installation could not have been evaluated until the contractor has access to the site and has started to excavate or open it up. Although the risk of the

unknown may have been transferred to the construction team, the building services engineer may still be involved with examining the construction information that will reflect the actual site conditions.

Improving early cost advice for mechanical and electrical services considering functions and client/design team communication (Swaffield and Pasquire, 2000)

This research suggests that the building services engineers responsible for the design were better able to control the costs of building services engineering installations during the construction phase, as they considered any changes in specification more profoundly.

The paper cites an example of a situation where a contractor re-routing the ductwork to save installing a bend subsequently caused in a clash with electrical cable trunking – meaning the trunking had to be re-routed and longer – effectively deviating from the original design.

Whilst quantity surveyors would process a claim for variations to the trunking as an additional cost variation on site, the building services engineers would have looked at the reasons for the change, noted the omission for the bend in the ductwork and concluded that overall no additional costs were justified.

2.2 Design team liabilities and obligations during construction

Design team members have liabilities and obligations to their clients and also to those affected by their work that are contractually and legally enforceable. These arise as a result of their performance, or failure to perform their professional services. Failure to discharge liabilities properly means they may be susceptible to being sued for negligence and breach of their duty of care.

Design liability

Building services engineers are liable for their design if they cause errors or contain omissions, which often only become apparent when the construction work starts. Exposure to design liability can be reduced by putting in place appropriate internal QA/QC procedures to ensure quality of design deliverables.

A more contentious method of reducing exposure to design liability may be to adopt a conservative rather than an innovative approach to design solutions. This would mean safe choices of materials, tried and tested technologies, strict compliance with guidance codes and generous allowances for spare capacity.

The bigger the better… not necessarily

Building services engineers may oversize equipment, for example air handling units or domestic hot boilers, with the justification of needing a reasonable safety factor to manage periods more extreme than the specific design conditions. Unfortunately, the safety factor easily becomes excessive and by doing so they are actually expecting clients to pay an immediate penalty due to increased first cost of equipment and an ongoing penalty due to maintenance and energy use implications.

Delegation of duties

Building services engineers may choose to delegate (under a subcontract arrangement) part of their design duties to a third party. This may be because of time or resources constraints or because they do not believe they have the necessary skills in-house; for example, electrical high voltage studies, calculations for medical gas systems, surveys of existing installations. Again, if errors are discovered later the responsibility would that of the building services engineers to have used reasonable skill and care in the selection and management of the third party; if such errors do arise then there is a duty to warn the affected parties.

Contractor (or subcontractor) led design

The procurement route may be that building services engineers are contractually arranged as subcontractors to contractors (or to trade subcontractors) rather than architects or end-user clients. As such, contractors take on risks of errors and omissions in design and design-related delays and client approval processes.

Issues may arise if contractors control the design process in such a way that puts pressure on building services engineers to focus on costs to the detriment to health and safety matters, clients' requirements, quality of materials and workmanship and long-term maintenance issues. However, this approach provides more opportunity for building services engineers to more directly and contemporaneously benefit from contractors buildability, cost estimating and programming skills.

Goods or services?

Since contractors are responsible for the provision of goods and the incorporation of these into the completed works, the obligation of a contractor in respect of the works falls under the Sale of Goods Act (1979). However, building services engineers are suppliers of a service (design) and thus fall under statute (Section 13 of the Sales of Goods and Services Act 1982 as amended by the Sale and Supply of Goods Act 1994). With regard to the standard of performance, there is an implied term that the services will be performed with 'reasonable care and skill'. The most important practical problem encountered in a contract where a contractor has appointed building services engineers as subcontractors is the unavailability of insurance to cover design liability for 'fitness for purpose'

Duty to correct errors

Even with the best building services engineers, unpressurised from any time and financial constraints, errors are possible: human errors are a fact of life and it requires the ability to undertake a realistic assessment and to be able to minimise, resolve and learn from them.

Design errors found during the construction phase do not necessarily mean that the building services engineers are culpable of negligent design. If building services engineers were initially justified in thinking that the design was adequate and suitable for the client's needs and purposes, then the building services engineer cannot be held liable for negligent design. However, they have a duty in such circumstances to take steps to correct the defective design.

What may be small errors to correct during the design stage can escalate, possibly exponentially, if they have to be addressed during construction. Possible sources of error for which building services engineers may be liable are illustrated in Figure 2.6.

Liability to provide accurate cost advice

Building services engineers will need to provide information to quantity surveyors to ensure that they have sufficient understanding of building services engineering systems to be able to produce accurate budget estimates and advise clients throughout the design and construction phases.

Building services engineers will generally have no contractual responsibility to provide specific cost advice to any party. Any specific requests for cost advice should be referred or the project quantity surveyor – if one is not appointed there should be a recommendation to appoint one. However, under their duty of care building services engineers should keep clients informed of any issues that may significantly affect the costs of building projects. This might include:

- Providing feedback from other projects in respect of tender pricing. It may be that there is an excess or a shortage of similar work in the current market place, thus tenderers are either increasing prices on tenders to discourage acceptance, since they do not want the work

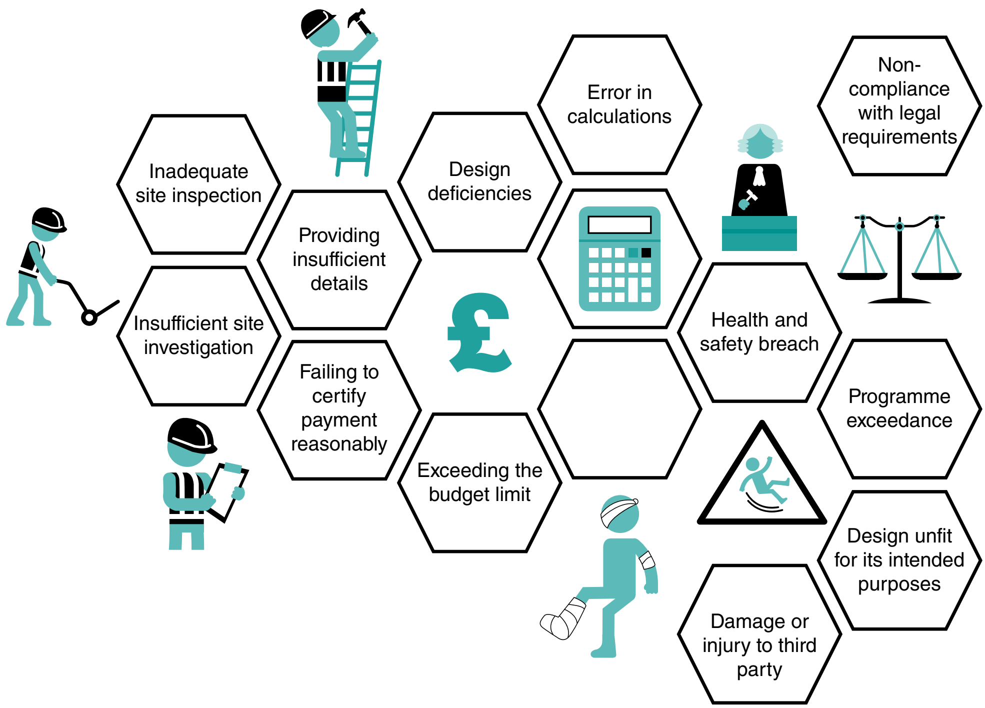


Figure 2.6 Duty to correct errors

unless it was highly profitable, or reducing prices to give themselves a better the chances of winning the work.

- Informal knowledge gleaned from the likes of representatives from product companies.

Issues such as shortages of materials, strikes and inclement weather can affect both cost and programme.

Liability to provide accurate programming advice

Building services engineers will generally have no contractual responsibility to provide specific programme advice to any party. However, under their duty of care building services engineers should keep clients informed of any issues that may significantly affect the programme of building projects. These might include:

- Identifying long lead items, which may be for equipment, products or systems, at the earliest stage of a project, so that their procurement, delivery, installation and testing can be undertaken within the overall programme.
- Highlighting any specific interdependencies between activities that will drive programme sequencing.

- Recommending sufficient time for site activities, in particular those relating to commissioning, where there is a tendency to try to compress the time available.

Liability for defective workmanship

Building services engineers are not directly responsible for the workmanship of construction works. That is the responsibility of the main contractor and they owe no duty to supervise their works. However, building services engineers owe a duty of supervision to clients; hence, they could be liable in negligence for defective workmanship if they failed in their duty of care with respect to supervision.

Liability for maintaining competency

Building services engineers are required to maintain relevant competencies to ensure that they discharge their duty of care. There are varying views as to how competency should be defined, maintained and regulated. For example, unless proven otherwise building services engineers may be defined as competent by virtue of membership of a professional body, especially if a continuous professional development programme is followed.

Responsibility for record keeping

Clear record keeping plays an important role in managing continuing communications and to avoid conflict. If all events and decisions are clearly recorded, it is easier to deal with issues that arise, particularly when in a position to make or defend any contractual or legal claim that arises during construction. The party keeping the most comprehensive and detailed records will have the decided advantage in any claim or dispute-resolution proceeding.

Any documentation produced or decisions made in relation to the construction phase should still be subject to the same vigour of an entities' QA/QC procedures as during the design phase. This applies to any reports created, responses to site queries and dealing with design changes.

Summary

Defective design works may only emerge during the construction phase and can have disastrous consequences on programme, cost and quality. As custodians of their designs building services engineers will, under their duty of care, want to monitor that their design intent is reflected during construction and not compromised due to cost cutting, programme squeezing or lowering of quality. If this is unavoidable they will need to document the consequences to inform the relevant parties. Building service engineers need to understand the scope of their liabilities and obligations with respect to their design liability, providing cost and programming advice, defective workmanship, maintaining their own competencies and record keeping. With respect to attendance on site, building services engineers are expected to fulfil the conditions of their contract, which should state expectations for frequency and nature of site visits.

Feedback question

1 Discuss whether a sole building services engineer working via an agency to an organisation owns the copyright to the work they produce?

Reference

Swaffield, L.M., and Pasquire, C.L. (2000) Improving early cost advice for mechanical and electrical services considering functions and client/design team communication. *Journal of Financial Management of Property and Construction*, **5**(1), 3–13.

3 The construction team

Construction teams provide buildability expertise, labour, materials and plant resources to plan, execute, monitor, control and deliver building projects to a client's requirements. These are measurable in terms of quality, budget and programme. Construction teams comprise main contractors, trade subcontractors and (non-construction related) support services providers, all of whom mainly operate on site. Off site the construction team is served by manufacturers producing standardised products, custom fabricated goods, assembled goods or prefabricated systems. The complete (on and off-site) supply chain is linked by logistics functions.

Figure 3.1 illustrates the main stages of construction. With respect to the building services engineers, their potential involvement at each stage may be:

- ***Pre-construction*** involves finalising and matching design information with cost and programme information. Building services engineers need to ensure that their key design criteria are not compromised;
- During ***mobilisation*** construction teams prepare for the necessary movement of personnel, equipment, supplies, and incidentals for the impending physical activities on- site (Figure 3.2). The planning and layout of the actual construction site in terms of types, quantities and position of equipment – for example temporary substations, cranes and concrete batching plant – can have a significant impact on the overall productivity and, hence, cost effectiveness of building projects. Spaces for pre-assembly, for example lagging of air conditioning units and assembly of light fittings, will influence the quality and time spent on site.

  Building services engineers should ensure that any requirements for office space for their site-based staff, including provision of ICT equipment (telephone, computers, printers), internal and external network connections, general storage space and car parking allocation, are allowed for. They should also ensure their names and details

Building Services Engineering: After Design, During Construction, First Edition. Jackie Portman.

Companion website: www.wiley.com/go/portman/buildingservicesengineering

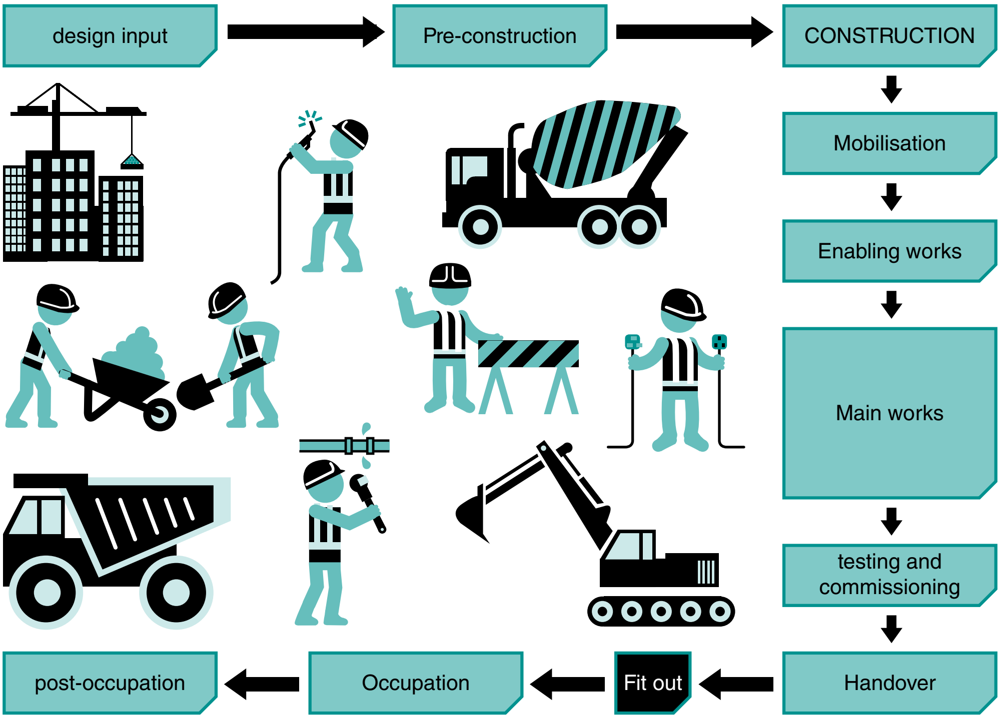


Figure 3.1 Stages of construction

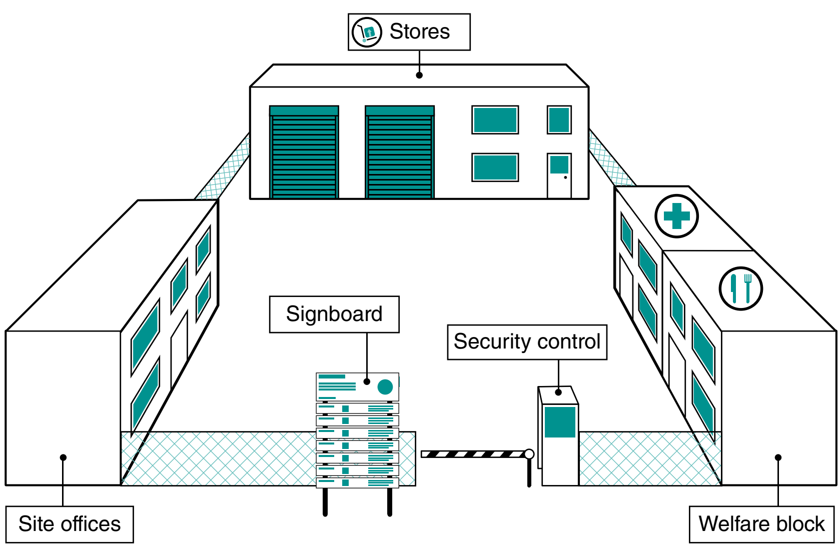


Figure 3.2 Site set-up

of their role on the project are included on the project site signboard. In addition, arrangements for personnel access to site (for their on-site and visiting staff) should be established. There may be special measures that need to be followed to allow for access; for example, if construction works are in security sensitive areas, or areas with young or vulnerable people, there may be requirements for vetting.

- ***Enabling works*** packages may be undertaken prior to the main building works. This may either be to 'buy some time' or to obtain more information about the site to feed into the design. Typically this may include:
  - Carrying out crushing and bulk earth movement and site grading to alter the slope and elevation of the soil to achieve the required levels. Either existing earth will be redistributed, additional earth brought to site or surplus material sent off site. This may affect the existing cover level of utility services, which may necessitate either diverting them or changing the levels (Figure 3.3).
  - Demolition of existing buildings on the site. With respect to building services engineering systems care is required to ensure that any live utility services serving existing buildings are safely isolated and disconnected and documented accordingly. This information must be passed to the construction team. Figure 3.4 illustrates an electrical isolation; the same principle applies to gas and water. In the case of a site with multiple buildings, there may be interconnecting services for fire detection and alarm system cabling, medical gas pipes and CCTV systems cabling.
  - Removing or stripping out the building services engineering systems in an existing building. This may comprise a whole or partial removal of the interior of the building, from structural

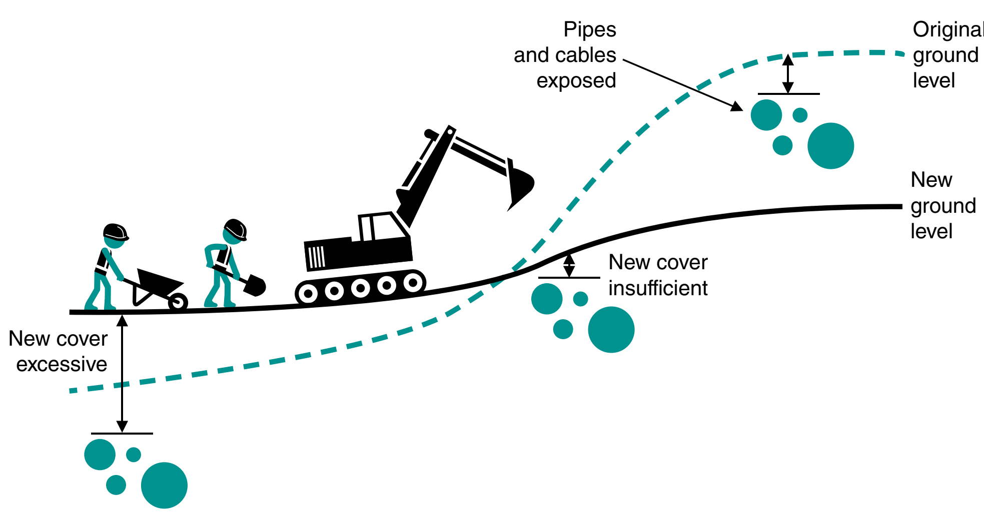


Figure 3.3 Grading and levelling

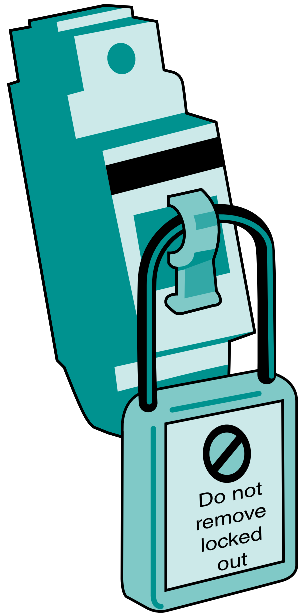


Figure 3.4 Electrical isolation

elements including floors, ceilings, staircases and block walls to fixtures and fittings. With respect to building services engineering systems, again care is required to ensure that any live services are properly dealt with.

- Providing car parking spaces to compensate for those spaces that will be lost during the construction works – which may require lighting, CCTV systems, electric barriers and surface drainage.

- The ***main works*** may be a new build, conversion, refurbishment, renovation, repair, demolition or dismantling of, or addition to, a building, with all the associated building services engineering systems and utility services required to provide an environment fit for the building occupants and/or activities taking place within and outside the building.
- ***Testing and commissioning*** involves setting to work the building services engineering systems to prove that they operate safely and that they function as set out in the design criteria. For example, airtightness tests measure the uncontrolled flow of air through gaps and cracks in the fabric of the building; this affects the indoor air quality. Also, thermal integrity, which measures the heat flow by means of thermographic scanning of the exterior and selected interior spaces. Assumptions will have been made in the design calculations and used in any building simulation models for the materials and junction details (wall–floor, wall–roof, lintels, jambs, sills and so on.

- There may be a ***fit out*** to customise the interior spaces to the requirements of specific occupants.
- At the end of the construction period there will be demobilisation activities and an official ***handover*** date, but there will still be (short and longer term) legacy issues to deal with.
- During first ***occupation*** the focus will be the buildings operation and fine-tuning the building services engineering systems in response to feedback from initial operating experience.
- Subsequently, building services engineers may be involved with defects that arise (only if their root cause originates in the design) and possibly further building works to the building.

3.1 Construction team parties

Main contractor

Main contractors are responsible for day-to-day overseeing of the physical site works and management of their subcontractors and suppliers. They control the construction means, methods, techniques, sequences and procedures. In addition, the construction team manages communication between all the involved parties throughout the course of project: securing the site, applying for building permits and inspections, providing temporary utilities, providing workers under its control with relevant information and instruction, providing site surveying and engineering, disposing or recycling of construction waste, monitoring schedules and cash flows, and maintaining accurate records. It will also facilitate the supporting functions that feed them – risk management, value management, information management, planning services, commercial management and quality management, staff development and training. For the purposes of clarity this book uses the term 'Main Contactor' to cover management contractor, construction manager, prime contractor, and design and build (D&B) contractor.

Trade subcontractors

Main contractors may subcontract part or all of their scope of works to trade subcontractors as an alternative to employing direct labour to perform part or all of their obligations. The reasons may include:

- As additional resources for a particular project, possibly to deal with peaks and troughs in workloads.
- To provide added value – lower cost and better quality than might be achieved in-house.
- To provide access to specialist skills.

- Because they are required by law to appoint an independent third party; for instance a CDM (construction design management) coordinator in relation to health and safety and third party verification of the sprinkler installer's work.
- Because, although there is no legal reason for an independent third party, the contract calls for independent testing for specialist activities, for example fire detection and alarm systems, building pressurisation.
- A means of transferring risk.

Often work is subcontracted from main contractors to subcontractors, then to their subcontractors, and onto their subcontractors and so on. This is known as multilayer subcontracting. With multiple subcontractors in a drawn-out supply chain it may be easier for parties to try to off-load work or blame to another party. This includes long communication channels and possibly problems of non-payments for lower-tier subcontractors, which may lead to project delays and work quality problems. Clients may attempt to control the extent of multilayer subcontracting by either including prohibition clauses or particular approval procedures in the contract.

Subcontractors may be nominated, named or domestic type. The key differences between each type are summarised in Table 3.1.

For a nominated subcontractor, clients select and appoint a particular subcontractor and instructs the main contractor to use them to carry out an element of the works. Clients obtain and agree a quotation for the work, which is either included in the contract documentation as a prime cost sum, or is processed as a post-contract variation. Main contractors are entitled to add their own mark-up (to allow for overheads and profit) and attendance costs (to allow for their efforts with respect to management and coordination).

For a named subcontractor, clients provide a short list of potential subcontractors from which the main contractor can select and appoint any to carry out an element of the works. The list is included in the tender documents, or included as a provisional sum if the list is issued as a post-contract variation. Once the main contractor has selected and appointed a subcontractor, the provisional sum is replaced with the actual price agreed. This allows clients to guide a main contractor's choice of subcontractors, whilst leaving responsibility for their performance with the main contractor.

Table 3.1 Comparison of nominated, named and domestic subcontractors

	Client selects	**Client appoints**	**Main contractor selects**	**Main contractor appoints**
Nominated subcontractor	√	√		
Named subcontractor	√ (shortlist)		√ (based on shortlist)	√
Domestic subcontractor			√	√

Clients may delegate their roles in the selection of domestic and named subcontractors to the design team and act on its advice. Clients may go through a formal or informal tender and tender adjudication process to justify their selection.

For a domestic subcontractor, main contractors select and appoint subcontractors on the basis of the information supplied by the design team, usually in the tender documentation.

Off-site supply chain

Materials and finished goods arrive on site from suppliers. These may be standardised manufactured products, custom fabricated goods, assembled goods or prefabricated systems.

Standardised manufactured products will either be held in stock by the manufacturers or passed to distributors. Distributors maintain large inventories of materials and goods sourced from a range of manufacturers. They act as a middleman between manufacturers and contractors or subcontractors that require the goods for construction.

Custom fabricated or bespoke goods are built to specific specifications. Manufacturers are alleviated of the need to maintain a stock of equipment, but clients' wait time is usually longer. Examples might be specialist luminaires or made-to-order furniture with built-in socket and data outlets and fans and heaters.

Assembled goods comprise of a number of component parts or subassemblies put together to perform a specific function. Figure 3.5 illustrates the case of low-voltage switchgear. Table 3.2 provides further examples.

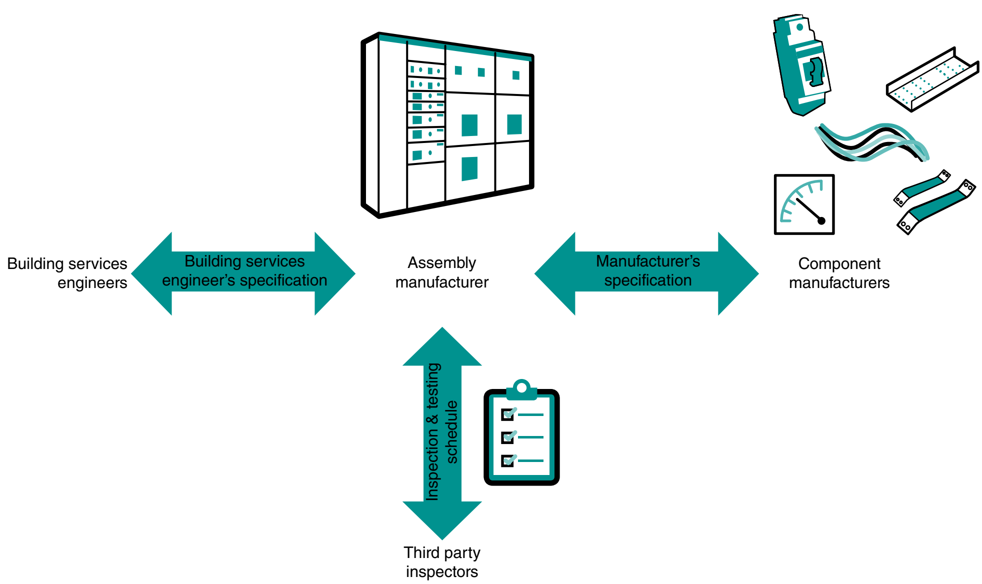


Figure 3.5 Low-voltage switchgear assembly

Table 3.2 Examples of assembled goods

Assembly	Component parts
Air handling units	Fans, heating and cooling coils, air-control dampers, filters, acoustic attenuation and controls devices, with connection points for the electrical supplies, building management system (BMS) air and water.
Generator set	Engine, alternator, fuel tanks and associated pipework and pumps, voltage regulator, cooling and exhaust systems, lubrication system, battery charger, control panel, controls devices, main assembly frame with connection points for BMS.
Motor control centre	Circuit protective devices, relays, contactors, timers, meters, control power transformer, motor starters, meters, controls devices power and control cables, cabling terminals with connection points for BMS and electrical supply.

BS EN 61439, Low-voltage switchgear and control gear assembly

BS EN 61439 differentiates between the obligations of an 'original manufacturer' and those of a 'manufacturer of switchgear and controlgear assemblies'.

The 'original manufacturer' is an entity manufacturing switchgear and controlgear assembly that is able to provide 'design verification' as described in EN 61439 as proof of compliance with the requirements. This can be done by means of testing, comparison with a tested reference design or assessment (checking calculations and design rules).

A 'manufacturer of switchgear and controlgear assembly' is a certified entity that builds switchgear and controlgear assembly but relies on the 'original manufacturer's' design for design integrity and compliance with EN 61439. They are responsible for the 'routine verifications' itemised in EN 61439 on each panel produced, according to the standard. Any deviations from the original manufactures specification as will necessitate the need to carry out again design verifications.

Building services engineers need to appreciate the differences between the two types manufacturers when either reviewing submittals or attending factory acceptance tests.

Prefabrication systems are sections of a buildings manufactured off site before transporting them on site for final positioning and connections. This may either be by preassembly or modular construction.

Preassembly refers to the assembly of several components to form a complex unit, for example:

- A combination of services pipework, ductwork, cable trays/trunking modules used in horizontal or vertical distribution.
- Pump sets complete with pipework, meters and valves.
- Sections of building fabric with cast-in conduit.
- Earthing in piles.

Modular construction refers to the assembly of multiple discipline components, for example:

- Packaged chiller plantrooms complete with chillers, pumps, pipework, control panels, electrical cables, fire detectors, controls devices.
- Bathrooms complete with all sanitary ware, pipework, luminaires, electrical cabling and surface finishes.

To ensure that the design leads to a successful installation, considerations are required with respect to:

- Competency and experience of designers in off-site manufacturing.
- Extent of standardisation/repetition/symmetry of building to benefit.
- Building tolerances affecting the integrity of the interconnections and interfaces.
- Transport constraints: be aware of the width, height, length and weight limits for vehicles and plan the route to avoid constraints due to low bridges and width and weight restrictions.
- Setting in position needs to recognise the need for off-loading, any temporary storage on site and cranage to final positions (Figure 3.6). This needs to coordinate with the programming/construction sequence.
- Deconstruction, dismantling and recycling after use.

Logistics

The control and management of building services equipment and materials from source to point of use on site are important. Equipment and materials damaged or compromised in transit or during storage

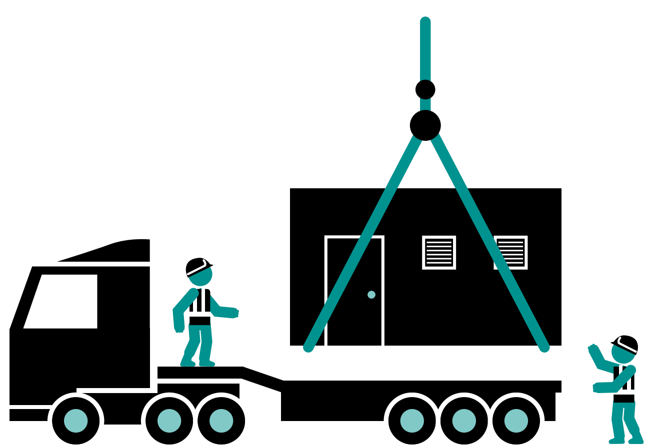


Figure 3.6 Prefabricated plant room

may not perform as per the design intent in the short term or, in the longer term, lead to premature failure. Whilst logistics management is the responsibility of the construction team, shortcomings may mean that building services equipment fails to perform as per design, meaning that the designers may become involved during the construction phase.

Organisation on site is important. Construction sites will be safer if materials and equipment are well organised and less cluttered, easily accessed and moved to their final location Ensuring that appropriate quantities of the right materials and materials are delivered to, or near, the point of use on a just-in-time basis has a great impact on productivity, project timekeeping, housekeeping and safety. As illustrated in Figure 3.7, materials and equipment may either arrive 'just-in-time' or else will require storage space allocated either within the building or within intermediary facilities.

Care is required to provide an appropriate environment for storage of materials and equipment; for example:

- Materials and equipment can deteriorate due to sunlight. Solar radiation degrades plastic materials.
- Dust (including cement dust) and moisture content in the atmosphere can attack exposed surfaces and damage the internal parts of motors, fans and, in particular, the electronics associated with control equipment if it is not suitably protected. Dust particles can form deposits on surfaces, which with atmospheric moisture can give rise to chemical reactions or can lead to corrosion. In electrical switchgear this can lead to flash-overs. To reduce condensation it may be prudent to install temporary space heaters in the storage areas.

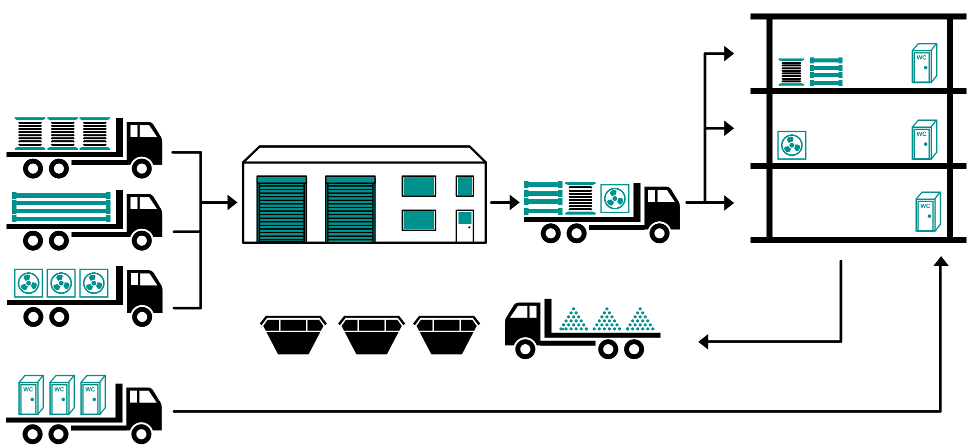


Figure 3.7 Site logistics

- The floors should be smooth and level to prevent disproportionate strain and distortion in the equipment.
- If the floor is not well drained there may be standing water.
- Physical damage may occur due to mishandling or even wanton vandalism.
- Protect from the risk of theft.
- Packing for shipping is not necessarily suitable for storage.

Storage facilities and lay-down areas away from the site may be required during groundworks and the fit-out stages of building projects.

Support services

There will be other entities that provide support to the construction activities. Depending on the nature, location and size of sites these may include:

- Site security to offset the risks associated with theft, vandalism and terrorism to plant, materials and fuel stored on site. The solution may comprise a combination of passive systems to provide physical containment and impediments (guards on patrol, guard dogs, fences, barriers, bollards, gates, secure storage etc.) and the provision of active systems (lighting, CCTV, access control systems, intruder detection, asset management and control systems etc.).
- Site catering to provide hot cooked meals and/or vending machines for hot and cold drinks, snacks and confectionery.
- Cleaning of site offices, welfare facilities, canteens, washrooms, and locker rooms.
- Resident nurses or nurse practitioners to provide welfare services; this is different to the first aid services, which will be provided by qualified first aiders.
- Other welfare services may be provided, such as visiting barbers, dry cleaners and so on.

3.2 Construction team arrangements

There are many ways of categorising the plethora of different procurement arrangements. This book distinguishes four main types, separated, integrated, management-orientated and product-based arrangements.

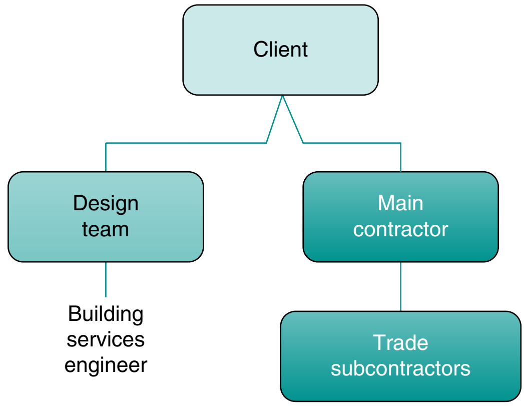


Figure 3.8 Procurement: Separated arrangement

Separated arrangement

In separated arrangements the design and construction activities are undertaken independently (Figure 3.8). Main contractor takes single-point responsibility for construction under a lump sum contract, with clients retaining responsibility for design. In principle, complete design information is delivered by design teams before the tender process leading to the appointment of a main contractor commences. In reality, particularly with respect to building services, some aspects of detailed design can only be carried out by subcontractors once final equipment has been selected and coordinated with the actual building fabric and structure. Therefore, main contractors will still have partial design responsibility through their subcontractor's design portion.

Integrated arrangements

Figure 3.9 illustrates an integrated system, where a client appoints a contractor to design and construct the works; for example, a design and build contract or custom-builds where building owners work with a developer that can take on the design and construction (and possibly site acquisition and arranging finance) of the building on their behalf.

Early input of construction expertise during the design stage and the ability to start construction before 100% design completion are beneficial, particularly in terms of streamlining projects in terms of time. This arrangement may also reduce the number of design clarifications and ensure that coordination issues are resolved promptly.

There may be a two-stage process with respect to design with some of the design progressing before a contractor is appointed. Thereafter, the design development will continue in tandem with the contractor.

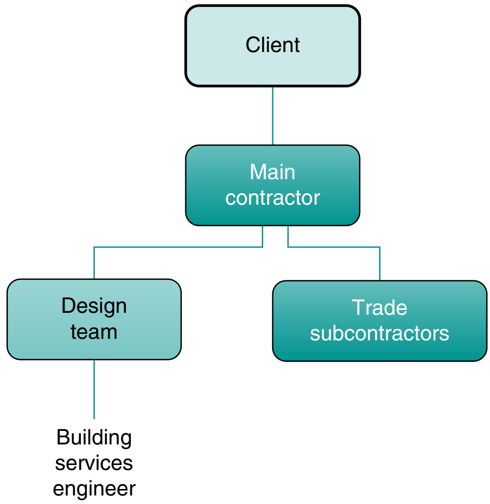


Figure 3.9 Procurement: Integrated arrangement

Management-orientated arrangements

Management-orientated systems, such as construction management and management contracting, rely on an entity to manage the process whilst the work is carried out by trade subcontractors These are illustrated in Figure 3.10, where, in the case of management contracting, trade subcontractors are arranged and administered under the management contractors direct responsibility, whereas with construction management the trade subcontractors are arranged and administered by the construction manager, but are contractually linked to the client.

Product-based arrangement

In a product-based arrangement, a delivery contractor is appointed to manage the design, construction, facilities management and financial requirements, then for a predetermined period operate the facility. Procurement options include Public Private Partnership (PPP), Private Finance Initiative (PFI), Design Build Finance and Operate, Design Build Operate (DBO) and Build Own Operate Transfer (BOOT). These may be applied to (the non-educational operations of) schools, (the non-clinical operations of) hospitals, local authority street lighting schemes, roadways and bridges.

There is no definitive organisational chart for these arrangements: each will be bespoke to the particular project (Figure 3.11). Each project will have numerous contractual arrangements involved, each defining the scope of works and how to share the responsibilities, profits and losses.

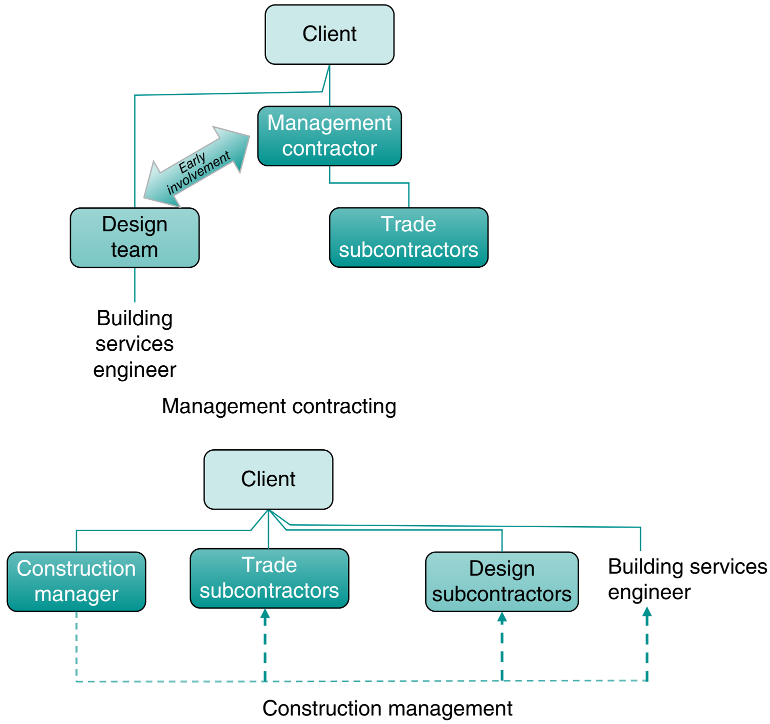


Figure 3.10 Procurement: Management-orientated arrangement

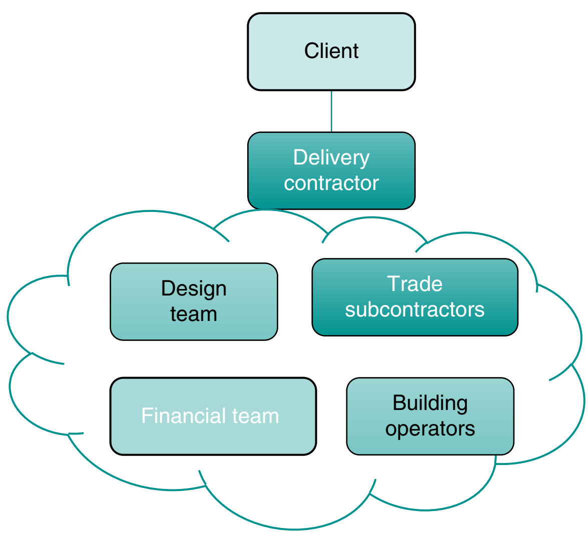


Figure 3.11 Procurement: Project-based arrangement

Partnering

As well as the strictly contractual arrangements, there may be expectations with respect to the ways of working and mind-sets that aim to increase cooperation across the organisation working on projects together. Partnering agreements aspire to semi-formalise this state. To succeed, partnering requires continuous and honest communication, trust, a 'win–win' attitude and a willingness to compromise; the unwillingness of participant to commit to the process can lead to ineffective construction partnering. Practical issues to be considered might be using information technology on common platforms, for example building information management (BIM) and shared ICT systems; implementing innovative ways of working and collocating staff for critical periods.

Figures 3.8–3.11 assume that the building services engineering work is part of a larger building works project. There are also projects where the building services engineering element is dominant and they are, in effect, the main contractors and will be supported by 'builders' as subcontractors.

3.3 Construction team liabilities and obligations

Health and safety

During the construction phase contractors are in sole charge of the construction site and have sole and ultimate responsibility for all health and safety matters pertaining to that site. This means that, so far as is reasonably practicable, that is taking precautions that are not only possible but that are also suitable or rational, given the particular situation, they have to plan, manage and monitor construction work carried out by them or under their control in a way such that it is carried out without risks to health and safety. This means:

- Ensuring that all subcontractors and their subcontractors are allowed adequate time to plan and undertake their activities.
- Implementing site safety systems; for example with respect to isolation and disconnection of existing electricity and gas services, permits-to-work system in potentially hazardous areas such as high-voltage switch rooms.
- Making sure that every worker carrying out the construction works under their control has sufficient information and the training required for the particular work to be carried out safely and without risk to health.

- Providing site inductions to communicate essential information regarding the site, the procedures and rules and the working methods and focuses in particular on health safety aspects of the site. This includes visitors to the site.

With respect to the building services engineering, the design should be reviewed particularly with respect to:

- Working at height for installing materials and equipment in ceiling voids and mounted externally at high level.
- Working in confined spaces such as fully or semi-enclosed water or fuel tanks, sewers, building services engineering riser shafts, building voids and enclosed plant rooms. There may be insufficient oxygen for respiration, a build-up of toxic fumes or heat, restricted emergency escape routes.
- Manual handling of equipment will require an understanding of the weights (and the spread of weight) of equipment, either whole or broken down into components and determining safe methods for moving them, for example with lifting hooks being fitted to equipment and using cranes. Manufacturer's advice should be sought.
- Hazardous materials, for example polychlorinated biphenyls (PCBs) and mercury, which may be found in electrical equipment and lead, which may be found in pipes that may be in existing equipment that will be removed.

Changes during the construction period, for example due to changes in equipment or final site coordination, should be properly evaluated with respect to any health and safety risk consequences.

Liability for design errors

Contractors and subcontractors have a duty of care to raise a query or warning should they come across shortcomings in the design information. Building services engineering subcontractors are essentially required to install systems are per the building services engineers design information contained within the contract documentation. They are not necessarily expected to interrogate, cross-check coordination and interfaces, and challenge design assumptions pertaining to the design information. However, they are expected to pick up any obvious error in the design information.

Subcontractors should not presume that just because they did not produce the design information, that under no circumstances will they be held liable for breach of duty of care to third parties for failing to spot, and warn of, design inadequacies; for example:

- The design of a fire detection and alarm system falls short in respect of the required coverage of smoke detectors.
- The fan sizes for a ductwork system are not big enough to pull enough air to properly ventilate the space intended.
- The fall of drainage pipes is insufficient to prevent blockages.

If a design is inadequate for a particular use then failing to raise the issue may well give cause to liability in negligence if: the subcontractors should have had the competency to be aware or something in the design information should have alerted a reasonably competent party to the fact that there were shortcomings in the design.

Liability for defects in construction

Contractors are required to undertake and finish the works in accordance with the requirements of the contract documents and any agreed variations. Contractors must put right, at their cost and time, any defects they cause. Construction defects may be due to:

- Design deficiencies.
- Materials deficiencies or wrong materials used.
- Specification problems.
- Good and workmanlike manner not followed.

Typically with construction contracts, at completion of the work by the contractor a certificate of practical completion is issued. This starts the defects liability period. At the end of the defects liability period another certificate is issued stating that all defects have been rectified, and thus the works are in accordance with the contract. However, after the final certificate has been issued contractors still have liabilities for any defects in their work that subsequently arise. Clients legal recourse against contractors for defective work is to claim for damages.

Care is required to differentiate between a construction defect and a nuisance claim, such as a noisy air supply system resulting from lack of maintenance or normal wear and tear.

Liability for subcontractors

Contractors can discharge their duty of care to clients by delegating responsibility to a subcontractor providing they have made a careful selection and have acted properly with respect to maintaining health and safety practice and providing reasonable supervisory and coordinating authority. As a principle, main contractors cannot necessary delegate away all health and safety matters, for example an inspection in respect of checking for gas leaks would be non-delegable.

Delegation of contractual functions – Cleightonhills v Bembridge Marine [2012] EWHC 3449 (TCC)

This case considers the obligations of subcontractors to warn about deficiencies in design and whether they are entitled to delegate, and hence off-load, their responsibilities to others further down the contractual chain.

Mr Cleightonhills (Cleightonhills) successfully sued his employer, Bembridge Marine Ltd (Bembridge), when he fell and suffered very serious injuries at work when a platform collapsed. The platform had been part of a building project where an old wooden workshop was replaced with a new two storey building to be used for the repair, maintenance and fitting out of boats. Figure 3.12 illustrates the parties involved in the design, construction or supply of the platform. The ruling confirmed that the accident was as a result of RMA Structural Engineers Ltd (RMA) negligent design.

Subsequently, Bembridge brought proceedings against Mr Ely, RMA, Mr Bennett, AFL, and Mr Martin. These proceedings turned on what duty of care means for a subcontractor.

Salient points were:

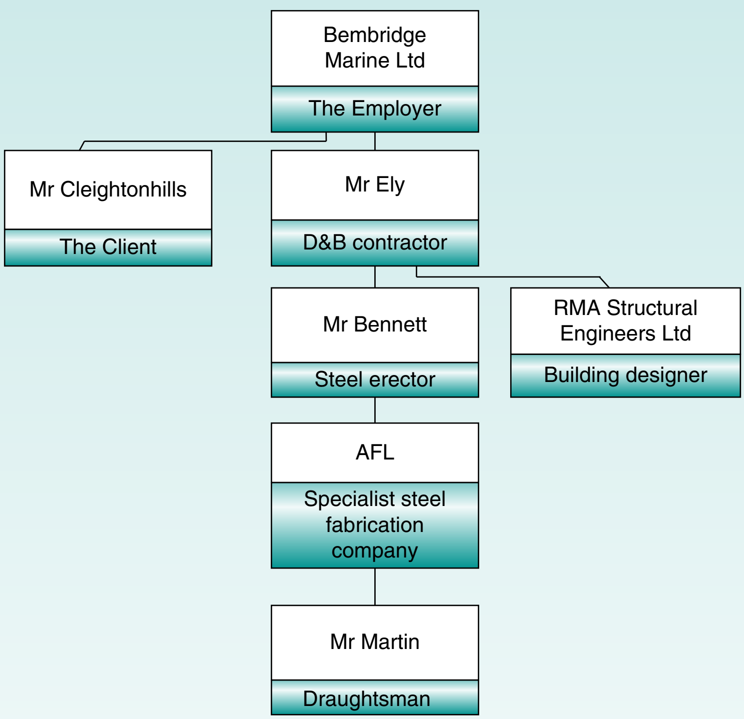


Figure 3.12 Parties involved

- All five parties owed a duty of care to Cleightonhills.
- Mr Ely and RMA were aware of the intended use of the structure and had failed to warn of design inadequacies in it, even though they should have been aware that the design was not fit for the particular purpose intended – in this case handling boats – and therefore were in breach of their duty of care and thus liable in negligence for the loss sustained by Mr Cleightonhills as a result of the accident.
- Mr Bennett, AFL and Mr Martin were not aware of the in intended use the platform for loading and unloading of boats of a particular size and weight and, therefore, were not in breach of their duty of care.

Liability to the general public

Contractors have liabilities to the general public with respect to health and safety and nuisance matters. They also have responsibilities with respect to the general public's image of the construction industry.

Contractors have to take reasonably practicable steps to ensure the health and safety of people who are not in their employment, principally the general public.

They must provide and maintain suitable perimeters and barriers at the site boundaries, so as to separate the general public from the site. There is legislation to control pollution originating from construction sites due to the likes of noise and air quality.

Contractors may be financially liable for the result of any accident causing personal injury to a member of the general public and property damage that occurs as a result of negligence. Contractors cannot be held liable in the case of illegal trespass or forced entry on to sites by those intent on criminal activity, providing they have taken reasonable steps to discourage entry.

Liability during warranty period

A construction warranty defines and limits the responsibility of contractors for repairs of building projects after completion of construction. This protects clients against defects or failures or any other non-conformances with the contract discovered within warranty periods. There will be an overall warranty period for the works that is typically one year from the date of practical completion. Contractors are responsible for correcting, at their own expense, defects or deficiencies in the works which appear during the one year warranty period.

Warranties for longer than one year (i.e. extended warranties) may also be included for certain products (product warranties) or portions of work (system warranties) in the specification sections of the contract documents. These will be expressed in the contract documentation and may be delegated to subcontractors and manufacturers.

Examples of product warranties (covering replacement of the product) might be:

- A luminaire manufacturer may give a lifetime warranty for a vandal resistant fitting damaged due to vandalism.
- A glazing manufacturer may warrant the availability of a particular coloured glass used as an exterior curtain wall for a certain number of years.

Examples of system warranties (covering replacement of product and the entire installation) might be:

- A plumbing subcontractor may warrant domestic hot and cold water systems against leakage for twelve years.
- A CCTV subcontractor may give a warranty to undertake all maintenance and repairs, including upgrades to software, for three years.
- An air conditioning subcontractor may warrant the ability of a system to achieve certain temperatures.

As contractor's works may accommodate building services engineers in the form of design information, the contractors warranty on works includes building services engineers liability in addition to that of the contractor throughout the warranty term. Whilst building services engineers are not normally parties to construction contracts, it is important that they obtain the benefit of these warranties as third-party beneficiaries of the agreement between clients and contractor. This status is important to allow the building services engineers to make claims against contractors in the event that the clients makes claims against building services engineers for failure to detect defective work.

Summary

The construction team comprising main contractors, specific trade contractors, off-site manufacturers, logistics efforts and support services collectively translates the design information into physical reality. It is important for building services engineers to understand the nature of goods sourced off site with respect to their approach to inspection and testing.

The main ways of arranging the relationships between contractors and the design team can be categorised as separated, integrated, management-orientated and product-based arrangements. Multilayer subcontracting is a feature of all these arrangements. Whilst multilayer subcontracting provides access to specialist services as well increased flexibility to main contractors, which may expand or reduce their construction capabilities depending upon their workload, there is a need to manage, control and select appropriate subcontractors otherwise there will be inefficiencies and jaded performance by all parties

Collectively the construction team has liabilities and obligations with respect to health and safety, and defects in construction, for their subcontractors and to the general public. These liabilities continue past the handover stage through the defects liability period and beyond.

Feedback questions

1 Contractors often have criticisms about the contract specifications, saying they are ambiguous, inconsistent or excessively restrictive. Given that it may take a year or more to put together a set of contract documents, then for a tenderer to have four weeks to review and produce a bid, there may be issues so subtle that it cannot be reasonably be detected in the timescale. Discuss whether, in such situations, contractors may be entitled to additional compensation for compliance. Should contractors share responsibility for the adequacy of the specifications? Or, should clients and their design professionals bear the full brunt of any shortcomings?

2 There is an increased use of self-certification by accredited tradespeople. Discuss for either electrical and plumbing installations or thermal calculations how this certification encompasses the design as well as the installation workmanship and how this can be properly policed for compliance.

Reference

BSI (British Standards Institution) (1990) BS EN 61439-1:2011. Low-voltage switchgear and controlgear assemblies. Milton Keynes: BSI.

4 Enforcing authorities

The term enforcing authority is quite nebulous. There are a plethora of enforcing authorities, each with their own particular terms of reference to define their purpose and structure. The dominant enforcing authorities that building services engineers are most involved with are usually the local authority building control and local authority planning departments. Building control departments act in the interests of the public in matters such as public safety and health, equitable use of limited resources and sustainability. Planning departments are concerned with the development of the built environment, including the use of land, the aesthetics of buildings, landscaping considerations, interfaces with public amenities and services, and the impact that building projects will have on the overall environment.

The legislative bodies of a jurisdiction, which may be a local authority, central government, European Parliament or by international agreements, treaties, protocols and conventions, will pass laws. Enforcing authorities are subsequently created by legal statute to administer this legislation.

Besides building control and planning departments there are other enforcing authorities whose terms of reference are broader than the construction industry. These may cover matters such as operation of a public service, advertising and promotion of a locality or lifestyle choice, maintenance of heritage. They may also have aspects that need to be considered in construction, for example the Health and Safety Executive, Environment Agency, The Sports Council, Civil Aviation Authority, English Nature, Historic Scotland, An Taise (The National Trust for Ireland), Highways Agency and so on.

There is also a proliferation of diverse and disparate primary legislations that deals with issues already covered in the UK Building Regulations; for example:

- Sustainable and Secure Buildings Act 2004.
- Climate Change and Sustainable Energy Act 2006.
- Regulatory Reform (Fire Safety) Order 2005 of the Fire Precautions Act 1971.

Building Services Engineering: After Design, During Construction, First Edition. Jackie Portman.

Companion website: www.wiley.com/go/portman/buildingservicesengineering

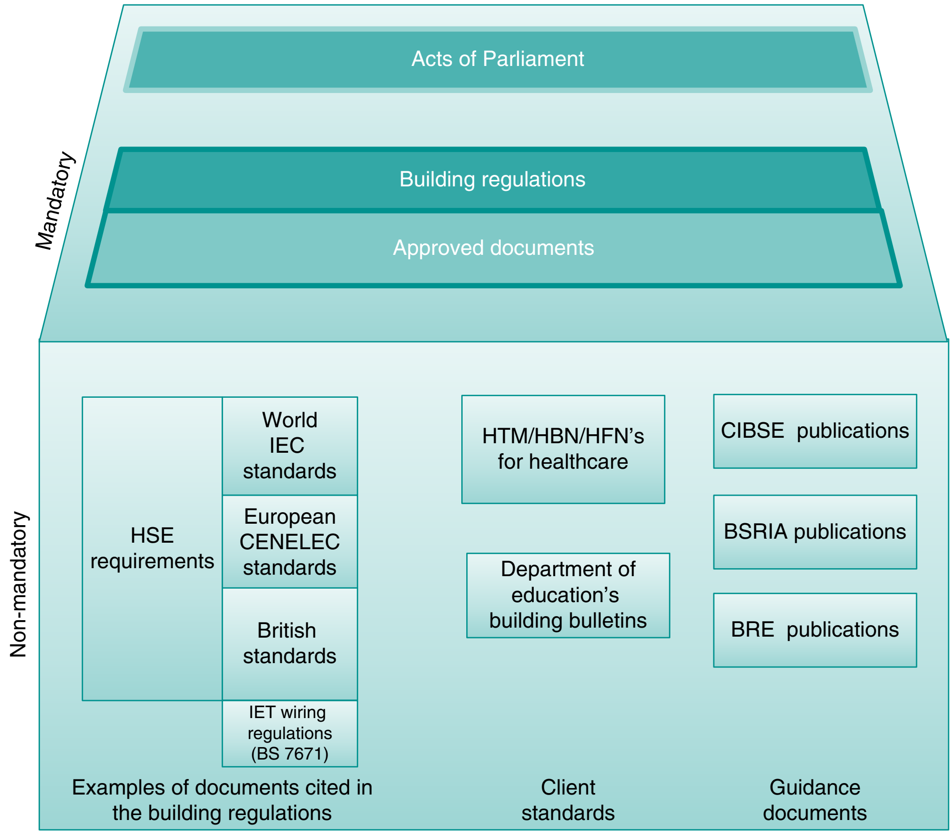


Figure 4.1 Hierarchy of legislation

This can cause duplication but also may introduce contradictory requirements and cause confusion.

Figure 4.1 outlines the hierarchy of legislation, regulation and guidelines that influences the electrical installation for building projects. Guidelines and codes of practice may not have a statutory basis but they often provide a valuable direction on implementation.

Enforcing authorities have rights to determine, publish, monitor and enforce regulations.

4.1 Defining

Typically regulations are written as a policy, often with an official 'legalese' style of language, which may contain Latin words, long sentences, verbiage (using more words than are necessary) and many double negatives (Figure 4.2). Thus, they are generally inefficient and often unfriendly in style.

Over time legislation may change, or by virtue of precedent the interpretation of legislation may change. These new requirements may be fully retrospective or there may a transition time to accommodate them.

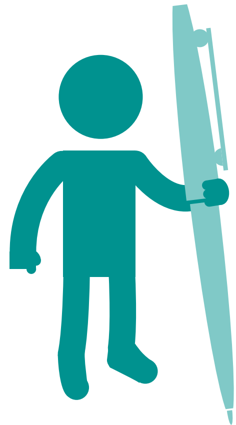


Figure 4.2 Defining enforcing authority requirements

Figure 4.3 Publishing enforcing authority requirements

Building services engineers need to be aware of such forthcoming change in order to inform their client and the construction teams. It may be that news of prospective amendments or new legislation is made available for either public or selected audiences through consultations. This provides a formal process through which stakeholders can gain awareness of possible impending changes. Feedback may be provided by means of written responses from the general public and targeted interest groups.

4.2 Publishing

Policies are typically translated and published as user-friendly documents describing how the legislation shall be implemented (Figure 4.3). Some requirements may be very prescriptive, stating absolute parameters, others may be more performance-based, defining objectives in terms of desired outcomes. The appeal of the performance-based approach is as much about introducing a regime that overcomes problems of overly rigid rules and inflexible enforcement as it is about regulating for results.

Be careful what you say

Building services engineers may unwittingly 'state' that they are a complying with a particular piece of legislation, for example The Building Act 1984 (and the Building (Scotland) Act 2003) with respect to the design of buildings. Whereas, in practice, they have never read the Acts: nor do they need to, as The Department for Communities and Local Government (DCLG) has defined the means to satisfy the legislation in its Approved Documents.

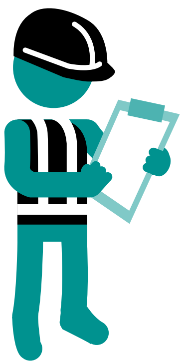
Similarly, building services engineers may refer the Disability Discrimination Act (1995) (colloquially known as DDA) with respect to designing lighting and hearing systems for buildings. However, the DDA is concerned with the unlawful discrimination against people in respect of their disabilities with respect to employment, providing goods and services, education and transport. It is Approved Document, Part M (Access to and Use of Buildings) that actually interprets how the spirit of DDA can be achieved and provides an interpretation and guidance on to what measures will achieve the requirements for lighting and hearing systems.

Guidance documents should be treated as providing direction only. For example, the Approved Documents which provide direction about compliance with specific aspects of the Building Regulations and what is likely to be accepted as a reasonable provision for compliance, can still be overruled by the local authority building control departments This is a particular risk in usual or highly innovative designs or installation techniques.

4.3 Monitoring

Monitoring (Figure 4.4) of enforcing authority requirements may be achieved by:

- Reviewing documentation and determining whether they provide sufficient evidence of compliance, and/or.
- Physically inspecting the installation of the works – this may be whilst construction is in progress and/or at completion and may include witnessing of testing or checking of test results.



Monitoring

Figure 4.4 Monitoring enforcing authority requirements

Enforcing authorities may undertake the monitoring themselves. Alternatively, the actual governance may be delegated to an independent third-party either through certified companies or certified individuals; this is known as a delegated authority. Alternatively, it may be possible for the installer to self-certify, providing it are deemed competent to do so. This competency may be evidenced by registration of an appropriate body.

Domestic wiring self-certification

All electrical work within domestic dwellings must be carried out in line with Part P of the Building Regulations. From 6 April 2014, electrical contractors who are registered with a competent person self-certification scheme are able to self-certify that electrical work has been undertaken in compliance with Part P of the Building Regulations. They are also able to certify the work of third parties.

However, there are a number of trade associations and other agencies – all authorised by the Department of Communities and Local Government (DCLG) – that operate these schemes. But, they each have their own particular requirements and compliance procedures with respect to self-certification schemes for electrical installations. This is at odds with a prime driver of enforcing authorities to have consistent processes leading to repeatable outcomes.

The monitoring role should ensure that any non-compliances are addressed and rectified prior to completion. Non-compliances may be observed as shortfalls within the documentation or actually seen during a physical inspection. In addition, failing to undertake a required action, for example providing certain documentation or requesting an inspection, could constitute a non-compliance.

4.4 Enforcing

Non-compliance with regulations may result in either no certificate or a non-compliance certificate of conformity being issued (Figure 4.5). It may mean that buildings cannot be insured or sold. Furthermore, this may lead to legal action, which may result in fines, termination of services and court orders to amend the works

One of the issues with some regulations is that some goals are not aimed at making things happen, but at making things not to happen. For example, with respect to fire safety requirements the aim is to ensure that fires do not start, and if they are they are brought under control in an appropriate matter to mitigate damage to people and property. This means that that any measurement is to do with measuring that something does not happen. This is a general issue with regulation that aims at prevention of harm; a consequence might be that enforcing authorities may be accused of costing too much whilst not producing much measurable output.

Regulators

Enforcing authorities usually have regulators who act in the interests of the customers of the particular enforcing authority, particularly to ensure the relevant stakeholders receive a quality of service, that fair competition ensues and to impose sanctions for non-compliances.

Figure 4.5 Enforcing authority requirements

Value of completion certificate

If a building is completed and issued with completion certificate by the local authority this means that the local enforcing authority is satisfied, after taking all reasonable steps, that the requirements of the Building Regulations have been met.

However it should be remembered that building control officers only ever make sporadic visits and, thus, are not present for the great majority of the building project. This means that the completion certificate is not a guarantee that all works have been done to the required standard. Primary responsibility for the building work rests with those who commission it and those who do the work.

Summary

Enforcing authorities are responsible for administering legislation passed by a particular jurisdiction. This covers defining, publishing, monitoring and enforcement. Building services engineering system needs to be compliant with the requirements of relevant enforcing authorities. However, there may be a number of applicable but conflicting or overlapping applicable standards that need to be dealt with.

Feedback questions

1 In developing countries the incumbent 'statutory' regulations and standards (pertaining to the building services design) and the accompanying enforcement procedures may not as developed as, say, in the United Kingdom. There may be issues associated with adequacy, feasibility, legal certainty and adaptability to be adjusted to specific actual and future circumstances leading to shortfalls in terms of safety and health matters, approaches to energy conservation and accommodating disabled users. This poses a dilemma. Discuss whether building services engineers should 'lower' their design standards to suit the local standards or design to international best practice standards?

2 British Standards themselves are not a statutory requirement. With reference to a particular standard, for example BS 5839-1:2013, which covers fire detection and fire alarm systems for buildings, discuss its position in hierarchy of legislation and how it is enforced.

5 Public utility services providers

In the context of building services engineering public utilities services covers the provision of electricity, gas, water, sewage and telecommunications services for building projects. These will be to tie-in (via cables or pipework systems, or through the airwaves) to the infrastructure of public utility services providers.

Historically utility services were provided by government run monopolies. The provision of public utility services is very asset-intensive with sizeable resources needed for development, operation and maintenance. During the 1980/1990s, UK government strategy decided that competition rather than regulation was preferred. This also relieved government of the responsibility of dealing with ageing assets. Hence, public utility service providers were progressively deregulated and the scope of services they provided fragmented according to functions.

As a result of deregulation there are multiple entities involved with securing the utility services requirements for particular building projects, some covering the physical equipment and apparatus, and others covering the actual service provision (associated with the availability, capacity and security of the commodity at the point of supply). Figures 5.1 and 5.2 illustrate these with respect to the provision of electricity and gas. Additionally, within each of the entities there may be multiple internal departments to deal with. Similar scenarios apply to water supply and removal, which may both be the responsibility of different service providers. Furthermore, with respect to the provision of telecommunications, clients may wish to choose to have multiple suppliers to add value to their building projects.

The design and installation of utility services for new buildings can be considered to be refurbishment rather than new building projects, as they comprise alterations to, and tie-ins to, existing infrastructure systems. Refurbishment projects are generally acknowledged to be more demanding and risky and, thus, need to be managed accordingly.

Building Services Engineering: After Design, During Construction, First Edition. Jackie Portman.

Companion website: www.wiley.com/go/portman/buildingservicesengineering

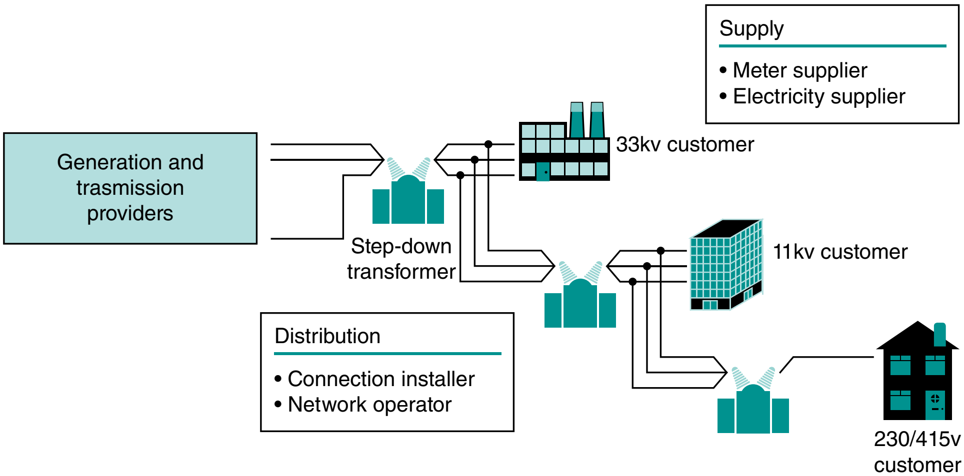


Figure 5.1 Electricity supply chain

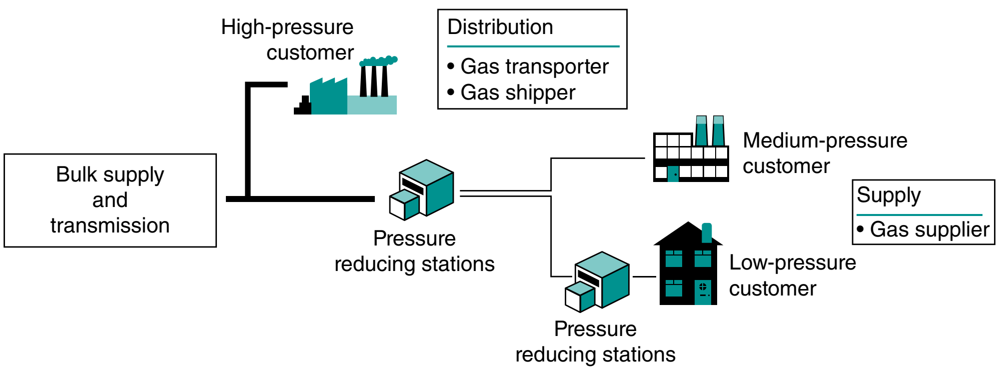


Figure 5.2 Gas supply chain

This is further complicated as the existing utility services (pipes, cables and equipment) are generally buried in the ground, making the ability to verify the precise location and condition by observation challenging.

Wayleaves and easements

Typically, public utility services providers have unfettered rights to designated land, to allow them to install, maintain, adjust, repair and alter their equipment. However, they still have a duty to arrange their access (except in an emergency such as a burst water pipe) and the works with the landowners.

5.1 Utility services provider's liabilities and obligations

Obligation to provide a utility service

The obligation of public utility services providers to provide a service to any premises should not be assumed. With the exception of water supply, where public utility services providers (the water undertakers) are mandated to respond to all requests for supply water to domestic premises, other public utility services providers are not necessarily legally bound to provide services to all building projects.

Similarly, they may only be mandated to provide a certain minimum level of service; for example, with respect to telecommunications services the Universal Service Obligation (USO) obliges BT and KCOM (in the Hull area) to supply a telephone and basic internet connection to a predetermined standard, upon reasonable request.

In the case of a gas or electricity supply request, if the existing reticulation (pipework or cables) within the boundary of a site (external or internal) is in an unacceptable state then an application for a new or upgraded supply may be refused until the existing reticulation is made good.

Alternatively, utility services may be provided *in situ*, for example using a diesel generator for electricity, providing stand-alone gas tanks, extracting water via boreholes or using septic tanks for waste water.

Provision of information

In response to an enquiry, public utility services providers are required to provide information regarding the existing physical installation and confirm its capacity to accept proposed new requirements – although they are entitled to charge for any necessary infrastructure network reinforcement and upgrading that may be required.

The record information should comprise up-to-date legible plans. They should show the location of all relevant cables, pipes and equipment – both below and above ground. Public utility services providers are required to use reasonable skill and care in providing this information. This does mean that they are free from omissions and errors. Reasons why record information may not be accurate may be due to:

- Not being drawn precisely to scale.
- Errors in drafting and reproduction.
- Position of references such as kerb lines or fire hydrants may have changed since the plans were drawn.

- Cover levels may have changed, hence the depths of equipment has changed.
- Pipes and cables marked in a straight line may, in fact, meander.
- Further works may have been undertaken since the records were drawn up.
- Plans may show spare ducts that have been filled with other services, or filled with debris and/damaged such that they are unusable.
- The routes of older services in particular may not have been recorded, so the absence of records should never be taken as proof that the area in question is free of underground services.

In any case, record information is usually caveated with comments advising that it cannot be relied upon. In order to reduce or 'design out' the risks arising from potential damage from underground services, there are a number of survey techniques that can be used to detect and locate the physical equipment underground and to help determine the service characteristics. These may be non-intrusive where nothing is touched, just recorded, or intrusive, which necessitates disturbances to the services and the surrounding areas. The main methods are:

- Electromagnetic wave scanners that can detect signals naturally radiating from metallic services or, in conjunction with a signal generator (colloquially known as a 'Genny'), that apply a distinctive signal that the cable avoidance tool (CAT) can detect.
- Geophysical methods (along with image processing techniques) which make use the physics of the earth and its interaction with the environment to detect and map the physical locations of underground utility services. The main options are ground penetrating radar (GPR), electromagnetic (EM) wands.
- CCTV surveys that use cameras to provide visual images of the inside of pipes. The information can also be used to verify the locations, sizes and configuration of pipelines as well as to assess the condition and integrity of pipes. These are most commonly used for drains and sewers;
- Trial digs that can be used to expose underground services *in situ* to verify the location, configuration and to assess their condition.
- Data logging, which can be used to measure the parameters of a utility service over a period of time.

Having reduced the risks to a level as low as reasonably practicable using survey information, information should be provided to the construction team about the risks that remain. In any case, as there are health and safety issues, the construction teams should never entirely rely on record and survey information, but must expect to undertake their own due diligence to mitigate risks.

Due diligence

Along with the dominant public services providers there may be others owners of utility services infrastructure that may need to be considered. The best way of identifying the possibility of their presence is by visiting a site and looking for clues such as manholes, fuel or water storage tanks and other street furniture.

Electricity
As well as electrical service cables belong to the public utility suppliers there may other electrical cables and associated equipment belonging to other entities, for example: motorway and trunk road lighting, street lighting and supplies for other related equipment such as traffic lights, which are the responsibility of a local authority; electricity generating companies; National Grid; Ministry of Defence; railway operators (usually Network Rail) and Independent Distribution Network Operators.

Gas
Most underground gas pipes are operated by public gas transporters. However, newer building projects may be supplied by independent gas transporters and properties fed from bulk-stored LPG, where the pipes may be owned by the property owners or other private individuals.

Urban combined heat and power (CHP) schemes

CHP schemes generate electricity and the 'waste' heat is distributed by pipes (and associated equipment) to end-users to provide heating.

Chilled water distribution
In hot countries, there may be site-wide water distribution systems providing chilled water for air conditioning systems.

Providing quotations

On receipt of all the design information, including the location, utility services characteristics and expected timescales for development, utility service providers will undertake feasibility studies and produce a quotation for the works. The site should be accessible for utility services providers to visit to help them develop the quotes

This must be provided within a specific timeframe, which may be dependent on the size and nature of the request of the installation. These include an estimate of the costs, timescales and a description of the works. It should also clearly show which elements of work are 'contestable' and 'non-contestable', that is which elements can be carried out by independent parties. Contestable works may include some installation of cables, provision of substations and reinforcement of downstream network infrastructure.

Typically, quotations are initially sought during the design phase by building services engineers. However, their validity will usually expire and they will need to be updated with latest information by the construction team. Thereafter, the construction team enters into a formal contract with the relevant utility services providers.

The total costs for all works associated with the eventual provision of utility services should include estimates from the utility services providers and miscellaneous builders work provided by the construction team. This may include:

- Excavations and backfilling of trenches to lay in cables and pipes.
- In larger projects, there may be underground tunnels to accommodate utility services.
- Access points, for example manholes and draw pits.
- Plinths and other builders work to support and provide access to equipment.
- Openings in walls and floors to allow utility services to pass through.
- Provision of buildings (fitted with building services systems) or spaces to accommodate utility services providers' equipment, for example for electrical substations.

Carry out the work and arrange payment

Following acceptance of quotations, utility services providers schedule their work to be completed within set maximum timeframes. These timeframes vary depending on the size and complexity of the work. There will also be guaranteed minimum standards of service with respect to obtaining the particular service; for example with respect to the accuracy of their quotations, attendance times, including notices for inspections and works and so on.

When the works have been completed there will be legal formalities to transfer ownership, usually initially to the contractor, until they are ready to transfer to the client. Thereafter, final payments for the work need to be made after carrying out any necessary reconciliations.

Standards and quality of utility services in operation

Once their service is connected utility services providers usually have liabilities with respect to integrity and security of supply, fair and accurate billing, managing planned and unplanned outages of their services and dealing with emergency situations. They will also have to ensure the service, at the point of connection, is delivered within prerequisite parameters. Specific parameters for each utility service may include:

- Electricity – voltage, frequency, prospective short circuit current (I_{pscc}), external fault look impedance (Z_e): including tolerances.
- Gas – supply pressure, chemical constitution, gas quality and odours (to ensure that any gas that escapes into the atmosphere is readily detected).

- Water – continuity, quality and pressure. Pressure is particularly important for water mains, as firefighting equipment depends on achieving a particular pressure to operate.
- Telecommunications – broadband connectivity rating.

Utility services providers have a duty to act with reasonable care in the delivery of services. The nature of the services they provide necessitates a high degree of care in the assembly, upkeep, operation and inspection of equipment and apparatus so as to prevent injury. However, they are not necessarily negligent if they fail to anticipate events occurring under unusual circumstances, or those that cannot be reasonably foreseen.

Exploring human error through the safety talk of utilities distribution operatives (Patel *et al*., 2012)

Striking electrical infrastructure can kill and cause serious injury, necessitate physical repairs and lead to significant business costs. Despite dedicated equipment, robust methodologies for processes and training programmes, cable strikes still occur on a regular basis. Most are attributed to human error.

This research asked operatives to identify root cause. These are summarised in Figure 5.3.

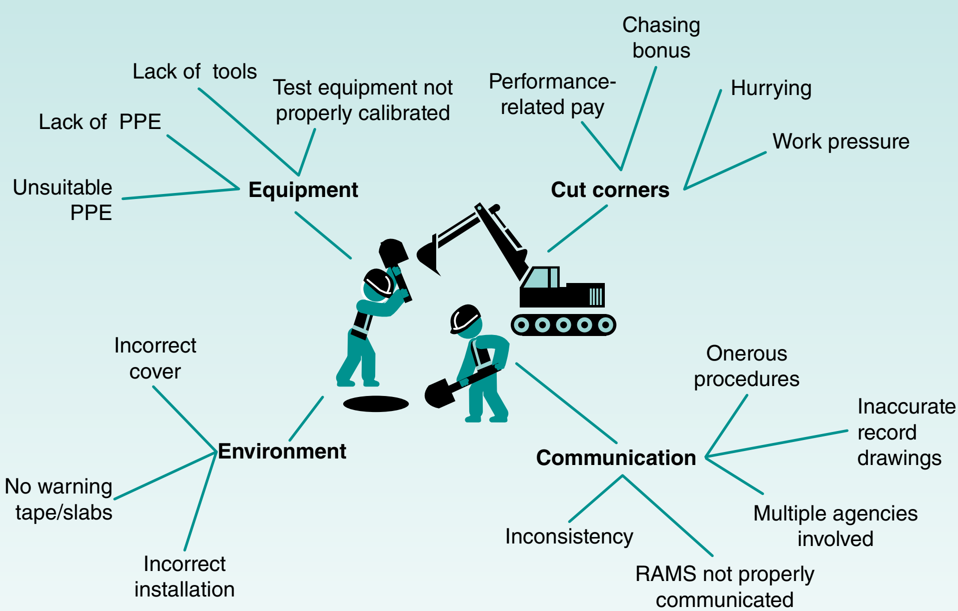


Figure 5.3 Causes of electrical cable strike

Utility services providers usually have industry regulators to help administer government legislation to ensure that they deliver services in line with predetermined standards, usually defined in their charter. They also deal with complaints relating to utility services providers within defined timescales. If found guilty the regulators are able to impose sanctions for non-compliances. This may comprise monetary compensation to affected clients and the requirement to rectify the error in a specified timeframe.

Summary

Without utility services buildings are unusable and it is important to ensure that their connections are not a source of delay. Public utility services providers are required to provide record information, provide quotations (including costs, planning and scope of works), undertake the work and maintain a minimum level of service after connection. They are required to discharge their liabilities and obligations in line with the requirements of their regulators.

Feedback question

1 For either electricity, gas, water or telecommunications systems investigate the level of service that the utility services providers are required to provide.

Reference

Patel, M., Sherratt, F. and Farrell, P. (2012) Exploring human error through the safety talk of utilities distribution operatives. In: *Proceedings of the 28th Annual ARCOM Conference* (ed. S.D. Smith), 3–5 September 2012, Edinburgh, UK. Association of Researchers in Construction Management, pp. 403–412.

6 Non-contractual stakeholders

There are potential interfaces with parties who have no contractual links to particular building projects. However, these parties have interests that building services engineering need to recognise, understand and manage.

6.1 Neighbours to a construction project

Occupants of neighbouring buildings can be affected by the construction works: for example:

- The characteristics of the electricity supply to the neighbouring building may be affected if the site electrical supplies are connected to the same electrical infrastructure. This may cause dips in the incoming voltage, which can affect the operation of electrical equipment. If there are large motors, such as those in cranes, connected this may cause trembling in the electrical supplies, which can cause flickering lights. Although the provision of site supplies is usually in the construction team's scope of works, it would be helpful for building services engineers to pass over any information and contacts they have with the incumbent electricity providers. The same approach applies to the other utility services suppliers.
- The drainage and other pipework in the road or footpath outside serving the neighbouring building may get damaged by site vehicles directly tracking over and from vibrations caused by site equipment. This may cause damage that affects their integrity and ability to properly serve the building.
- The construction process may introduce contaminants (airborne chemicals or compounds, dust, sand, smoke and other particles) into the air, which may affect the external environment close to the neighbouring building and infiltrate into the building. These can be

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harmful to occupants' health and affect the performance particularly of the ventilation and cooling systems where they rely upon pulling in external air. Building services engineers should consider buildability methodologies during design to mitigate the likelihood of impacting on air quality.

- As illustrated in Figure 6.1, there may be disruptions with respect to access to and egress from neighbouring buildings due to the public circulation routes (roads and walkways) being closed or altered. Building services engineers should understand how this affects the fire engineering for the neighbouring building; for example access for fire engines and access to fire hydrants. Also, if road closures are required for utility services work, consideration should be given during the design as to whether there are alternatives.

Utility services serving new building projects may pass through neighbouring sites or there may be existing utility services that require alterations to serve the new building. These may be above or below ground. Although wayleaves and easement agreements give public

Figure 6.1 The effects of construction sites on neighbours

utility services providers rights to access to their equipment to perform specified tasks, they still have a duty to inform and liaise with the neighbours to minimise the disruption and impact.

There may be situations where neighbours have a legitimate case in respect of a complaint about the effects of a construction site. To support such a claim it may have been beneficial for neighbouring building owners to have undertaken a pre-construction condition survey to record the state of their building and the immediate environment before work begins. This way, it will be clear to both parties if damage occurs from the construction.

6.2 The general public

Information on forthcoming building projects is theoretically visible to the general public throughout the design period, for example via local authority planning application web sites and may also be discussed in the media. However, often it is not until the first hoardings and signboards appear on site that the general public becomes aware of projects and lobby for changes.

The finished building may impact on matters such as external lighting, right to light, noise and vibration from building services equipment, or just the general appearance. Care is needed to ensure that any changes made during the construction phase do not impact on the design intent with respect to these.

6.3 Awards bodies

Awards bodies may reward parties for some aspect of the construction. This could be improving the image of construction or relate to something particularly relevant to building services engineering, for example inclusion of sustainability features or innovative construction methods. These may either be planned for as part of the design or simply awarded retrospectively.

6.4 Trade unions

Trade unions are entities that support and represent individual employees either based on their trade, for example electricians and plumbers, or based on their employer, for example, local government and the National

Health Service. There are also general unions that accept members independent of trade or employer. A trade union's particular aims depend on their charter but are likely to include:

- Advancing the interest of their members through campaigns.
- Monitoring and achieving the best working conditions for their members – this may include restrictions on what and how certain work can be done, for example working at heights and working with hazardous materials, which building services engineers should be aware of.
- Negotiating pay scales and benefits for their members.
- Supporting their members by attending grievance and disciplinary hearings.
- Providing their members with legal advice and financial advice.

6.5 Trade associations

Trade associations are entities that support and represent their members, which tend to be companies rather than individuals. Their particular aims depend on their charter but are likely to include:

- Advancing the interest of their members through campaigns.
- Working with the likes of government bodies and enforcing authorities to improve the quality of the built environment in their specialist areas. This may include collective responses to consultations and membership of special interest groups. This can lead to changes in design standards.
- Facilitating certification schemes aimed at standard setting and governance for the scope of works involved.

6.6 Special interest groups

Specialist interest groups are not-for-profit organisations with a particular mandate. Their focus may be to promote best practice and industry improvements, to influence government through lobbying or to generate and publish construction industry key performance indicators (KPIs).

Special interest groups may be created, on a less formal basis, on social media platforms in the form of 'members' hosting and posting forum-like questions and discussions relating either to specific building projects or aspects of construction-related matters.

6.7 Industry regulators

Industry regulators set standards and regulate behaviour on behalf of the party (for example government) to ensure the general public receives the required quality of service, that fair competition ensues and to impose sanctions for non-compliances.

Summary

There are stakeholders who are not within the direct control of clients, the design or construction teams. However, they have influence such that their actions can impact on the building services engineering design as it progress through construction. Building services engineers need to identify and manage their needs.

Feedback question

1 Discuss the role of social media and how it may support or detract from the construction phase of building projects. As well as the likes of Facebook, Twitter, instant messaging and other means of conveying news and opinions, consider the role of web sites such as blogs, online forums, YouTube and LinkedIn.

Part Two Processes

Part Two of this book focuses on the particular processes and procedures building services engineers may be involved with during construction and post-construction. Health and safety obligations and professional ethics are themes covered in each chapter.

Health and safety

Measurement of health and safety success or failure is mainly focused on the construction period, as most accidents occur during this stage, but there is an increasing recognition that awareness during the design stage is vital, as designers can positively influence construction site safety by integrating safety considerations into the design process. Thus, it is important that these decisions made upstream from the construction site are monitored through the examination of construction documentation and observation of the physical installation to ensure that they are not compromised during the construction phase; for example, designing access areas for high level equipment via permanent gantries (Figure P2.1).

Professional ethics

Professional ethics should be driven by personal ethics, where a balance of both the requirements of clients, contractors and the impact on the built environment should be maintained by building services engineers when making decisions. However, there can be a fundamental dichotomy where building services engineers may feel that their obligations to their client far overshadow their responsibility to others.

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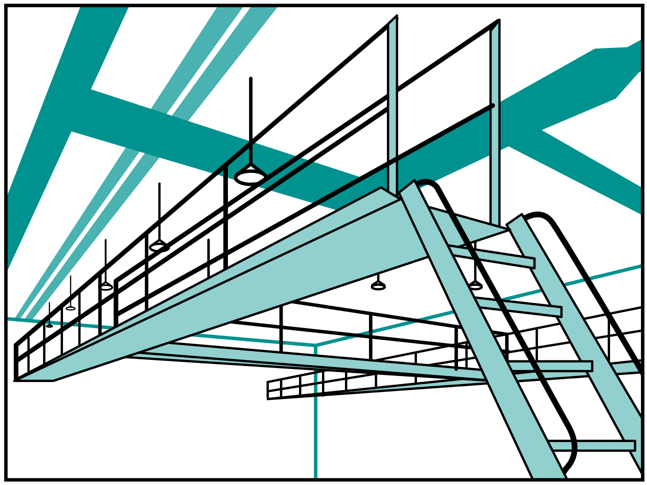

P2.1 Access to high level building services equipment

Unethical conducts during the construction phase may be manifested by poor tendering practices, not reporting issues in construction documentation or observed during installation or fraudulent actions; for example, artificially altering soil resistivity with an additive in order to achieve the necessary earth resistance reading.

7 Contract management

During construction, the building services engineering package is often the largest individual subcontract on building projects and is distinguished from other subcontract packages by the degree of specialist design required, extent of interfaces with other subcontractors and the need to commission active systems.

Contract management in the context of this book, focuses on the roles and responsibilities of building services engineers with respect to procuring and establishing the construction contracts, which includes the building services engineering subcontract(s), the subsequent administration of the contract, the interfaces with the construction teams cost and programme management responsibilities.

7.1 Contract procurement

Figure 7.1 illustrates common steps, along with the inputs from building services engineers, in connection with selecting a construction team. Depending on the procurement route and the nature of the project, there may be one or multiple construction contracts in place eventually. These may be for different phases of construction work; for example enabling, demolition, main works and various fit-outs all have their own construction contract, or a site may be split into geographical areas each with its own construction contract.

Announcement of tenders

There will be an expression of interest where clients ascertain an indication of interest from potential tenderers who are capable of undertaking specific work. This may be done by means of open tendering, selective tendering or negotiation.

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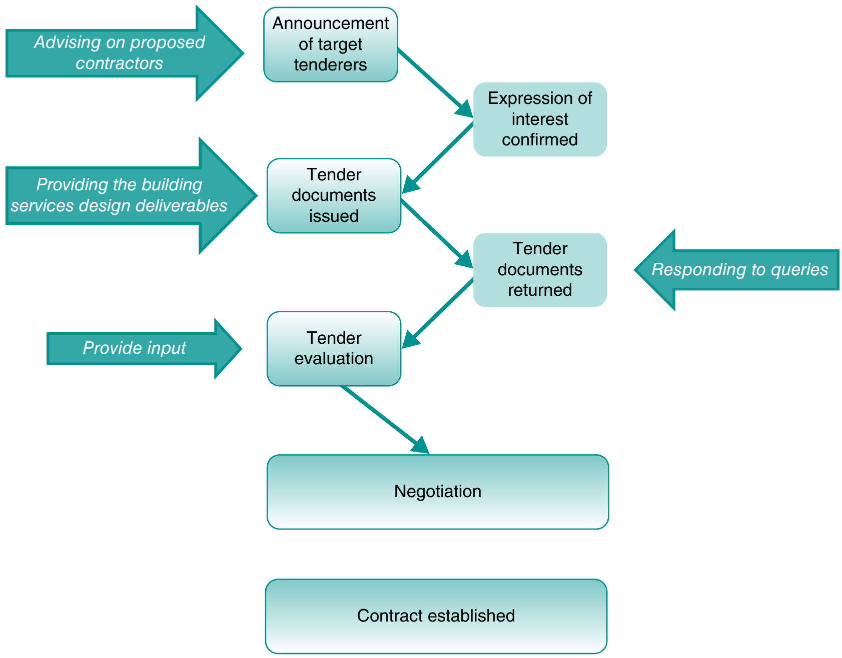

Figure 7.1 Input to the construction contract tender process

With open tendering clients advertise the prospective building projects. This allows any interested tenderers to apply for the tender documents and to decide whether they wish to submit a tender. Clients may request a deposit from applicants, the deposit being returned 'on receipt of a bona fide tender'.

With selective tendering clients advertise the prospective building projects and invite tenderers to apply to be placed on a shortlist of contractors. The successful shortlisted contractors will be invited to bid for the project. Tenderers applying are given a list of requirements (normally in respect of relevant experience, financial standing and resources) that they need to demonstrate in order to pre-qualify.

With negotiation, clients chose the tenderers. This may be from an established framework arrangement, by creating a shortlist of potential tenderers from the marketplace or by a direct invitation to a single entity to negotiate.

Advising on proposed contractors

Building services engineers may often be asked to propose a long or short list of potential contractors or subcontractors to be approached with respect to being considered for a particular project.

> When suggesting potential contractors it must be remembered that the performance of any entity can vary due to the key personnel involved, the terms of the contract and client team's performance. Also, just because a particular contractor performed well (or badly) on one project does not necessarily mean it will perform the same way on another project. The contractors have a different set of priorities on different projects. As such it may be prudent to caveat the 'advice' being given.

Tender documents issued

The tender documentation comprises all the documents that when combined describe the works. The tender documentation needs to provide sufficient definition of the project to enable the tenderers who are estimating/pricing the cost for the works to understand the project sufficiently. The level of detail produced will depend on whether the construction on site will be built strictly in accordance with the information produced by the design team or based on information developed further by the construction team.

The building services engineering contribution to the tender documentation includes the design deliverables produced by the end of the design phase. These generally comprise drawings, schedules and specifications (to cover materials and workmanship and description of the works). Whilst the design concepts and principles need to be of the highest quality they also need to be communicated effectively through the documentation. The quality of the design and tender documentation process is the ability to provide the tenderers with all the information needed to enable construction to be carried out as required, efficiently and without hindrance. There are a number of criteria that determine the level of quality including:

- Accuracy, in so far as being free of errors, conflicts and inconsistencies such that the correct materials and equipment are procured and installed as intended by the design team.
- Completeness, as incomplete information or information that has not been developed as part of an integrated holistic project design may lead to inaccurate assessment of the quantity and quality of work required.
- Coordination between design disciplines, including allowing for space flexibility and divisibility, and for ease of maintenance.
- Conformance in meeting the requirements all statutory regulations and relevant practices codes and guidance.

In addition to the building services engineers design deliverables, there is additional information that enables those tendering to assess the resources they will need to allocate to fulfil the project requirements. These depend on the form of contract and project, and may include:

- ***Bills of quantities.*** These itemise, to varying degrees of detail, the materials, equipment and resources required to complete the construction works. They may include contingencies to cover unforeseeable costs, for example due to site conditions found after award of contract and changes in legislation. The bill of quantities can be helpful in valuing variations and assists in the preparation of progress claims. These are usually prepared by the quantity surveyors for review by building services engineers.
- ***Identification of any phasing requirements.*** This defines phases if the project is to be broken down according to: (i) work categories – for example all works associated with the lighting system would be done first, then the fire detection and alarm system, followed by another system and so on – (ii) sectioning the project into distinct physical areas or (iii) partial completion, as typified by a shell-and-core contract followed by a fit-out contract. This can be complicated by items that appear in buildings intended for later phases but which are required for the operation of earlier phases, for example electrical switchgear and runs of pipework.
- ***Requirements for mock-ups, testing, samples or models.*** These may be physical or computer generated images. They may be necessary to satisfy performance or public relations requirements to allow clients to make final selections.
- ***Identification of long lead time equipment and systems.*** It may be necessary to make an early choice of manufacturer. Not doing so could cause sequencing conflicts or delay the completion and beneficial use of the project.
- ***Restricted suppliers list.*** It may be necessary to restrict the list of potential equipment and system suppliers. This may vary from nominating a specific supplier to including a named short list or being completely open. A short list may be based on clients' preferred suppliers or as recommended by building services engineers.
- ***Deleterious materials.*** A schedule of materials which are either dangerous to health or which are the cause of failures in buildings; increasingly, materials that are environmentally damaging are included, for example chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) are considered to be 'greenhouse' gases. Also, lead found in materials that might be ingested or absorbed, such as pipes and paint, would be included.

- ***Nominated or named subcontractor lists.*** Clients wish to impose their requirements on the selection of subcontractors.
- ***Factory acceptance tests.*** To confirm the requirements for the specification are met, particularly for custom fabricated goods, assembled goods or prefabricated systems; for example, bespoke luminaires, air handling units and electrical switchgear, and prefabricated bathroom pods.
- ***Status of agreements with enforcing authorities.*** This includes any sign-offs, approvals, and agreements for derogations which have been obtained and documented.

In addition, if the design work is not complete an Information Release Schedule (IRS) may form part of the tender documentation. This provides dates and details for the release of information from the building services engineers and other parties.

The tender documents may be made available in hard or soft copy formant, or else may make use of electronic tendering (eTendering) procedures. Typically this will use secure portals to conduct the entire tendering process electronically. Clients will require organisations to register an interest online, at which point they will be able to access all tender information.

The tender documentation may include invitations to site visits and a mid-tender meeting/presentation. The site visit may be a mandatory part of the tender process, so as to ensure that tenderers become generally familiar with the local conditions and compare them with the tender documents. If site visits are not mandatory tenderers are well advised to attend to familiarise themselves with the nuances of the site.

Tender documents may not be perfect. This may be due the design having been done from a variety of sources working on different time scales with time lags. This causes information problems: information is missing because it is either not produced or not distributed properly; information is not received at the time required; information is not coordinated and therefore difficult to read together with other documents – drawings/specifications; and conflicting information received from different sources. If tenderers have any specific questions these must be raised and responded to in writing. Responses will be in the form of a question and answer and distributed to all tenderers usually without revealing the identity of the entity raising the query.

If there are errors or omissions in the tender documents, supplementary information in the form of an addendum will be issued during the tender period. This may result in an extension of the bidding period or a redefinition of the scope of the project. Any revisions to the documents after they are sent out for bid could potentially mean more cost to the owner and/or design team.

Tenderer's duty of care

The rationale for tender clarifications of documents with clear errors and omissions is founded in fairness and common sense. If a tenderer is aware, or should be aware, of a mistake, contradiction or omission in the drawings and specifications, the tenderer should not be allowed to financially exploit the error. Under their duty of care tenderers must bring this to the attention of clients. If tenderers fail to do so, they should not automatically expect to benefit financially.

Difficulties arise, however, when it is a close call as to whether an ambiguity is blatant or subtle. It must also be remembered that tenderers have a relatively short time to review the tender documents compared with the time the design team had to develop them. Tenderers are not expected to be design experts, although they are expected to have design capability. After all, it was the client that commissioned the design.

Tender evaluation

There are varying degrees of formality with respect to the return, opening and recording of tender returns.

There may be strict instructions to return the tenders in sealed envelopes to a specific location or tender box. A tender box is a secure mailbox that is used to receive the physical tender or bid documents; it may be physically closed once the tender time has been reach. In the case of electronic tendering, tenderers may be required to complete and submit their tender submission online, again by a specified date and time – after which the portal will not accept the submission.

Double envelope tender return

The double envelope system separates the technical proposal (based on and intended to meet the statement of work) from the financing or cost proposal in the form of two separate and sealed envelopes.

During the tender evaluation, the technical proposal would be opened and evaluated first followed by the financing proposal.

The objective of this system is to ensure a fair evaluation of the proposal. The technical proposal would be evaluated purely on its technical merits and its ability to meet the requirements set out in the tender documentation without being unduly skewed by the financial proposal.

The tenders are usually opened by a team of two or more people. This may be in the presence of the tenderers or they may be excluded.

The information found on opening should be recorded. For a negotiated or framework tender, the return information may be less formally submitted.

Clients select contractors on the basis of the relative importance of tender evaluation criteria. The purpose of tender evaluations is to determine the lowest evaluated compliant tender determined by applying pre-determined evaluation criteria from amongst the substantially compliant tenders received. This may not necessarily be the lowest priced tender but the most economically advantageous. Too low a bid may lead to cost cutting in the construction process, primarily in materials and labour, which may lower the quality of the work.

Tenderers may be invited to attend an interview, submit samples and/or provide a demonstration or a presentation as part of the evaluation process.

In the first instance, the tender returns should be assessed for compliance with the conditions of the invitation to tender. Often it is easier to insist that only fully compliant tenders will be reviewed. An alternative tender is one that is presented alongside a conforming tender but still complies. A non-conforming tender is a tender that is not priced by reference to the conditions of the invitation to tender.

Building services engineers undertaking a tender evaluation need to understand their scope with respect to the tender evaluation. Sometimes, a purely technical evaluation is required as such costs and other criteria need to be considered.

Building services engineers need to ensure the process they follow with the evaluation leaves them in a defendable positon that is able to withstand internal and external auditing; this achieves both accountability and transparency and provides each and every tenderer with fair and equitable treatment. They should be clear on what criteria they are using for the evaluation and what is included and excluded, and be careful not to allow 'bid shopping' to occur. This is the practice of disclosing information in a tenderer's bid to other prospective tenderers or before the award of a contract in order to secure a lower bid.

Firstly, as part of checking for a compliant tender it is prudent to check whether there are gaps in the tender return. Whilst the tenderers are responsible for including everything to comply, under their duty of care building services engineers must check that there are no potential gaps in the scopes of works. There may be no definitive 'right' answer as to which party should take the responsibility for an element of works but there should be no gaps. There are several particular areas to check.

Building management systems

Building controls systems involve controlling and monitoring mechanical, electrical, utility services and other equipment. Monitoring and controlling devices associated with this equipment are connected by cables and the associated cable containment system, either directly or via a series of intermediary points, back to monitoring and control units.

Some of the equipment, for example water pumps, will be under the responsibility of mechanical subcontractors but others, for example lighting control systems, generator systems and uninterruptable power supplies (UPSs), may be under the electrical subcontractor, whilst others, for example lifts, vehicle barriers and utility services, may be under other subcontractors. It is sensible to check that the requirements for all sensors, meters, cabling and other devices will be provided by a party; for example, a pressure gauge in the domestic water system could be supplied by either the plumbing or mechanical subcontractor.

Mechanical control centre panels

Mechanical control centre panels are a form of electrical switchgear that may also accommodate motor starters and drives required for the mechanical plant. Therefore, either the electrical or mechanical subcontractor could provide them – or assume that the other has included for.

Builders' work risers and secondary steelwork for building services equipment

Builders work risers are not necessarily just about the provision of clear open voids. They may include cast-in fixings for pipes, ductwork and cable containment. There is potential for mechanical and electrical subcontractors to assume that these will be provided 'by others'.

Building services engineering subcontractors may assume others will provide for secondary steelwork required to support building services engineering equipment.

Fire stopping

Fire stopping is required at the boundaries between fire compartments to ensure that the integrity of lines of fire compartmentation is not compromised. There will be a requirement for electrical containment and ductwork to be included in the fire stopping as the services passes through compartments. This could potentially be provided by the mechanical or electrical subcontractor or by a fire stopping specialist.

Electrical accessories in furniture

Electrical accessories (small power, data and telephone outlets, including the associated cables and cableways) may be fitted into furniture for the convenience of end-users to plug-in and position their portable devices for use and to alleviate potentially dangerous trailing cables. These may be included by the electrical subcontractor or furniture subcontractor.

Internal and external drainage systems

The internal drainage systems connect with the outside drainage systems at some point to form a continuous system. The demarcation point could, for example, be the boundary of the building, or 1m… 2m….3m… from the building boundary, the first manhole or the site boundary. Whatever, the demarcation point needs to be agreed to avoid potential gaps or overlaps.

Once it has been established that the complete works has been priced, that is there are no gaps, tender evaluations can focus on compliance with aspects such as selection of materials and equipment and on criteria that demonstrate competence, such as availability of required key personnel and construction and design methodologies. Furthermore, past project performance, company standing (reputation), financial basis as well as tender price elements are normally taken into account in the evaluation.

Materials and equipment

The tender documents may, at one extreme, specify materials or equipment by their brand names with parts numbers, or at the other extreme by means of their output performance characteristics; for example, luminaires have to achieve certain lux level, motors have to deliver certain power requirements. They may or may not be followed a phrase such as 'or approved equal' or 'equal and approved'. These terms need to be understood in this context. It can simply mean that any proposed alternatives must be equivalent to those specified, but who decides what is equivalent and who has the authority to approve if an alternative is accepted needs to be clear and agreed at tender stage.

Building services engineers may be reluctant to consider substitutions during the tendering process, as it enables contractors more opportunity for last-minute substitutions, requiring hurried consideration during the evaluation period.

A further situation may occur when building services engineer's specifications are such that the product described is no longer commercially available. This constitutes a deficiency in the specification. Building services engineers may have to consider alternatives to that specified.

Key personnel

The tender may include information (often in the form of CVs) of the proposed key personnel who will be responsible for discharging the responsibilities of the contract, for example the building services design manager and building services contracts manager. Some tender documents call for very precise requirements in terms of qualifications, expertise and technical background, others do not. Checking their current workload is significant to ensure that they will be available for the project being tendered.

Construction and design methodology

This describes the proposed method of delivery and any technical solutions. The tenderer should provide information on how the building services engineering subcontract(s) are arranged. This should demonstrate the technical ability of the tenderer to deliver, to provide the confidence that it knows exactly how you propose to deliver and has thought the process through carefully. This should include information on health and safety practices, policies and incident rates, and management safety accountability. It may include information on approaches to sustainability.

Past project performance and reputation

Inclusion of appropriate past projects can be relevant if they demonstrate a particular experience in similar projects to that being tendered. However, a list of past project only provides an inventory of experience for a particular classification of work but does not quantify the quality of the work. It may be prudent to obtain references directly from clients.

Reputation may be assessed by reported past failures or successes. However, the media has the potential to influence public opinion through its portrayal of the 'facts' and mass media plays a crucial role in forming and reflecting public opinion. There may be journalistic articles alleging the failings of a contractor. Whether these projects can be classified as failures, or not, is a complex issue and may include factors such as stakeholder expectations, client performance issues, funding streams and financial models, the long-term impact of the project (on people, the economy and the environment) and the impact of external factors (political, economic, social, technological, legal and environmental (PESTLE)) outside the control of the project. These problems are seen as either construction related (projects being completed late, over budget or of a lesser quality than anticipated) or operational. Operational problems arise when those who use/occupy the building are not experts in managing it but, nonetheless, have knowledge and opinions about its performance in relation to their own objectives

Financial basis

This considers the past, present and future ability to complete the particular project. It may include a review of financial stability, credit rating, banking arrangements and bonding.

Negotiation

Negotiation should not be confused with mid-tender interviews and clarifications. If during the tender evaluation process it is found that none of the tenders is acceptable, for example due to the level of non-conformance or because their costs are woefully different from the cost estimates, negotiations may be conducted with the strongest tenderer(s) that submitted the nearest tender to the evaluation criteria with the aim of achieving a mutually acceptable tender. However, care should be taken not to overly 'squeeze' tenderers such that this leads to specification adjustments perhaps dictated more by financial pressures than by good engineering practice. Value for money may not always be achieved by forcing down tender prices.

Establishing the construction contract

The construction contract is a binding agreement between clients and contractors to construct the building project. The contract conditions define the legal rights and obligations, or the rules by which each party must comply. With respect to buildings services engineering information, this includes the tender information, generally updated with any information included within the tender process. The contract may include for the novation or assignment of building services engineers who have been working on a project for a client up to the tender stage.

The contract documentation provides a last opportunity to incorporate all the requirements, and thus needs to be accurate. The potential for and severity of professional liability for errors and omissions are often tied to when they are discovered. An error discovered during the tender phase can be corrected with an addendum to the contract documents as clients have not yet entered into a contractual relationship with the contractor; corrections to errors at this point typically involve limited costs to the project or the building services engineers. However, errors and omissions discovered post-contract award may necessitate the need for re-design of the affected areas and the revised information reissued, which may be more costly.

The project risk register – is it a confidential document?

Contract documents do not necessarily include risk registers, as some parties consider that it contains information that should not be passed to tenderers or contractors. For example, they may contain financial information, such as the solvency of a subcontractor, degree of uncertainty to be expected in funding and the client's financial limit on a particular risk.

A compromise could be to withhold the potentially sensitive elements and issue a sanitised version.

7.2 Contract administration

Contract execution involves ensuring compliance with the contract and putting procedures in place to allow for any deviations, whether they are additions, omissions or alterations. Contract execution also includes reporting, responding to queries and issuing certificates.

Clients will want to ensure construction conforms to the contract documents and supports the design intent. Clients may appoint contract administrators to act on their behalf for the purpose of administering the construction team's contract(s). The rationale being that costs can pay for themselves in identifying and resolving construction problems early, risk reduction and in savings on time, materials and changes during the construction process.

The responsibility for contract administration is usually delegated to an agent, who has the authority to act for the clients in dealing with contractors. Contract administrators are required to act with probity (integrity and honesty) and fairness in their actions and decisions. The contract administrator may already be appointed as part of the design team; for example the architect, quantity surveyor or building services engineer, or may be an independent party, such as a project management organisation. This is in addition to a clerk of works, who acts as the clients 'eyes and ears' on site in order to make decisions on behalf of the client, to monitor progress, level of resources being deployed and to ensure the required levels of workmanship are achieved.

Managing client changes

Contract administrators should ensure that client changes to aspects of projects are referred for review to the right person at the right time and that changes are properly documented and reflected in all project information. This involves:

- Seeking instructions from the client.
- Determining the impact of the change. This may require input from the design and construction teams.
- Preparing information for client evaluation.
- On receipt of a client's decision instructing the design and construction teams accordingly.
- Monitoring and managing the change.

Reporting to clients

Contract administrators will prepare reports relating to construction progress, costs and quality matters for clients.

With respect to costs, contract administrators will also coordinate with clients and contractors commercial staff to ensure proper invoicing, collection and distribution monies as per the contract.

With respect to quality matters, contractors are responsible for their own quality management systems on site. The contract administration may undertake audits to ensure that all contractual requirements regarding the quality management system are in place and being properly followed. This may involve making sure that the approved documentation (project quality plan, method statements, inspection and test plan, procedures etc.) is being followed on site.

Responding to queries

Ideally, all queries regarding any errors, deficiencies, ambiguities, contradictions or being unduly restrictive should be addressed prior to establishing a contract. In reality the contract documentation may be imperfect, thus requiring clarifications to be provided by the design team. For example there may be:

- Omissions, such as lack of dimensions, lack of elevations, missing sections and details committee;
- Errors requiring clarification about the information provided, such as wrong dimensions and wiring elevations.
- Hidden or unexpected site conditions, where the actual site conditions differ from the information provided in the contract documents, requiring changes to the design.
- Inconsistencies, such as different pipe locations on structural and building services engineering drawings.
- Changes requested by the contractor associated with buildability/ constructability issues.
- 'Just to confirm', if information provided or previously discussed is correct.

A formal process is generally used to officially acquire the information clarifications needed to allow construction to continue. The name will depend on the particular contract, but terms such as Request for Information (RFI) and Technical Query (TQ) are often used. These are usually passed through the contract administration to expedite. It may be that the responses to the queries justify a change or variation in the contract.

Is it for me to answer ?

With any request for information from the construction team, building services engineers need to first reflect as to whether they are contractually in a position to respond. Building services engineers will have to deal with requests from the construction team to deviate from the documentation included in the contract award. This may be for changing a piece of equipment, system, material type, method of installation, testing criteria or using of a particular supplier. Possible reasons that may be cited include:

- To meet programme requirements for delivery or installation times.
- To save money, either capital cost or running costs.
- The originally specified item is no longer available.
- Because the construction team believes that it can provide a 'better' alternative.

The onus is on the construction team to justify the reasons for the change.

Building services engineer need to evaluate the technical elements of the proposals to ensure there are no technical compromises but should also refer the matter to the contract administrator to determine if there are impacts to programme and costs.

To ensure progress is not disrupted, it is essential that the information required is supplied to the contractor efficiently and without delay. Any delay in responding to an RFI can result in the contractor's delay, consequently resulting in a delay in the project as a whole.

Issuing certificates

The types of certificate issued will be dependent on the particular contract. However, there are broadly four categories of certificate:

- Payment certificates, including interim certificates, which provide a means to make payments to the contractors as works are in progress.
- Time certificates are associated with a failure to complete the works as described in the contract documents (including any agreed extensions of time). A certificate of non-completion gives formal written notice to the contractor that it has failed to complete the works.
- Quality certificates relate to how the installation compares with the requirements of the contract documents. For example, a practical completion certificate issued when the works compared with the contract documents are substantially complete, or a certificate of making good defects.
- Final certificates, which recognise that all works in the contract documents have been fully finished.

When certifying or giving an assessment or decision, contract administrators have to act honestly and reasonably and their decisions are open to challenge via the dispute resolution procedure unless the contract makes their decisions final and conclusive. They will act on advice from the likes of building services engineers.

7.3 Cost management

A contract sum will be established as part of the contract documentation. Thereafter, contractors are responsible for controlling the construction costs during the construction phase. This will lessen the risk of overspending and prompt corrective action can be taken if necessary.

Construction costs need to be value managed and controlled to optimise delivery of the project without compromising quality of design, reliability, performance or goals.

Building services engineering works are usually the largest single package of works on building projects by value, typically from 25% to over 50% and more than the combined value of the next two largest packages (typically, the cladding and structural frame). With respect to the costs for building elements, for example foundations, walls, ceilings and furniture, these can be accurately estimated using quantity rates (per square metre, per length or per unit) of historical data and adjusting indices for complexity, size and prevailing economic conditions. However, this does not work as well for building services engineering systems, as cost relationships may not be linear with quantity.

Building services engineering equipment may be custom fabricated goods, assembled goods or prefabricated systems for which there is a wide range of design parameters involved. Consider the cost of a range of generator sets from different manufacturers. They may superficially do the same thing, for example have a power output of 1 MVA, but have slightly different noise characteristics, running costs, reliability, life expectancy and provision of spares, which may not get documented sufficiently to be costed accurately. There are further issues with central equipment, distribution systems, final outlets and building management systems.

Central equipment

Some building services engineering systems consist of central equipment, for example a central boiler supplying domestic hot water, a central chiller supplying chiller water or a high voltage switchboard distributing power, all prior to distribution to the final terminals. The relationship between the number of final terminals and the size (and hence cost) of the central equipment is stepped rather than linear.

Another factor, relevant to boilers might be that a conventional boiler is 75% efficient whilst a condensing boiler is 90% efficient but disproportionately more expensive – which is justified by off-setting against the long-term running costs.

Distribution equipment

Distribution systems include pipework, ductwork and electrical reticulation, comprising cables and their containment (to distribute the electrical power and signals). Costs need to take into account the complexity of the routes as well as the actual length.

Also, distribution costs for building services engineering systems are not necessarily proportional to floor area, because the whole system would have to be re-assessed if the area was increased significantly – higher capacity plant and larger pipes or ducts may be required to accommodate the increased flow.

Final outlets

The final outlets provide the interface with the building services engineering system and the buildings occupants. Their costs depend on the aesthetics, materials used and form of the space they are serving.

There are wide range choices, as illustrated in Figure 7.2 for wall mounted radiators. Hence, the cost of radiators is not proportional to floor area or number of units. This is a similar scenario to the situation with respect to luminaires, taps, socket outlets, grilles and diffusers. Also with respect to radiators, the number required is not necessarily related to the floor area but more to do with the number of windows and their orientation.

Building services controls

Building services control systems are used to modify the way the building services engineering systems run. These systems comprise controllers, wiring and may include data acquisition devices and controllers and the means to calculate, display, report and archive the information. The hardware is supported by software. The software may be able to assess the current and historical performance of a building/facility as a whole, and its significant energy consuming systems and components. The software may be connected to a graphic interface, which allows the user to navigate and interrogate the system using a web browser.

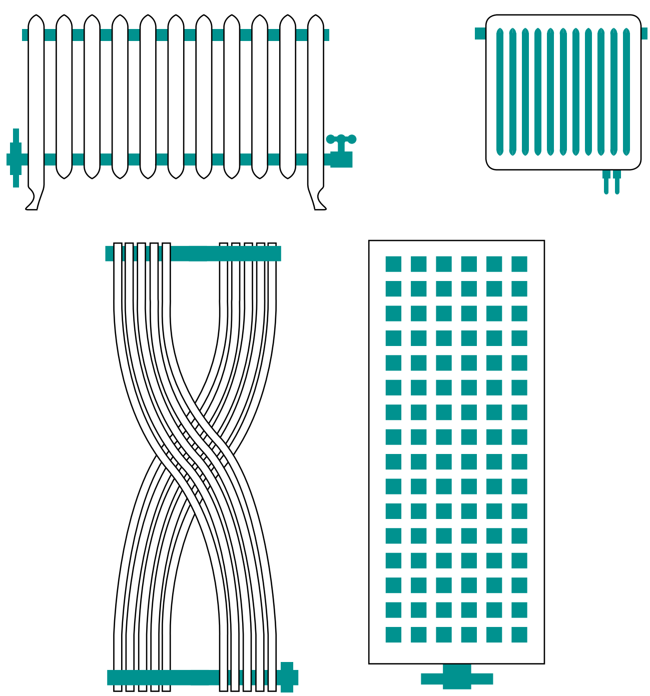

Figure 7.2 Options for radiators

Through this interface, they can view analysis, graphics, trends and reports and perform functions such as updating lighting schedules and managing alarms.

The configuration of the final design depends on the function, form and orientation of the building as well as the performance required from the systems and the quality of the terminal outlets.

So, although the costs are related to the number of devices, there are so many other factors to consider. Furthermore, there will be costs associated with commissioning that are again dependent on complexity rather than numbers of devices.

Bills of quantities

Bills of quantities are schedules typically prepared based on the tender information. They can be very detailed, for example itemising the precise specification and details of the equipment required, as illustrated in Table 7.1.

Alternatively, they may be more at the system level, as illustrated in Table 7.2.

The advantages of bills of quantities with respect to building services engineering are seen as:

- Based on the ‘if you can measure it you can build it’ attitude, the process of taking off the quantities acts as a good check on the quality of the tender documents.
- They provide information for detailed cost analysis, which benefits cost forecasting and cost control.

Table 7.1 Example of a detailed line item in a bill of quantity

	Unit	Quantity	Unit price	Amount
Supply, install, testing and commissioning of, 16 mm PEX pipes in 25 mm sleeve pipe. The rate to include; copper elbows (type GIACOMINI), 1/2" male and female adaptors and all accessories for connection between copper collectors to fixtures as per drawings, specifications and related codes.				
a Ø1/2- "	Length (m)	4.5		
b- Ø3/4"	Length (m)	3.5		

Table 7.2 Example of a high level line item in a bill of quantity

	Unit	Quantity	Unit Price	Amount
Supply, installation, connecting, testing, and commissioning of complete domestic hot water system c/w storage units, pipework, valves as per consultants specifications	No.	1		

The disadvantages are seen as:

- There is an additional cost to clients for the production of bills of quantities.
- There may be a time delay to measure the final design accurately. In line with good practice, building services engineers are more likely to be involved with projects early; however, this does not necessarily mean that they delivered completed information at the same time as the rest of the design team. Although collaboration suggests that all parties are equal in terms of inputting to the design process, in reality building services engineers' information needs to follow the form of the building and structure more than the other way around. Hence, the architectural design is usually substantially complete before the start of structural design, which is normally at an advanced stage before building services engineers begin their design. Therefore, it follows that the building services engineering information will be issued last.

However, bills of quantities are not used as much with building services engineering systems as for the main building works. If used, bills of quantities may contain provisional sums or prime cost sums for the building services engineering elements.

Valuations

Contractors usually wish to secure the maximum payment for the work done at the earliest possible time to avoid any possible cash flow problems. This will include interim and final applications for payment works as set out in the contract documentation, and variation orders if drawings or site instructions vary the work.

As part of the processing of applications for payment, building services engineers may be asked to confirm that the work has progressed to a certain state of completeness. Despite contract language to the contrary, this certification is often interpreted to mean that the work covered by the application is in conformance with the contract documents.

7.4 Programme management

Contractors are responsible for the planning and programming of the works on site to ensure activities are completed to achieve project objectives. This involves defining the tasks, estimating the required resources and the duration of individual tasks, and identifying the interactions among the different tasks and plotting their execution against predetermined milestones (either cost or time). This is used to monitor and control the progress of the project. Programmes may also be used to help build claims against clients. The term programme management is used interchangeably with 'planning' but really planning should be considered to be strategic whereas programming is the organisation of events by which strategy will be implemented.

The overall programme will consider the works on and off site, which includes subcontracted activities, material deliveries and relevant activities in order to deliver the project. Particular features of programming building services engineering work are:

- The programming of building services engineering site works needs to ensure that the building services engineering subcontractors are given clear possession of large working areas. In practice, it is often more efficient to delay bringing building services engineering contractors on site until unobstructed access can be provided. Delaying the start date for the building services engineering installation will not affect the overall project duration as long as unobstructed access to working areas can be provided.
- Building services engineering plant and equipment and components are combined to form systems that are threaded through, fixed to, connected to and support by the structure and fabric of the other work. Hence, it needs to be in place and, if necessary, tested before the building services engineering installation can start.
- There are specific items of builders work that may need to be in place, for example:
  - bases for boilers, pumps, electrical switchgear;
  - holes (and chases) in walls, floors and ceilings;
  - fixings, which may be built in, drilled, welded or clamped;
  - secondary steelwork for supports, access (ladders and stairs) and protection (guardrails and stepping-over points).
- Approvals of mock-ups and samples may be required before materials and equipment can be ordered.

As well showing the time for each phase of works or services, programmes should also show the time allowed in the programme for release of residual design information from the design team.

Summary

Contract management is concerned with procuring and establishing the construction contracts, the subsequent administration of the contract and the interfaces with the construction teams' cost and programme management responsibilities.

Contract procurement involves going through a process that results in a construction contract being established. This provides the basis for contract administration, which is concerned with managing the contract for compliance and managing the relationships between the parties involved during the construction phase. This involves dealing with clients' instructions, reporting, managing cost, progress (programme) and quality management issues, responding to queries and issuing certificates. Ideally, construction documentation is complete, accurate and explicit. Unfortunately, in reality it is often incomplete, conflicting or erroneous, thus requiring amendments and clarifications to be provided. In these situations it is essential that the correct information is provided to contractors in good time. The 'Request For Information' (RFI) process, where contractors and subcontractors formally obtain clarification of information regarding the contract documents supplied, provides a mechanism for doing this.

Accurate cost estimating of the cost of building services engineering systems relates to the form and function of the building, and the quality required by clients. Programme management needs to recognise the idiosyncrasies of building series engineering installations.

Feedback question

1 Building services engineers may caveat the design deliverables included in the tender and contract documentation to the effect that the site team cannot fully rely upon it. Discuss whether they are able to limit their liability in this way if the information has been developed in a building information modelling model, given that a building information modelling model is supposed to accurately represents (and even behaves) like a real building

8 Post-contract design changes

The need to make changes to the original design is a matter of practical reality. This may be due to the need to discharge residual design responsibilities, new design requirements arising or rectifying errors in the base design.

Where the contract contains a variations clause, clients have the right to issue instructions that contractors are obliged act upon. These amendments to the scope of works, before practical completion as described in the contract documentation, are referred to as a variations or variation orders. They may be:

- Varied or additional work, including additions, omissions, substitutions and alterations to the design, quantities, quality.
- Changes to administrative arrangements, for example using building information modelling (BIM) or distribution of drawings.
- Alteration, addition or omission of any restriction imposed in the contract; for example access to the works, limitation of working space and hours and the execution of work in any order.

Variations cannot change the fundamental nature of the scope of works. Occasionally, clients might use the variation process for an unrelated variation; in this case contractors must be in agreement – or else they are entitled to refuse. Variations cannot be used to omit work from one contractor in favour of another or if work was the subject of a prime cost sum (work that was nominated by clients).

The exception to the requirement that a contractor must undertake variations is if a contract is awarded with all the work to be carried out for a lump sum and there is no provision for variations. In this case the contractor is under no obligation to carry out variations to the works as instructed by clients. If the contractor wishes to accept the instruction, it is not obliged to keep the same prices and terms as the original contract.

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Any changes to the design during construction raise the question of design responsibility. No literature has been able to unequivocally define design, hence defining design responsibility is not straightforward.

Variations and programme

It is not usually ideal for the *ad hoc* release of design information to drive the construction sequence. This could lead to scenarios such as completed buildings with utility services supplies not being available for the foreseeable future or utility services provisions to buildings being woefully undersized, such that water tankers, diesel generators and gas bottles have to be located outside to support the buildings. Also, ceilings may be completed, but the building services engineering systems within them are not installed, meaning that at some point the ceilings will have to be demounted to provide access for installation – then put back in place. Similarly, plant equipment cannot be put into place, as any opening in the building fabric has been closed up.

8.1 Discharging residual design responsibilities

The need to discharge residual design responsivities may arise due to the nature of the particular procurement arrangement or because new information becomes available that may necessitate reworking of the design deliverables

In the case of separated procurement arrangement, such as traditional design-bid-build projects with a single lead design organisation and clear delegations of design responsibilities, building services engineers design responsibility contractually ceases when the design has been delivered. Although building services engineers may have delivered their completed work they still have a duty of care.

Other procurement routes are such that the design is intentionally only partially developed at the point of appointing a construction team and is intended to be completed during the construction phase. For example, in the case of integrated procurement arrangements such as design and build it may be that a certain amount of design work has been undertaken prior to the appointment of a design and build contractor, leaving the need for the design work to be completed. This may either be done by the original design building services engineering organisation, novated to the construction team. Alternatively, a new building services engineering entity is appointed, albeit there will be issues with copyright that needs to be addressed.

Residual design information is the information required that was not available when the tender documentation was issued or the construction contract executed. This may be due to:

- Final information from specialists, as they were either not appointed until the construction phase, still updating information or bringing in new technologies, for example catering, spa, water features.
- Coordination with specialist subcontractors – finally selected plant, equipment and materials may differ from that originally specified.
- In the case of refurbishment or extension projects, including upgrades, major repair works, renovations, alternations, conversions, extensions and modernisation of existing buildings, information pertaining to the base building may affect the accuracy, and certainty of the design information may not be available until the construction has started on site. As such, designers may need to revisit and modify the design as more information becomes available during the construction phase.
- Some elements of the final design are dependent on the idiosyncrasies of the final building and fixtures and fittings and occupancies; for example wireless routers are not easy to model as signal propagation depends on all materials in their path, including loose equipment and people.
- There may be, for whatever reason, changes made on site that will vary what has been allowed for in the design drawings and specification's but has a knock-on effect to the building services engineering design; for example:
  - there are obstructions which mean that cable/duct/pipe route lengths and twists and turns different;
  - changes in finishes – with material or colour-wise that will alter the reflectances;
  - the integration of equipment into the ceiling plan;
  - changes in floor/wall specifications – affecting the cooling and heating loads;
  - ventilation design (especially natural) assumes a certain quality of outside air – but this may change;
  - abundance of natural daylight changes due to new buildings
  - lighting designs – the selection and layouts of luminaires are produced as the result of precision calculations, based upon precisely positioned luminaires in a fixed relationship to each other and to the area under examination. In practice, the values may vary due to tolerances on luminaires, luminaire positioning, reflection properties and electrical supply.

These knock-on changes that the construction team makes are a frequent source of dispute.

An information release schedule (IRS) that gives dates for the release of information from the building services engineers may be prepared and included in the tender documentation.

8.2 Addressing new design requirements

During the construction phase new design requirements may arise, either in the form of changes or extra work, which constitutes work outside the scope of the contract ordered or directed by clients. In turn, this necessitates a change to the design information.

Client changes

New clients' requirements may arise due to changes in their business needs, a response to external divers over which they have no control or simply a change of heart. These may be manifested as a change in the project scope (programme requirements, size, complexity, quality), scope of services (including design and management), timeframe, schedule, programme, sequence of work or project budget for construction cost.

Excessive change orders threaten the timely and cost-effective completion of a project and can lead to expensive and protracted litigation.

Beware of scope creep

At the start of building projects there is a keenness to not only proceed with the works but to also to maintain good working relationships (Figure 8.1). Hence, it is not uncommon for contractors take on works that are not explicitly in the contract documentation, all done in good faith with the expectation that these issues will be 'rewarded' in terms of good will. Scope creep is the drift of the actual works from the original scope of works.

Scope creep can derive from a scope of work that is not defined well, with imprecise requirements for deliverables with ambiguous contract language (terms such as 'standard' and 'reasonably' do not help) and incomplete design documents. Furthermore, as the client team is not a unitary body, so is without a strong single point of contact, there is opportunity for different members to flex their 'I am the client' wings as the project progresses.

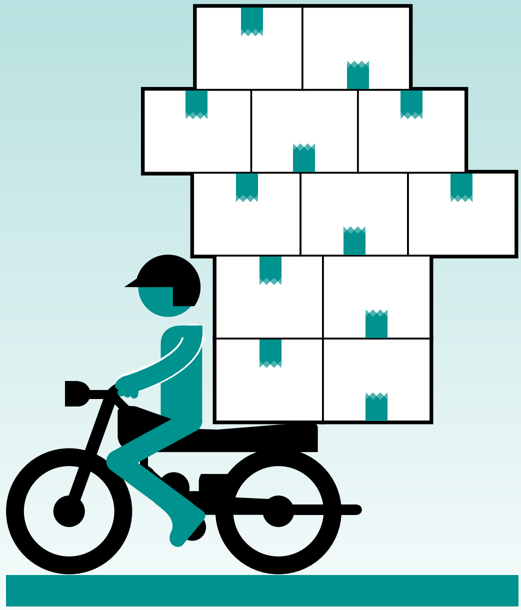

Figure 8.1 Scope creep

Changes in legislation

There may be changes in legislation. These changes will include a timeline for the progress of the legislation, including consultations to implementation, and also the date when it will come into effect. There will usually be a time by which all new construction has to comply. It may be that the timescales for a particular project, exuberated if there are delays, may not comply with the legislation. Usually there will be transitional arrangements; it is rare that legislation, unless it pertains to health and safety matters, is issued and requires retrospective action that results in changes in the design.

Building Regulations, Part L (HM Government, 2010) Transitional arrangements

Part L of the Building Regulations is concerned with conservation of fuel and power and is periodically updated with new targets and methodologies for demonstrating compliance. The 2013 version replaced the 2010 version and the following transitional arrangements were put in place:

Part L 2010 – comprising Approved Documents L1A, L1B, L2A and L2B – applied in England until 6th April 2014. From that date, the new regulations came into force. However, if a Building Regulation application was made prior to the new regulations taking effect, Part L 2010 still applied – providing that work on site commences within 12 months. 'Starting work' typically means digging foundations or laying drains, and only one plot on a site needs to start in order for all plots to be built to Part L 2010.

This results in a lag, where new properties need only conform to a previous set of regulations some 12–18 months after the regulations were changed! And by that point, consultation is likely to have started on the next revision to the regulations.

Changes in reference information

Reference information is information produced by third parties and comprises material which may be referred to for data and facts, either for guidance or as a statutory requirement to be inputted to the design; for example,

- 'Standards' for plantrooms produced by utility services providers.
- Historical weather data.
- Maps.

These may be updated during construction and require redesign work.

New information on site conditions

A design would have been based on the best information available at the time. When projects start on site, 'new' information may arise that requires reconsideration of the design information. It may also lead to conflicts, delays and disruptions. However, it is only when the construction team has possession of the site that the final information will arrive. This may either directly affect the building services design, for example the actual soil resistivity is needed to design the both the lightning protection system and the earthing system, or indirectly, for example foundations being redesigned due to cavities.

Differing site conditions are frequent sources of disputes between clients and contractors. Many contractors proceed with work under changed conditions with the misconception that conditions at the site, which they neither expected nor included in their bids, automatically constitute extras and should be addressed as such. Unfortunately, this assumption can lead to costly disputes between the parties of a construction project.

Emergence of new technologies

Clients may wish to embrace new technologies or innovations, especially if they have an early adopter mindset.

This also applies to building services systems that are supported by software. It is prudent to consider whether it is beneficial to have the latest software release – which may be different to that specified in the contract documents.

Changes due to value engineering

Building services engineers should have the mentality to make value engineering judgments as part of the design development process. However, due to the fragmented nature and complex interactions characteristic of the design process, value may get lost. Hence, it may be prudent to include a dedicated value engineering process at the outset of the construction phase. The resulting decisions from the process may result in changes to the original design.

8.3 Rectifying errors in the original design

Preparing a successful design calls for a unique combination of scientific and technical expertise, and accomplishing it in a perfect manner is difficult, if not impossible. Any discrepancies or shortcomings at the design stage left unchallenged/unaddressed may be magnified at the construction phase. Even using the very best designers and implementing seemingly the most robust review and checking processes will not guarantee that there may not be shortcomings in the original design that do not become apparent until the construction phase and even after handover.

The liability for such claims resulting from design deficiencies is generally aimed against the designer, on the basis that it failed to satisfy its contractual obligation to provide a design that met the expectations and requirements of the owner. There will need to be an evaluation to determine who is responsible for paying for the change and considerations on pricing and apportioning the costs associated with design defects.

Summary

After the construction contract has been established it is likely that there will still be further deign activities or variations to the contractual requirements. This may be due to the need to discharge residual design responsibilities as required by the particular procurement route because new design requirements emerge or rectifying errors in the base design. In all cases issues pertaining to cost and programme, impact will need to be managed.

Feedback questions

1 What is the effect on the contractor's financial position if the contractor when preparing his tender makes an arithmetical error and, as a result, the tender is lower than otherwise would be the case.
2 A contractor includes in a tender a bill of quantities that uses a rate which due to an error is either much higher or lower than it should be. If the quantities of the item substantially increase should the incorrect rate still be used?

Reference

HM Government (2010) Building Regulations 2000: Approved Document L: Conservation of fuel and power. NBS, London.

9 Examining construction documentation

Building services engineers design deliverables are used firstly as part the tender documentation to obtain a cost and for planning the programme for the finished project, then formalised in the contract documentation.

The contract documentation is used as a starting point for developing the construction documentation. This comprises the representation of the final building along with the information describing how it will be built and incudes details of final selection of actual equipment, construction methodology, confirming coordination amongst construction trades, construction sequencing, procedures for approvals, and site safety compliance. In doing so it also addresses aspects of the site that present previously unforeseen challenges, or any number of other residual issues in the design that only become apparent once construction begins.

Construction information is needed by:

- The design team – to ensure that its design intent is still maintained and that the testing and commissioning activities will prove this.
- The construction team – to provide information for procurement, guidance on installation and basis of payments.
- Enforcing authorities – to ensure their requirements are implemented.

Although clients may not necessarily be involved with the preparation of construction documentation, they are responsible for ensuring adequate time and funding for the activities, and making decisions and giving instructions when required in order to allow construction teams adequate resources to perform the duties required.

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Building services information in construction information

Examples of information that would be expected to be found on construction information, but not within contract documentation, are:

- Final selection of equipment, components, systems and software to meet the specified performance parameters.
- Preparation of coordinated installation details as specified and spatial coordination between building services engineering systems, building fabric and structure based on the design issue layouts and schematics.
- Coordination of technical requirements and details at interfaces with trade subcontractors.
- Design of support systems for building services plant and equipment and any proprietary products supplied.
- Confirmation of pump and fan duties based on final installation drawings and equipment selections.
- Sizing and positioning of ductwork, refrigerant pipework, cable containment, including cable trays, ladders, trunking and conduits, and syphonic rainwater system based on actual site conditions.
- Sizing of distribution boards and size of all final circuits from distribution boards in relation to grouping and containment routes.
- Builders' work information for plinths for equipment and openings for distribution of building services engineering systems.
- Requirements for secondary steelwork structures and bracketry, fixing systems, lifting beams, access panels for maintenance.
- Details of equipment that will be built in, for example pipe sleeves, frames, inserts and fixing anchors.
- Check the cable sizing for all submains using selected equipment actual loads and site measured cable lengths.
- Checking of acoustic performance and attenuation of plant and equipment based on final installation drawings and equipment details.
- Develop the design intent details using selected system/equipment supplier details for lighting control system, lightning protection system.
- Details of expansion joints in building services engineering systems to take into account building movement.
- Carry out electrical grading study of electrical distribution system to prove discrimination will work.
- Develop a switchgear interlocking scheme with switchgear vendor.
- Controls sensors and actuators located.

9.1 Construction documentation

Health and safety information

The health and safety documentation includes policies and procedures covering the contractors, subcontractors and visitors to site in respect of site arrangements: for example, permits to work, training requirements and personal protective equipment (PPE).

Technical information

Working drawings, specifications and calculations represent the detailed design requirements for construction in a particular project. They will recognise knowledge of principles, conventions, standards, applications and restrictions pertaining to the manufacture and use of construction materials, components and assemblies. The drawings provide the illustrative dimension of construction documentation, the specifications represent the written and the calculations provide the supporting justification.

Drawings, specifications and calculations are meant to match one another rather than one having priority over the other. Thus, it is important for them all to be developed in parallel, rather than sequentially, with all increasing in level of detail in finalising the construction documentation.

The definition of the different types of working drawings is included in the contract documentation. However many refer to the definitions included in 'Design framework for buildings' (BSRIA, 2014).

Installation drawing

These are the drawings that trades (electricians, plumbers, mechanical fitters) use to guide them when installing the materials and equipment for their part of the works. They usually include (wall, floor or ceiling) plans, cross-sections and elevations, either in two- or three-dimensional format. With respect to each trade:

- Electrical installation drawings show conduits, cable trays and trunking in their precise location with the necessary supports and fixings, including cable saddles and ties. They will also show the wiring connecting electrical components.
- Pipework installation drawings show pipework at actual size in its precise location with the necessary supports and fixings, including pipe saddles and details of jointing system.
- Ventilation and air conditioning installation drawings show the ductwork (with insulation), fans and heaters (based on actual equipment selected) all as actual size and in precise locations (including any tolerances), with details of supports and fixings. The drawings should show the space provisions for future operation and maintenance. This may include provisions for lifting and putting into position.

Manufacturer drawings

These are the drawings that are prepared by and used by manufacturers to assemble the equipment included, for example electrical switchgear, air handling units, pump sets, lift motors and winding gear. They usually include elevations and sections either in two- or three-dimensional format and include information about:

- Specification for all materials and components to be included in the assembly.
- General assembly information to show how the materials and components fit together.
- Requirements for finishes.
- Interface points indicating size, type and dimensioned location.
- Electrical wiring diagrams shall clearly show the requirements for any on-site wiring by others.
- Dimensions of space required for installation, maintenance, removal and repair should be indicated.
- Weight and distributed load points, together with any other mounting details such as vibration isolators' dimensions assembly instructions, should also be included if required.

Shop drawings

These drawings are prepared by suppliers, specialist subcontractors or fabricators in respect of their own equipment to show the proposed material, shape, size and assembly of the parts and how the entire unit will be installed by themselves; for example, drawings for ductwork, prefabricated pipework, fire detection and alarm systems, sprinkler systems control and symphonic drainage system. These should also give an indication of the coordination of that component with other building components to ensure constructability onsite. The main features of a shop drawing are:

- Component parts and assemblies will be fully itemised.
- Dimensions reflect either on-site measurement or allow for on-site building tolerance such that minimal on site cutting of components is required.

Builders' work drawings

The builders' work requirements may initially be produced by suppliers, specialist subcontractors or fabricators to demonstrate their particular requirements for amendments to the buildings structure. These may either be in the form of standard details or customised details; for example:

- Structures – up-stands and plinths for equipment or whole rooms or buildings to house equipment.
- Penetrations – cutting and sealing holes, chasing in walls, floors and roofs.
- Fixings – foundation bolts or other groundings.

- Secondary steelwork – such as ceiling access panels, decking, step-overs, platforms, ladders and handrails.

This information from all the trade subcontractors may need to be further developed by contractors to allow for coordination of the requirements, as these affect the buildings structure and need to be supported by the necessary calculations and specifications.

Specifications

The specifications included as part of the construction documentation describe the actual building materials, equipment and construction systems as well as describing the levels of quality and the standards to be met. At this stage they will usually be structured to reflect the responsibilities of each of the trade subcontractors.

Materials

This comprises manufactured products to prove that the actual materials are the same as intended. Either manufacturer's information or representative samples will provide.

Mock-ups

Mock-ups allow for verifying installation issues. They may be full size or to scale or they may be virtual (computer generated).

Construction methodology

This is the set of documents defining the processes and procedures of how the installation will proceed. It takes into account requirements for installation methods and techniques, quality control, sequences of installation, procedures for approvals and site safety precautions, all of which contribute to the specific and final details required for procuring and putting into place the finished work.

In general, building services engineers do not get involved in the details of how the work is being performed, but rather focus on whether the work will result in, and can be proved to meet, the specified outcome.

Construction method statements

Construction method statements describe the work to be undertaken, identifies the conceivable hazards that may arise and the necessary remedial measures that need to be in place in order to protect the on-site workforce and in some cases members of the pubic who may be affected by work actions.

Quality control documents

The purpose of the quality control documents is to define the Quality Management System for the particular project. These will advise the quality objectives and demonstrate how quality will be achieved, controlled, assured, demonstrated and managed.

They identify responsibilities and authorities with respect to matters such as incoming material control, the examination and inspection program, correction of non-conformities, construction, codes and standards required, examinations of the physical installation, inspection and testing requirements, calibration of measurement equipment and record retention.

Inspection and test plans

Inspection and test plans (ITPs) describe in detail what, by whom, when (frequency and milestones) and how the general installation and specific pieces of equipment will be inspected and tested, on site or off site. The aim is to provide objective evidence of conformance of the installation with the requirements in the contract documentation. ITPs identify the relevant standard particular criteria, with any tolerances, to determine whether the installation is acceptable or not. ITPs should also detail the requirements for supporting documentation.

Building services equipment and systems form a significant volume of the works included in ITPs, but other items, for example window cleaning equipment, vehicle barriers, load bearing structural members and so on, will be included.

Commissioning plans

Whilst ITPs aim to prove that the quality and workmanship of the installation is compliant with the contract documentation, the aim of the commissioning is to prove that the systems operate and perform to the design intent and specification, for example balancing the air volumes and load bank testing.

’Independent’ inspection, testing and commissioning

Typically, contract documentation requires the commissioning of building services to be undertaken by a third-party entity not affiliated with the building services subcontractor; this is to give assurance of independence. Some larger building services subcontractors have wholly owned subsidiary firms that perform commissioning work and, despite the specifications, employ this subsidiary as their third-party commissioning agent. These subsidiary firms may be given a completely different name to the parent company, seemingly so that the association with the parent company is not readily apparent. The fact that this company is not a true, unbiased, third party is rarely noticed. This is not an easy issue to catch, so researching the corporate structure of the proposed third-party commissioning firm is an effort that should be included in the building services engineers checks.

Programme

The programme sets out the contractor's view of how the works will progress. It should be presented so as to adequately demonstrate the completion of the project in the required timescale. This should consider practical issues, particularly where the sequence or timing affects the design intent; for example:

- Ensuring that building services equipment sensitive to dust is not installed in areas before they are finished and cleaned.
- Ensuring that the building structure is ready to accept building services systems, for example plinths to support switchgear.
- Ensuring that the required inspections and tests are specifically planned for.

Risk register

Risk registers provide a mechanism for recording, quantifying and ranking perceived risks, along with their impact or consequence, probabilities and countering strategies.

9.2 The submittal process

The construction documentation may not be perfect: there may be omissions or errors, or a need to provide clarifications, and additional information may be added. The submittal process provides a mechanism for examining the construction documentation and reporting back on the findings. It is the last chance for building services engineers to check how the contractor proposes to conform to the design concept expressed in the contract documents.

Submittals are pieces of project information that the contractor is contractually obligated to forward to the design team for examination; they document the construction team's intentions. However, submittals are not contract documents within the designer's contract. Building services engineers need to understand the function and purpose of submittals, as well as their relationship to the design and the contract documents, and to exercise reasonable care in processing them.

At the outset, it is important to identify and confirm clients required formats or standards, for example sheet sizes, layouts, sequence, numbering, symbols, and abbreviations. Procedures may be in place for the electronic handling of drawings for comment, review and coordination. Where digital drawings are required, file formats, naming and layering conventions may have to be adhered to. Increasingly, building information modelling is used as a means of managing project information, coordinating the design and detecting clashes. This can be useful to suppliers in providing clear information upon which shop drawings can be based, and allowing the shop drawings themselves to be re-incorporated back into the building information model, eliminating time consuming manual practices and minimising errors.

Contractors must identify the specific contract requirements relating to submittals and approvals and should keep a log to record the progress and status of each submittal, including date of submission, response time and response information.

Purpose of the examination

Building services engineers will check the installation information for compliance with the contract documentation. The terms of reference for the examination need to cover the documents to be checked, the purpose of examination, the means of reporting and the requirements for following up on the initial examination. The scope may cover:

- Confirmation that the drawings and specifications have been prepared under the supervision of qualified professionals.
- Statutory code compliance only.
- Checking whether the design conforms to the contract design intent, including maintenance considerations.
- Checking against a specific issue, for example energy efficiency, accessibility requirements.
- Identifying value engineering opportunities.

Also, the scope of their examination in terms of completeness, accuracy and coordination among disciplines needs to be understood.

Example of maintenance considerations for valves, electrical terminal boxes and dampers associated with air systems

Ideally, equipment such as valves, terminal (VAV) boxes, dampers and other items requiring periodic maintenance should always be located just within a ceiling so that they can be easily accessed. However it may be easier for these items to be placed directly beneath the structural slab to reduce the extent of the supporting structures, but for projects with significant ceiling void depths this can create a maintenance problem.

A similar maintenance concern involves items that require periodic maintenance that are located above a toilet ceiling. Access doors should never be located over the toilets, as the toilet partitions make it difficult to safely stand a ladder. It is advisable for the building services engineers to explicitly prohibit this practice in the design documents. As a good management practice, potential maintenance problems such as this should be examined during the submittal review process and monitored with the project's quality control programme.

> It is always best to position equipment requiring periodic maintenance over corridors rather than over rooms, especially offices. This means that any work and the associated clearing up during normal working hours will not disturb the occupants in terms of noise, dust and general disruption.

Documents to be checked

Submittals may include working drawings and supporting calculations, product literature and materials information, site survey data, samples of products and models demonstrating particular construction techniques, or mock-ups showing how portions of the project are to be constructed. The building services engineering systems being evaluated do not stand alone in building projects but must interface with other systems and the buildings fabric and structure. Therefore, knowledge of the construction sequence and a multidisciplinary approach to thinking improves the evaluation process.

Building services engineers should examine all information describing the building services design relevant to their scope, including the provision for public utility services, plus significant other information that affects the building services engineering design, for example:

- Structural engineering information describing the builders' work provision for building services equipment.
- Wall construction for thermal properties that are used in the heat gain and cooling load calculations that form the basis of the design of the heating and cooling systems.
- Landscape architecture drawings for inclusion of external sockets, taps and pumps.
- Finishes schedules with respect to reflectances for floors, walls and ceilings that are used in the lighting design calculations.

Similarly, other discipline engineers and architects should examine the building services subcontractor information.

Calculations

With respect to software generated calculations, it is important to understand the source of the software used in order to be confident about its legitimacy. It may be in-house developed software, from manufacturers, which will be biased towards their own equipment, from professional institutions and other not-for-profit organisations or from commercial organisations. The situation of most concern might be 'freebies' of unknown pedigree, meaning, in the worst case scenarios, that they may be created by a well-meaning enthusiastic but incompetent amateur or worse still a 'troll'. Although they may be provided by a totally proficient person with an altruistic desire to share their knowledge.

Deferring design responsibility

Building services engineers may not show the positions for wall or duct-mounted thermostats on their design drawings. Instead **there may be a** note to the effect that the contractor shall locate them and show them on their working drawings for approval by the design team

A justification for this postponed effort is that these locations are unlikely to have a cost impact, so deferring may appear to be a resourceful risk-free approach. But whether or not an element of work has a cost impact is not the differentiating characteristic between the design responsibilities of the building services engineer and the building services engineering subcontractor.

The differentiating characteristic is whether or not the issue has an impact on the appearance or function of a building project. If an item has an impact on the appearance or, in this case, the function of the building, it should be included in the design documents. Generally, the party responsible for making a decision is also responsible for performing the respective design work. In this case building services engineers are responsible for the decision as to where thermostats are located, and therefore they also hold the design responsibility. When the building services engineering subcontractor locates the thermostats they are not necessarily taking on the design responsibility.

Quality conformance

There are a plethora of different third party agencies involved with ensuring quality all with different focuses, for example:

- Certificate of country of origin: in this case the manufacturer states that the product complies with some specifications pertinent in that country. Evidence of the country of origin may be shown in the Bills of Lading and customs documentation.
- Although the certificate might not be very reliable, failure to comply with the specifications can be legally actionable.
- Accredited laboratory test certificate: the test is performed on a small sample, and therefore cannot guarantee all production. These certificates should be used with caution due to their limited scope.

Accreditation agencies

UKAS

The United Kingdom Accreditation Service (UKAS) is the only national accreditation body recognised by the UK government to assess, against internationally agreed standards, organisations that provide certification, testing and inspection and calibration services in the UK as well as relationships with and governances of other national bodies. Accreditation by UKAS means that evaluators, testing and calibration laboratories, inspection and certification bodies have been assessed against internationally recognised standards to demonstrate their competence, impartiality and performance capability.

There are equivalents worldwide and there are multilateral agreements for the purposes of mutual recognition through the European Cooperation for Accreditation (EA), the International Accreditation Forum (IAF) and the International Laboratory Accreditation Cooperation (ILAC). Those bodies that are signatory to these agreements are deemed to be equivalent, having undergone stringent peer evaluations.

So anything accredited, tested and certified by a UKAS approved agency means that the country of origin is irrelevant.

UL and FM Global

UL and FM Global are members of the Nationally Recognized Testing Laboratory (NRTL), a United States Occupational Safety and Health Administration (OSHA) designation given to testing facilities that provide product safety testing and certification services to manufacturers.

So it does not matter where goods are manufactured as long as they are certified by UL, FM Global or another member organisation.

- Product type approval certificate: this approves a prototype design and, therefore, does not guarantee the quality of the subsequent manufacturing process.
- Standard compliance seal or mark: its scope includes continual production and, therefore, it is more reliable than other certificates. When the product is very new and there is no specific standard to regulate it, the certificate is issued in the form of technical suitability documentation.

Equal and approved

With respect to the provision of plant or equipment, a service or the provision of a complete system specification may include a single named supplier or a shortlist of, say, three potential suppliers, or else it may be open to all possible suppliers who comply with the particular specification. In the cases of a single named supplier or a numbered shortlist, specifications may allow for an alternative provided it is ‘equal and approved’. The AND (Figure 9.1) is contractually significant and the ‘equal’ and ‘approved’ need to considered separately.

Equal

The test on whether a proposed alternative is equal necessitates determining whether the salient features provided by the original supplier, as set out in the design deliverables, are displayed in the alternative.

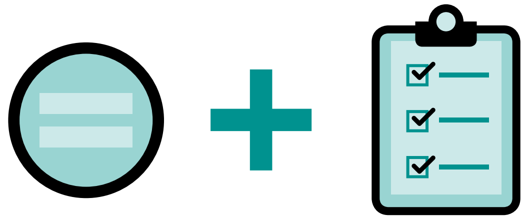

Figure 9.1 Equal and approved

Issues that might be specified, and hence would need to be considered in any appraisal, might be:

- Technical performance – thermal properties, acoustic properties, water permeability, optical properties, hygiene, comfort, safety.
- Aesthetics – visual impact, colour.
- Availability – delivery times.
- Fire safety performance – fire resistance, flame spread, smoke development, toxicity, fuel load, combustibility.
- Coordination – interchangeability or compatibility with existing systems.
- Durability – resistance to wear, weathering, adhesion of coatings, dimensional stability, mechanical properties, viscosity properties.
- Practicability – transport, storage at the site, handling at installation, field tolerances, connections.
- Compatibility – jointing materials, coatings, galvanic interaction or corrosion resistance.
- Maintainability – compatibility of coatings, indention and puncture (patching), chemical or graffiti attack.
- Environmental impact – resource consumption at production, life cycle impact.
- Cost – installed cost, maintenance cost.
- (For the provision of services) matters such as quality and reliability may be relevant.

Appropriate means of providing evidence of equality could include:

- Desk study of manufacturers technical literature, including drawings and specifications, COSHH sheets and environmental impact statements.
- Examination of samples.
- Visits to factory or existing installations where an alternative is installed.

As part of the design process, building services engineers consult with manufacturers to assist with selecting plant and equipment. The manufacturers may undertake calculations and provide specific technical literature. In return, the specification, which although intended

Not just a straight swop

Sometimes a unilateral change can have an unintended consequence on unaltered design, for example:

- If an alternative luminaire or fan coil unit is proposed, it may be that **its** technical performance is exactly the same but **it is** physically slightly deeper. This could mean that either the ceiling void would have to be increased or the design for the ductwork, electrical containment and other items in the ceiling void need to be re-routed. There will be extra design costs and effort required costing the new scheme. **F**urthermore, there may end up being a requirement for more ductwork and containment. The contractor will be expected to pay for the associated redesign costs and ignorance will not be an acceptable defen**s**e.
- **A** contractor proposes an alternative external CCTV camera whose performance appears to be the same. **H**owever, two years after handing the project over the cameras are vandalised because they were not fit for purpose. If it could be proved that the original proposal would have been sufficiently vandal proof then the building services engineers may be liable for the costs as they still retain the design liability.

to be open, will end up being written around this manufacturer. It may be such that no other product that can comply and the 'or equal' clause is ineffective. The specification may be written such that products are commercially available, but must not be so obvious that the specification is, in fact, really only describing the product of a single supplier.

It may be that contractors offer a superior quality product as an alternative. Such a substitution may be rejected for not complying exactly with the contract specifications. However, if it is accepted the contractor should not automatically expect to receive extra compensation for such a substitution.

Approved

Note that the phrase 'or equal and approved' means that building services engineers may be happy that the alternative is an equal but are not obliged to approve it. Building services engineers may or may not have the authority to approve an alternative. It is, therefore, important to remember the 'approved' part of the equation, and contractors who do not get the necessary approval would be in breach of contract if they installed an alternative product without gaining the necessary approval.

Finally also bear in mind the programme. If an alternative product is proposed during the course of the project, sufficient time must be given to building services engineers to consider this alternative, without jeopardising the programme.

Leedsford Ltd v The Lord Mayor, Aldermen and Citizens of the City of Bradford (1956) 24 BLR 45

This case centered on the design and supply of artificial stone for a new infant's school. The bill of quantities included an item for artificial stone with the named supplier 'Empire Stone Company Limited' but included the term 'or other approved firm'.'

In this case the judge ruled that **the** phrase 'or other approved firm' gave the contractor the opportunity to submit other names to supply rock, that the architects obligation was to act in good faith, but this did not extend to the architect being obliged to approve an alternative or even having to give reasons for non-approval.

Recording and reporting findings

The method of recording and reporting findings will also be included in the contract. This usually includes a formal written process, but may include for attendance at meetings, workshops and so on. The reporting should focus on recording any departures noted from the reviewed construction documents and industry standards, as well as any deviations from the construction contract.

Many contracts use a system of lettering (maybe A, B, C, maybe D and E) that may, depending on what was included in the contract, mean the following:

- **A** means there are no comments and the contractor can carry on.
- **B** means that the submission is not in accordance with the contract requirements but the contactor can proceed but should take cognisance of the comments.
- **C** means that the documents are not acceptable; the contractor cannot carry on and must resubmit.
- **D** means the whole package is rejected and needs to be totally reworked before being submitted.
- **E** might be reserved for any other response.

Building services engineers are employed in a reviewing capacity where their role is to assess the deliverables against the contract documents and technical standards, normative or otherwise and make technical comments only. As such they do not officially direct, instruct and educate the contractor.

Compliance statements are declarations of opinion that to the best of the signatories knowledge, belief and professional judgment, the information referred to meets the requirements identified. These may be prepared by building services engineers confirming their professional opinion, based on stated reasonable grounds, that aspects of design of a building achieve compliance with specific criteria.

A source of concern for building services engineers with the approval process is that it has the potential to expose them to claims, for examples delaying the construction schedule due to late submittal return or time spent discussing findings. They may also be liable in the event that injuries are sustained by persons due to a construction failure, where the failure can be traced to negligence in submittal review.

(Not) approved

Some professional literature advocates avoiding the word 'approved' in the outcome of an examination of a submittal, whilst others have rejected the idea that building services engineers could avoid responsibility for reviewing construction documentation by merely using some other words or including caveats, for example:

- 'Comments made by the reviewer do not relieve the contractor from compliance with requirements of the contract documents' ... perhaps adding that the contractor is responsible for all dimensions, site conditions, coordination with other trades and information pertaining to the fabrication process.
- 'Review of such submittals is not conducted for the purpose of determining the accuracy and completeness of other details such as dimensions and quantities'.
- 'Review shall not constitute approval of safety precautions or of construction means, methods, techniques, sequences or procedures'.

Summary

Construction documentation provides the instructions to convert the building design into the physical reality. Building services engineers are usually involved in the review and approval of working drawings, specification and calculations. The nature of the scope of services provided in that respect and the required turnaround time depend on the procurement arrangement and the particulars of the contract. The reporting of the examination by building services engineer's does not alleviate the contractor of any responsibilities. Furthermore, with respect to materials transmittal approval of specific items does not infer approval of an assembly of which the particular item is a component

Feedback questions

1 If there is a conflict between information shown on contract drawings and included in a schedule as specifications, for example a rating for pump or fan or a cable size, which one takes precedence?
2 Constructors and subcontractors may venture into the design process and subject themselves to its attendant risks and liabilities. Discuss whether they are able to limit their liability for design detail as a result of providing the information to others for review of overall compliance with the design intent.

Reference

BSRIA (2014) Design framework for building services, 4th edn. BSRIA Limited, Berkshire, UK.

10 Observation of the physical installation

Examination of the construction information is effectively a desk-study study of what is intended to be installed. The examination of the physical installation aims to detect non-conformances with respect the contract documentation (Figure 10.1). This includes examining equipment off-site before it comes to site and on site to scrutinise the construction team's performance with respect to the materials, equipment and the operation of systems in their final location. The examination of the physical installation comprises two parts: firstly, the static installation is inspected and, secondly, when the systems are made active, it is examined via the testing and commissioning procedures.

Building services engineers need to understand their liability for the works performed by the various contractors and subcontractors, both on and off site. The particular format and focus of building services engineers' off and on-site attendance depends upon the contract as a whole, both its express and implied terms. For example, the contract may specify continuous versus non-continuous presence, the frequency, duration and timing of visits, the intensity of inspection, the reporting requirements and action to be taken upon discovery of deficiencies. Or else it may imply the frequency of site visits necessary to satisfy the contract or the standard of care; as such it is left up to the building services engineers' professional judgment.

Factors that may influence these are:

- Any specific standards of supervision included in the building services engineers' contract.
- The amount of repetition of work – if a particular element of work, for example bedhead trunking in a hospital ward or a bathroom pod, is to be extensively repeated, it should be expected that the earlier installations are inspected more so than the latter ones.
- The size of the project.
- When crucial steps are undertaken, such as pouring concrete onto ducts and pipes, or closing up ceilings – especially if this requires

Building Services Engineering: After Design, During Construction, First Edition. Jackie Portman.

Companion website: www.wiley.com/go/portman/buildingservicesengineering

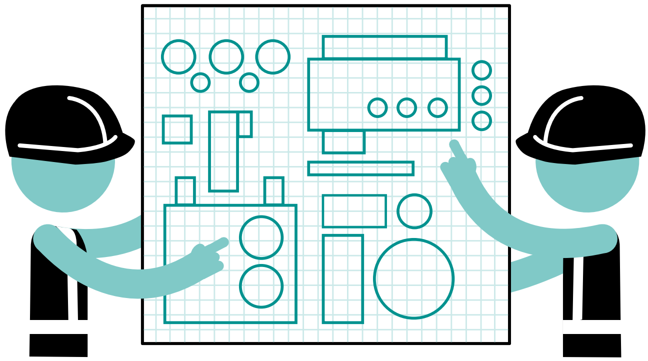

Figure 10.1 Examination of the installation

the opening up for inspection of any work covered up or tests of materials or goods or executed work.

- The price paid for the building services engineers' services.
- If the contractor is guilty of faulty work, a higher standard of care is required.

For on-site works this involves checking the installation for compliance with the contract design information. Building services engineers should act in a quasi-judicial capacity, showing no partiality to either clients or contractors. They will not have control over, or charge of, nor be responsible for, the construction means, methods, techniques,

Self protection

Building services engineers may think that by avoiding going to site, somehow they divest themselves of any responsibilities for deficiencies in the completed project, or that by visiting the site more often they will increase their exposure.

Building services engineers may opine that by not visiting site, and maybe relying upon third party certification processes as confirmation of quality, they will reduce their exposure to risk. However, they still have design liability and by visiting the site they are able to satisfy themselves that the design is working. Even the best design deliverables require some extent of interpretation. It is prudent for building services engineers to protect themselves and those of their clients by being there to provide clarification and interpretation.

However, if building services engineers are not retained for any services during the construction phase whatsoever, they should refrain from visiting the site or volunteering uncompensated services. The standard of care requires design professionals to render the same quality of service whether properly compensated or not. In these cases, the building services engineers might seek indemnification for lack of involvement mandated by the client.

sequences or procedures, or for safety precautions and programmes in connection with the installation, as these are solely the contractor's responsibility.

Building services engineers may be authorised to reject work that does not conform to the contract documents, although clients may subsequently accept non-conforming work.

Building services engineers' presence on site does not guarantee that the contractor and subcontractors will complete their work in accordance with the drawings and specifications. In monitoring the construction, building services engineers will be alert to whether the contractor has carried out the design intent and the contract requirements relating to quality of workmanship and materials.

Site observation versus site supervision

Building services engineers' on or off-site observations should not be confused with the direct and constant supervision of workers exercised by contractors and subcontractors. Supervision includes the duty to intervene in contractors' work, to give instructions and correct potential failures found in the permanent features in the design.

In spite of the attempts to protect building services engineers from liability through the use of careful wording in contract documents, issues may arise on the basis that building services engineers have been present on the site.

When construction defects arise for which the building services engineers are alleged to have responsibility, the question of whether they have failed to act in accordance with contractual or common law standards of professional care is one of fact. A frequent issue is whether the building services engineers should have discovered the alleged defect during one of these site visits or, in accordance with the standard of practice of the reasonably prudent professional, whether building services engineers should have scheduled a site visit when a certain item was under construction. When put into practice at the site, the distinctions between observation and supervision become blurred, often even in the mind of building services engineers for whose protection they were devised. It is not uncommon for the building services engineers during the construction phase, to assume greater responsibility for the construction defect than has been provided in the contract documents.

10.1 Types of deficiencies

A defect is an aspect of the design, building work or materials that fails to meet some applicable criteria, such as the contract documents or the requirements of enforcing authorities.

Patent and latent defects

During the construction phase, building services engineers are looking for patent defects. A patent defect is discoverable and may be open to view, exposed, evident or obvious. A patent defect is one that is detectable either at or before apparent practical completion or during the defects liability period. In the past, the courts have opined that patent defects must be apparent on inspection but need not necessarily have been seen by the people carrying out that inspection.

There may be other defects, latent defects, which may not become apparent or readily detectable (even with the exercise of reasonable care) until many years after completion of the project, long after the end of the defects liability period. By definition, building services engineers cannot detect latent defects, as these have not yet presented themselves; they will exist before it is discovered as hidden or concealed flaws in the work. When a latent defect presents itself, it ceases to be a latent defect and becomes patent defect. At the moment a latent defect becomes patent, the mechanisms under the contract for dealing with latent defects are usually relevant.

Building services engineers may remain liable and may owe a duty of care to clients for latent defects by failing to adequately specify design parameters or negligently failing to properly check contractor's designs.

Workmanship deficiencies

Poor workmanship occurs because the work was not carried out in a good and workmanlike manner in accordance with good practice due to inadequate skill and care by contractors or subcontractors. Common causes for poor installation techniques are lack of recognition of manufacturers requirements, inadequate training in respect of skills and knowledge, programme constraints, cost constraints and design ambiguities.

Materials deficiencies

Materials deficiencies may occur due to technical failures, poor handling, inadequate installation (including coordination) or unapproved substitutions. These could be potentially harmful, for example:

- The materials for potable water pipes should be neither nutrient for microorganisms nor leach out any toxic material to the water.

Technical failures of materials

The on-site workforce should be fully familiar with the characteristics of the materials they are installing. It is important that contractors ensure site staff are suitably trained and aware of how the equipment is to be installed. Though it may be considered to be elementary good practice, it is important manufacturers' literature is absorbed and understood before installation. Fixing and mounting equipment correctly can significantly help to minimise failures.

Materials supplied by manufactures do have failures, although they are commonly due to a component or part of the material or equipment failing and not the equipment as a whole. Specifically, within the building services industry many items of electrical equipment such as light fittings are supplied with internal electronic components such as resistors, diodes, fuses and so on. These internal components of equipment are all type tested before being built into the complete fitting and the light fitting is tested as whole once built. Usually only batch tests are carried out when testing these electronic components, which means some defective components may slip through for sale.

Materials may come with certification/accreditation which needs to be understood.

Poor handling

Equipment stored badly or inappropriately on site may affect its performance, for example if material is stored in very hot or cold conditions or roughly handled and generally treated in a casual way

During storage, materials are again likely to be exposed to the elements, so any precautions that need to be taken should be arranged. Many items of equipment may have to be inspected and turned over by hand at regular intervals. Control devices, electric motors and starters, control panels and instrumentation are likely to require special consideration. It may be necessary to provide air conditioned site storage for certain items of equipment.

Unapproved substitutions

Materials, assembled equipment and prefabricated systems may be approved through the transmittal submission process but different products arrive on site. It may be accidental and should be picked up as part of the contractor's procedures. The goods may be fake or counterfeit. The counterfeit goods may arrive with seemingly authentic certifications, import documents and bills of lading to 'prove' that they has been shipped from a particular destination.

All fur coat and no knickers

Counterfeit equipment could be a hybrid of fakery. For example, with respect to electrical switchgear, the outer panels, including doors, could be to the original manufacturers standard but the components inside not.

One product particularly susceptible to counterfeiters, because of its small proportions and ubiquity, is the low-voltage circuit breaker. This has a safety function in so far as it is designed to disconnect the source of electricity if there is an overload or short circuit current. This mitigates the risk of electric shock and overheating, which can lead to a fire. Thus, using counterfeit equipment can impact life safety and put lives at risk. Less importantly, inclusion of counterfeit goods can affect equipment and system warranties.

Certified products

There is often a misconception by contractors that simply installing a certified product is sufficient to comply with regulations. It is important that the designers pay close attention to installation details and site inspections to verify installation compliance.

It is particularly important to ensure the use of quality fire products for the design of buildings. Products should be certified to internationally recognised bodies, examples include:

- Universal Laboratories (UL)
- Factory Mutual (FM)
- Loss Prevention Council Bureau (LPCB).

Some countries may require products to be tested and locally certified. It is important that any new products introduced to the market are checked with the local enforcing authority for certification requirements, as this could delay the approvals process and, ultimately, the project.

Care should be taken to ensure that products are approved products. Clearly substandard products jeopardise the safety of the public and the consultant should check that installed fire products are certified and listed as per the design.

Changes to equipment made locally may affect manufacturer's warranty, particularly of concern when related to life safety issues–UL listing.

10.2 Off-site visits

Building services engineers may have sufficient knowledge, experience and confidence of a supplier that the goods will be manufactured as per their design requirements. Elsewhere, building services engineers may be looking for some reassurance of product integrity and quality. This could be achieved by means of a desk study of the supplier's technical submission along with information on their quality management system (QMS). However, a statement of conformity to such a QMS should not be considered as a substitute for a declaration or statement of product conformity. This may best be determined by visiting the factory to ascertain evidence of quality control systems within the factory.

BS EN ISO 9001:2015 Quality management systems. Requirements

Sometimes suppliers refer to being 'ISO 9001 certified', or having an 'ISO 9001-compliant QMS'. This normally means that they are claiming to have a QMS meeting the requirements of ISO 9001, the only standard in the ISO 9000 family that can be used for the purpose of conformity assessment. It is important to understand, however, that ISO is the body that develops and publishes the standard and that ISO does not 'certify' organisations: that is done by certification bodies.

Also, it is also important to check that any ISO 9001 certificates are in date, and refer to the specific location in question and the specific product.

Off-site examinations comprise inspections to verify the quality of components, to examine off-site assemblies or to examine pre-fabricated components. As well as looking at the manufacture of the particular equipment, it provides an opportunity to undertake a quality audit of the factory.

Manufactured equipment

Manufactured equipment is 'mass' produced with all products from the same range being essentially identical, for example light switches, conduit, cable, pipes and supply and extract grilles. The QMS should cover all activities, such as material control, design control, fabrication, examination, control of packing and marking, control of loading and dispatch to the construction site.

Assembled goods and prefabricated systems

Some building services equipment is assembled off site, for example electrical switchgear and air handling units. Even with a detailed specification and robust submittal review process, misinterpretations can occur. Occasionally a special feature does not work out as anticipated. Detecting these problems in the factory allows them to be corrected in a controlled environment by people intimately familiar with the required fabrication and assembly processes. Most equipment manufacturers have a vested interest in this approach because they avoid the costs associated with sending skilled technicians and engineers to the construction site to correct a deficiency not caught by their own quality control process.

Prefabricated systems may be bespoke to a particular project and the testing must be relevant to the intended use of the building and application. As such, a tailored approach to inspection, testing and certifications may be required with components and subassemblies being tested individually and then the whole unit tested.

It may be that building services engineers attend the factory to observe the design, manufacture or inspection of the testing – sometimes called a factory acceptance test (FAT). FATs ensure that design, operation and maintenance features can be verified prior to the unit being shipment and corrections can be made at the factory. The attendance of building services engineers at a FAT may be part of a risk management strategy to managing the risk of delay if the factory dispatched equipment is defective.

Attendance at a FAT will vary according to how the responsibilities of the contract are allocated but might include a client's representative, building services engineers (or their representative), the commissioning services provider and building services subcontractors.

Alternatively, the responsibility for a FAT test may be passed to a third party inspector (TPI), but the nature of the responsibilities still needs to be properly understood and to be seamless. Even passing the work to a TPI can cause problems with respect to demarcation of responsibility, proper briefing and follow up.

10.3 On-site visits

Building services engineers may visit a site to understand the progress being made and the associated quality to give confidence that the building services engineering systems, when completed, will perform in accordance with the contract documents (Figure 10.2). When on site it is important to set up a proper communication channel with contractors

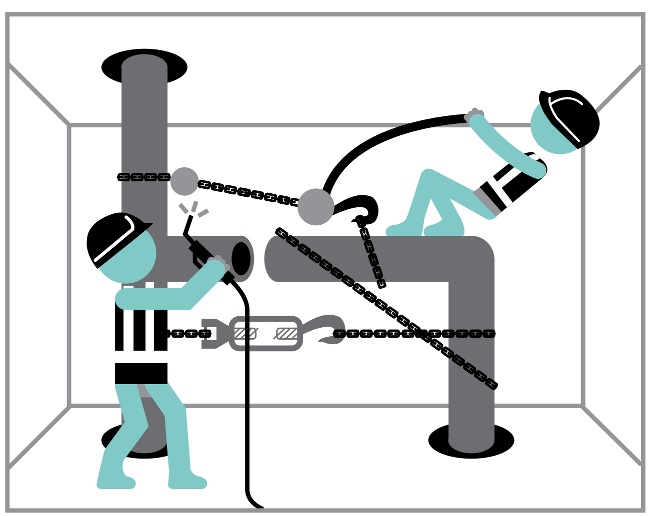

Figure 10.2 Actual installation versus design intent

and to avoid giving an appearance of providing supervision or instruction to contractor personnel.

The formal reporting requirements in terms of frequency, content and intended audience will be described in the building services engineers appointment. Even if the contract is silent on reporting requirements it is good practice to issue a report after a site visit; this provides a rigor to the visit as well as an auditable trail if required. The content may include:

- Condition of the work in progress and its degree of completion.
- Any faults identified during the visit and suggested actions.
- Any subcontractor coordination matters.
- Any impediments or obstacles to the completion of the works.
- The adequacy of the installation in terms of future operation and maintenance.
- Verification that the correct materials have been used.
- Recognising if the installation is different from the design intent in such a way that the design calculations are voided.

Routing of pipes

Pushing water through a straight pipe is one thing but any additional resistance to that water flow means the water pump has to work harder. And having the water bend round corners is going to create turbulence and resistance, which means the pump has to work harder, such that maybe the originally specified pump is no longer be adequate. But what if this is not picked up until the commissioning stage or the system is up and running and you are just not getting enough water somewhere? What cost then to put things right? … And so on and so forth. The whole thing, a small change somewhere, has knock-on consequences, often hidden, which is why the more things can be picked up during the installation process the better.

- Checking that the processes for record drawings are in place, for example that 'redline' drawings are being undertaken. These are used to record actual live information on the installation in terms of any deviations from shop drawings, or records of any precommissioning activities to parts/sections of systems.

The inclusion of photographs or videos may be beneficial. These can be used as evidence and substantiation of the facts in a future claim situation. However building services engineers need to ensure that the photographs are digitally dated and time stamped, and the photographer named.

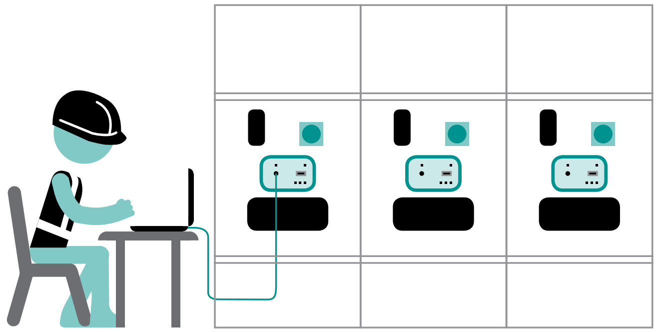

Figure 10.3 Testing low-voltage switchgear

Site acceptance tests

Typically, site acceptance tests will be required to re-verify some of the factory test items. This is especially true for larger equipment, such as electrical switchgear (Figure 10.3) and air handling units that must be disassembled for shipment. The responsibility for correcting problems that show up in these re-tests usually falls to the contractor, not the equipment supplier. If the unit was not factory tested, the lines of responsibility for correcting problems uncovered in the field can become controversial, especially if the problems are not immediately discovered.

10.4 Inspection and testing

The purpose of inspection and testing is to determine whether the building services engineering systems have been installed to the quality needed, materials and workmanship requirements of the contract specification have been met and are in accordance with manufacturers' instructions, such that they will perform properly when put into operation. Thereafter, the systems are ready to be made live and put into operation. Inspection and testing will include visual inspection and measurements of parts of overall systems, for example:

- Pressure testing sections of ductwork to check for air leakage before cleaning them.
- Pressure testing sections of pipework to ensure there are no leakages, then flushing, cleaning, filling and venting the system.
- Continuity of lengths if electrical cables, including earthing cables.
- Testing the operation of individual smoke detectors and sounders in the fire detection and alarm system.

Building services engineers role in inspection and testing may be achieved by:

- Witnessing the inspection and testing of systems undertaken by others.
- Reviewing reports and certificates from contractors or third party inspectors and testing agencies to determine whether they have verified compliance of the reported item of work with the contract.
- Organising inspection and testing themselves.

As part of the design, building services engineers should have included for facilities such as testing points, inspection hatches and measuring devices to enable inspection and testing to be carried out.

Aside from building services engineers there are parties that may be interested in different inspections and tests, such as clients, insurers, public utility services providers and enforcing authorities. It may be necessary to include hold points (to pause the works to allow the interested party to inspect the works and give the go-ahead to carry on) and witness points (to pause the works to allow for witnessing by an interested party).

The ITP will show whether there is 100% inspection and testing of systems – which may be neither practical nor desirable and it may be necessary to adopt a testing frequency and sampling process.

10.5 Commissioning

Commissioning focuses on verifying and documenting that building services engineering systems are can be used and operated and maintained to meet the design performance requirements. Commissioning raises the building services engineering systems from a level of static completion to their active state. This process will, firstly, check that the safety and, secondly, that the functionality of the buildings services engineering systems are acceptable; the design criteria will usually set out the minimum acceptable performance benchmarks.

Commissioning can be thought of as a checks-and-balances system, providing a collaborative process for planning, delivering and operating buildings.

Some of the services that need to be commissioned are:

- Heating systems.
- Air conditioning systems.
- Natural ventilation systems.
- Renewable energy systems.
- Fire detection and alarm system, including all the interfaces with other systems;

- Lighting system, include lighting controls.
- Emergency lighting.
- Structured cabling.
- Fibre optics.
- Lifts and escalators.
- Lightning protection system.
- Electrical distribution system.
- Building management systems.

The commissioning of construction projects is a managed process that shares responsibility for tasks between the client, design and construction teams. The commissioning procedures must be planned well in advance of the completion of construction. This is a process that starts in pre-design planning, possibly with the appointment of commissioning manager and undertaking commissioning-focused design reviews, and is implemented throughout the construction, start-up and post-construction phases of the project. The commissioning process is closely associated with the overall construction of the project and is driven by the construction schedule.

Test methods and validation methodology should be specified by the building services engineers during the design phase. It should be incorporated into a commissioning programme, which building services engineers should review. This should incorporate milestones, sequential paths, interrelationships, individual systems, details of how the different handover phases will be commissioned then recommissioned as more and more gets handed over and brought on line. Where available and appropriate, methodology should be taken from a standard code of practice or similar reliable source. Also, during commissioning, it is necessary to re-visit the design information, so this should be readily available. This includes, for example, for the ventilation system design air-flow rates, design air velocities, pressure differentials and noise levels and for the electrical system, the external impedances and prospective short-circuit current, load analysis and discrimination study.

Unlike aspects of structural engineering, where it is likely to be known at an early stage if there is a problem, with for example the failure of a beam, the dynamic nature of the building services engineering systems – and the need for them to be proven and witnessed to the satisfaction of all parties – means that the moment of discovering whether they perform as expected (and thus the effect on project success) may not be known until much later, when they begin operation. This may be the first point that it is realised there is a problem.

Building services engineers become accountable for their design deliverables through the commissioning process. Specific criteria for the functional use of each space, assembly and system are defined at the outset of the design process. These include measurable, such as temperature, humidity, airflow, airtightness, sound insulation, illuminance levels, noise, durability, aesthetics (materials and colours), and secondary parameters, such as service life, reliability, redundancy and the like.

Prospective short-circuit current

At the point of supply the external electrical network will present an overall impedance, which is a function of the equipment, including transformers, switchgear, cables, and the interaction with earth. This provides a value for the impedance used in calculations for ratings of electrical equipment and cable sizes.

Building services engineers will usually use a figure, at the design stage that is usually based on a maximum or minimum figure that the supply authority is committed to maintaining. However, the actual measured value will be measured as part of commissioning and this may lead to amendments to the design.

Summary

Site presence (either visiting or full-time resident) can help mitigate clients against fraud and shoddy workmanship, which can lead to patent and latent defects. Building services engineers can add value during the installation by observation and commenting on the physical installation, attending off-site locations where goods and materials are being manufactured, assembled or prefabricated, and being involved with inspection, testing and commissioning.

Building services engineer's duties are not absolute and their presence during construction does not guarantee that the contractor and subcontractors will complete their work in accordance with the drawings and specifications. Furthermore, defects in construction will not by themselves be sufficient proof of a lack of supervision by building services engineers.

Feedback question

1 Discuss the precautions building services engineers can take to prevent fraud in terms of 'fake' assembled goods, for example switchgear or air handling units arriving on site.

11 Handover and post-construction

Handover marks the end of the construction phase and the start of the post-construction phase. Building services engineers may be involved with closing out defects, examining handover documentation, dealing with legacy design issues and post-occupancy evaluations.

Handover is formalised by documentation, such as the issuing of a Certificate of Practical Completion, or substantial completion from the contract administrator (usually the architect, but maybe an engineer). At this point, responsibility for the building project is officially transferred from the contractor back to the client. The building will be in a state of operational readiness: it will be fit for occupancy and usable for its intended purpose. This triggers a number of events, for example:

- The start of the defects liability period.
- The requirement for clients to release some of the retention money, which had been held back throughout the works in part to guarantee the works are completed.
- Contractor's liability for liquidated damages cease, as they would only have come into effect if contractors failed to complete the works by the due date.
- Defines the starting point for many guarantees and warranties.
- Ends contractor's right to access to the site. Clients are now responsible for security of the building and any further access by contractors requires permission and arrangement to be agreed with clients.
- Terminates clients right to instruct variations for changes in work from contractors.
- Transfers responsibility for management and payment of utility bills to clients.
- Clients take responsibility for operation and maintenance of the building.

Building Services Engineering: After Design, During Construction, First Edition. Jackie Portman.

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- Clients responsibility for insuring the building services engineering systems commences.
- Clients responsibility for fire safety commences.
- Starts the schedule for writing down from any contractor's performance bonds.

11.1 Defects liability period

At the start of the defects liability period building projects should be complete and free from patent defects. If defects are not evident at practical completion but become apparent during the defects liability period, they may be addressed in that period.

The defects liability period typically lasts between six months and two years, or for the period stated in the contract documentation. When the end of the defects liability period is reached the final account details can be agreed, including the adjustment of prime costs, provisional sums and allowances for variations. When all outstanding defects have been made good, the remainder of the retention fund is released and the final certificate issued.

Once the final account has been settled, the parties can no longer pursue claims against each other, except for those relating to any legacy defects. Liability for legacy defects normally runs for a period of six years from the date of completion.

Despite its legal and commercial significance, determining the point at which projects are complete is complex and the precise definition will vary from project to project. Practical completion does not necessarily mean the project is 100% complete, but that it is substantially complete, with minor omissions and defects to be rectified in the defects liability period. There may be an element of subjectivity in deciding whether to issue a completion certificate under a building contract, hence it is important to define, as clearly as possible, the criteria for completion for specific cases.

Clients sometimes accept buildings at handover whose building services engineering systems do not work as per their original requirements and are willing to accept suboptimal performance. There is generally no provision in the contract for this, but it can be agreed by the parties to the contract that clients settle for accepting a defect in return for discounting payment of the final account. The circumstances are usually related to avoiding business or operational disruption; for example if handover is tied to the start of a school term or a significant sporting event. In these cases a schedule of significant snagging items is included in the certificate of practical completion.

Furthermore, there may be more than one handover in a project. This may be organised as either:

- Sectional completions, which are defined in the contract, where physical areas are handed over providing they are substantially complete. This triggers all clients' responsibilities for the area.
- Partial possession, also referred to as beneficial occupation, amounts to the same as sectional completion, but is mutually agreed outside of the contract and clients do not have all the responsibilities they would have with sectional completions.
- Staged completion, for example the building may be completed to a shell and core level and handed over to start a tenant's fit-out.

In the case of procurement arrangements that are product orientated, for example a private finance initiative (PFI) project, completion has a slightly different emphasis. Clients are, in general, buying a service they can use, rather than a defect-free building at completion, so are concerned with when they can derive benefit from the services being provided.

Is it finished yet?

As the end of a project is in sight, building services engineers, and everyone else, become weary with the project and are eager to move on whilst contractors, clients, investors and prospective tenants have their own drivers for getting the project classed as being complete.

The decision as to whether practical completion has been achieved includes an element of subjectivity and discretion. Building services engineers have to assess the extent of completion against the contract requirements and quantify those matters that are not complete.

There needs to be an equitable balance between a contractor's desire to get paid as much as possible as soon as possible, and the need to ensure that payments are in proper proportion to the work that is completed and does not get paid until all contractual obligations are properly completed.

Other issues may arise if more than one party is tied to a completion date, for example if a completion date triggers the start of a rental agreement. A misalignment may result in one party picking up the financial consequences of another party's breach.

The issue of a practical completion certificate does not necessarily mean that all the work has been completed in conformance with the contract drawings and specifications, and it would be most unwise for building services engineers to make such a statement. Even if building services engineers had been on site full-time they cannot ordinarily inspect all of the contractor's work throughout the construction project.

However, it is not unheard of for clients to request building service engineers (and other members of the design team) to be a signatory to the certificate, albeit with the language of these certificates limiting the building services engineers to 'the best of his or her knowledge based on his or her periodic observations' of the construction work.

11.2 Collateral warranty and latent defects insurance

Clients procuring a building for their own use have the contract with the contractors to provide them with protection against defective building performance. However, occupants who are not responsible for building procurement, for example tenants with full repairing liabilities and entities who purchase buildings from property developers, will not have any form of contractual relationship with the building services engineers and will consequently, need to protect themselves against financial loss resulting from defects that may appear in the building services engineering systems after practical completion.

For building services engineering systems, these parties can arrange for a collateral warranty, which is be a contract between the building services engineer, who is the warrantor, and themselves. The warranty can either be in the form of a 'simple contract' that allows the injured party to sue up to six years after the breach of contract or a 'contract under seal', for which the period is extended to 12 years.

Alternatively, parties may be able to arrange latent defects insurance to provide cover in the event of an inherent defect in the design, workmanship or materials becoming apparent after practical completion. This does not require the recipient to prove negligence or breach of contract, enabling cover to be provided on a 'no fault basis'.

11.3 Defects management

Ideally, all defects are eradicated at source, using the best building services engineers working within the best design teams, all with as much time and money as required. However, the total elimination of defects is impractical. It is, therefore, essential to ensure defects management processes are in place to ensure that the system or equipment as installed and operated does not adversely affect the end-users comfort and well-being, nor compromise the building operator.

Root causes and responsibilities for any defects can be complex and challenging to resolve. They may be attributable to design (thus the responsibility of the design team) and/or workmanship and materials (thus the responsibility of the construction team). After the expiry of the defects liability period, clients are usually entitled to monetary compensation only if they suffered a loss in terms of both direct and indirect costs associated with defects.

Snagging

Snagging will have been carried out prior to handover when the project is considered complete by contractors and is offered for scrutiny.

Snagging is not a contractual term but an informal expression colloquially understood to mean the process of identifying, by observation, uncompleted or minor defects, errors or omissions in the allegedly finished construction works and formulating them into a written report for the contractor to correct. Technically, the provision of a snagging list is an extra to contractual requirements. In reality, most parties see the benefit of the process. They make good sense to the parties to a building contract, providing a mechanism for communicating amongst the parties at the end of construction in order to facilitate an orderly transition between the construction of a building and its final use.

An area should not be offered for snagging without proper cleaning, including removal of debris or any unwanted materials, removal of protective materials and the operation of full and permanent lighting. Snagging may need to be carried out in sections, as agreed by all parties, as areas are progressively completed and closed off. Thereafter, the snagged areas are best locked-out to unauthorised access, so as to prevent deterioration, and will still require final inspection prior to handover.

Although it is possible to insist on completion of all snagging items before issuing the practical completion certificate, discretion and pragmatic judgment usually prevail to certify practical completion when minor works are still outstanding, for example touching up of painted surfaces and final fixing of labelling.

Rework is the work that has to be done to correct or rectify a defect because it was not done properly in the first place. Contractors have to bear the cost for this.

11.4 Documentation for handover

The aim of handover documentation is to provide a record of the installation, guidance on how the building should operate and demonstrate compliance with legislation and standards. This should be supported by the development and delivery of training programmes for the clients facilities management function.

Record of the installation

As-built drawings and the commissioning results provide a record of what has been installed. Together these provide information for the facilities management function to plan and manage the installation and as a starting point for designing future modifications and changes.

As-built drawings are based on the working drawings and include all the changes that have been made as the installation progressed.

Commissioning information provides evidence that the building services engineering systems are set up to operate in accordance with the design intent.

Guidance material for operation of the building

Guidance is required for both the non-technical end-user of the building and the technical operator of the building.

A user guide will provide information to manage the user's expectations of the building, for example what has been provided in terms of control for lighting, heating and cooling. It may include information to direct users to how they can contribute to the energy and water-saving measures.

The operations and maintenance (O&M) manuals define the requirements and procedures for the effective operation, maintenance, decommissioning and demolition of buildings. These usually include names and details of the building services engineering entity responsible for the design together with contact details. They will include an overview of the original design intent and descriptions of the building services engineering systems. Other supporting documents include:

- Health and safety file.
- Building log book, with guidance on energy targets and monitoring.
- Construction stage report.
- Design intent information.
- Keys and other security codes and passwords.
- Details of plant and system guarantees and warranties.
- Schedule of recommended spares and consumables.

Compliance with legislation and standards

Where there are statutory requirements for equipment, for example lifting and pressurised systems, to be tested prior to being put into use, evidence shall be provided.

11.5 Legacy design issues

There may be reasons that building services engineers are retained for design work after handover. There may be further design work, issues around latent defects to address or matters arising once the occupants and processes are in place within the building.

Residual design issues

It may be that there is still some design work required after handover, for example if a building was finished to a shell and core standard, possibly because the future occupants were not known or had not finalised their requirements. Further design work will be required to fit-out the building. For a commercial type building this could be a category A fit-out (Figure 11.1). Although there is no standard definition of category A for building services engineering systems, it is usually understood to mean that floors are fitted out for open plan use. A category B fit out is usually understood to mean partitioned offices and functional areas complete with small power and ICT outlets to suit furniture layouts, local control of lighting, heating and cooling.

Latent defects

There may be defects in the original design that may not become apparent or readily detectable, even with the exercise of reasonable care, until after the end of the defects liability period. Some latent defects do not appear until after occupancy, as they are dependent on the how the occupants use the space.

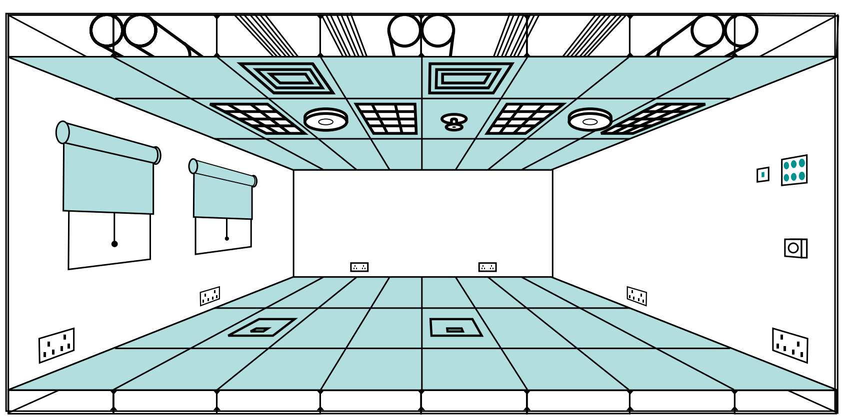

Figure 11.1 Category A fit-out

Examples of common latent defects include:

- Equipment located outdoors does not cope with the local microclimatic conditions, which may have change since the design stage, and weathers to a point that its functionality is affected.
- Under-strength concrete or misplaced reinforcement allowing movement damage to the structure, which shifts building services engineering distribution equipment out of alignment.

In such situations building services engineers would need to be involved to rectify the design defect.

Some care is necessary in determining the responsibility for faults that appear some time after handover, when the client is operating and maintaining the building. There may be issues determining whether a genuine defect and a nuisance claim has arisen. The likelihood of nuisance claims can be reduced by ensuring proper transfer of information and good training of the facilities management team.

Operations and maintenance

Buildings may underperform against design expectations due to lack of maintenance and poorly trained facilities management teams.

Particularly with respect to high-performance buildings, special care should be taken to identify and train the building operators and maintenance staff with reference to the specific building services engineering systems, to ensure continued performance. This is especially true in the case of mixed-mode building, which uses a combination of natural ventilation from operable windows (either manually or automatically controlled) and mechanical systems that include air distribution equipment and refrigeration equipment for cooling. Proposed set point temperatures should be clearly identified during handover and on system documentation, as temperatures are often set lower than would be required for thermal comfort of the occupants, because these low temperatures are perceived as a luxury.

Energy metering systems and monitoring and verification (M&V) programs can also provide highly useful information for fine-tuning operation and maintaining energy performance, but must be properly implemented and well supervised in order to have any impact; a high-tech monitoring system that is never accessed by the building operators saves no energy.

Complex discussions arise in respect of economic loss due to latent defects and unless the liability is completely clear and accepted by building services engineers, their insurers should be notified immediately of the incident because they may wish to be involved in the investigation process. There will need to be an agreement on what modifications are required and what compensation is due. If there is a health and safety matter or neither party is willing to accept liability for the defect, clients should take immediate actions and seek to recover compensation later.

Occupancy issues

Adjusting comfort for occupants with respect to building services engineering systems, particularly heating ventilation air conditioning, building management and lighting control system installations may not be achievable during the pre-handover commissioning. This is because the actual behaviour of the occupants and the actual processes happening within the areas are not tested. These may vary from those considered for the design basis and may change over the lifetime of a building.

Deficiencies that were not identified before occupancy may come to the attention of facilities management personnel through user complaints or routine operation. Initial underperformance can easily remain undetected, leading to long-term chronic problems that never get fixed. Or else it may be as simple as building occupants not being aware of the level of control they have over their local environment.

11.6 Post-occupancy evaluation

It is only when buildings are in operation that the building services engineering systems are truly tested for client expectations, design intent and performance outcomes and functionality. Often operational issues arise when those who use and occupy the building, but who are not experts in managing it, nonetheless have knowledge and opinions about its performance in relation to their own objectives that they wish to vocalise. A separation between construction and operation can mean that buildings are handed over in a state of poor operational readiness, particularly when programme delays have led to condensed testing and commissioning and pre-handover periods.

The benefits from implementing post-occupancy evaluations are the opportunities to provide a feedback loop to enhance continuous improvement processes, improve the fit between occupants and their buildings and the optimisation of services to suit occupants' real needs.

Although a seemingly good principle, post-occupancy evaluations may not happen because they are not integral to many procurement arrangements – although some building services engineers have altruistic rather than commercial drivers to provide the information. However, unless the findings are properly shared there is a danger that a standalone document will have limited visibility, meaning audiences who would benefit are unaware of the findings. Also, some building services engineers may feel that they are opening themselves up for potential liabilities by exposing potential failings in their designs.

There are different parameters that may be evaluated in a post-occupancy evaluation; for example occupant health and wellness, environmental conditions and energy and water-use monitoring.

No pat on the back

Of course if nobody moans, does that mean that everything is OK? How do we know that we are putting in a really good or the best possible design? That we are achieving the best possible comfort conditions for that building? That this is the best choice for a system? How do you know? What feedback do we get?

Most building services engineers are very reluctant to go back and say to people 'Did you like this, is it working alright, are you happy with it?' Because we are a litigious industry, everybody is frightened that someone might say 'No, and now you come to mention it, we want to have words about this.'

For if there are problems then everybody is looking for somebody to blame. Whose fault was it? What happened? What went wrong? … And it can cost millions of pounds to put right.

Of course, there have been studies, but these are few and far between, which is a pity because on the facilities management side you are in an ideal place to get reliable data. It is the facility management team that has to cope with the day-to-day problems and complaints.

Occupant welfare and wellness

Building users rate their satisfaction with their building. As well as the 'workers', users might include patients and visitors (for hospitals), shoppers (for retails units), exhibitors and visitors (for museums) and so on.

With respect to the building services engineering systems the focus would be on environmental comfort and control over environmental conditions; for example, the ability to control temperature and lighting.

What not to expect

Rarely, if ever, do building projects get finished and handed over and the new occupants walk in and enthuse about the contribution of the building services engineering to their working environment, and the building operators think they can put their feet up with respect to the building services systems.

It just does not happen. Architects may win awards for beautifully designed buildings of glass and steel with attractive staircases and things. But building services engineers? No! With any luck, the best building services engineers can hope for is an absence of complaints.

Measuring the environment conditions

This involves measuring the actual environmental conditions and comparing them with those included on the design deliverables. This is particularly important if there are gaps pertaining to health and safety and wellness matters, for example, associated with air quality, ventilation rates, noise lighting, acoustics and thermal comfort.

Energy and water-use assessment

This type of evaluation considers the actual usage of energy and water. Any performance gap between predicted and actual can be attributed to a mixture of poor assumptions when predicting energy consumption at design stage, for example standardised assumptions for occupancy hours and controls.

Occupant and management behaviour/approach can largely influence building energy consumption; ultimately governing how much, and for how long, energy systems are used. It should be remembered that building services engineers only design the fixed installation and cannot control what happens in-use, for example what is plugged into socket outlets, what is connected to water taps.

Summary

It is only when buildings are in operation that the building services engineering systems are truly tested for client expectations, design intent, performance outcomes and functionality. As part of this stage, building services engineers may be involved with closing out patent defects, examining handover documentation, dealing with legacy design issues and post-occupancy evaluations. Also, they may be able to support clients with respect to operation and maintenance matters, including fine-tuning to reflect the needs of the occupants and processes within the building.

12 Reporting and advisory roles

Building services engineers may be involved in reporting and advisory roles after the design work is completed. This may be as auditors, expert witnesses, expert advisors or as part of a dispute resolution process (Figure 12.1).

12.1 External audits

External audits may be commissioned by clients after the design has been completed. These aim to gather evidence in systematic way against specific audit criteria on an unbiased, fair, and independent basis: and to provide a properly written accounts in the form of reports.

Post-design audit

This is effectively a peer review on the design deliverables before construction commences. This may be part of a risk reduction plan to detect and correct design issues before they become apparent in the construction phase. The aim is to ensure that the design is as robust as possible in order to mitigate or eliminate the potential for construction defects. This is because the consequences of design errors left unnoticed go beyond re-work, extending in some cases to a knock-on effect on coordination, an increase in claims and disputes and, at the end of the process, higher operating and maintenance costs. This peer review may result in recommendations for design modifications or construction techniques.

Construction audit

A construction audit may be undertaken to ensure the project is being completed according to the contract terms. This may cover auditing paperwork and well as the activities on site.

Building Services Engineering: After Design, During Construction, First Edition. Jackie Portman.

Companion website: www.wiley.com/go/portman/buildingservicesengineering

Figure 12.1 External audit

Of particular relevance to building services engineers is witnessing the testing and commissioning. This is the last opportunity to verify the integrity of the design and installation before putting it into operation. Witnessing may take place in the factory, in a dedicated testing facility or, for the completed installation, on site. Although this may be undertaken by the building services engineer responsible for the design, due to its importance clients may choose for a second party audit.

Post-completion audit

Once the installation has been complete it may be prudent to review the integrity of the design; for example:

- An audit of the actual energy consumption and utility usage patterns against predicted energy consumption, and any targets or benchmarks set out in the design documentation.
- Post-occupancy 'complaints' from end-users relating to health and wellness issues such as indoor air quality (IEQ),thermal conditions (being too hot or cold), humidity, water quality, issues with the lighting installation and noise matters. The findings may conclude that there are issues that need to be referred back to the construction or design team, or else there will be a need to manage the expectations of the end-users. It may be that perception of IEQ can be affected by the psychosocial atmosphere at work and by job stress.
- Forensic investigation into failures of systems to comply with the design requirements. This may be tied to a specific event, for example the failure of the standby power system to operate in the event of the loss of the mains electrical suppl, or maybe a nuisance issue, for example hot water coming of a tap not being

of the right temperature. These investigations review the procedures associated with inspection and testing as well as the actual installation.

Types of audit

There are three classes of audit: first party, second party and third party.

It is expected that entities undertake a self-assessment of their own information prior to delivery. This is a first party audit. This should be done be personnel who are sufficiently independent of the design process but suitably experienced in the areas they are auditing.

One entity auditing another with which it either has, or is going to have, a contract or agreement is a second party audit; for example, before a design is assigned or novated to another entity it is likely that a second party audit will occur. This may be by the clients or the party taking the design forward.

Third party audits are performed by independent organisations, typically certification bodies or regulators.

First party audits are internal whereas second and third party audits are external.

12.2 Expert witness

Construction litigation in England and Wales takes place before the Technology and Construction Court (TCC), a specialist division of the High Court. Building services engineers may be commissioned to provide their knowledge in the form of independent expert opinion and to support their opinion during the course of litigation. As expert witnesses they provide specific knowledge in a certain subject area where their capability s beyond that of the normal person, sufficient that others may officially and legally rely upon their opinion about an evidence or factual analysis within the scope of their expertise; this is referred to as the expert opinion. This may require cross-disciplinary understanding of law, technical matters and practice.

Expert witnesses may be appointed by either party in a dispute. This may be clients, contractors, subcontractors, material suppliers, product manufacturers, law firms, insurance organisations or government departments. However, their opinion must be independent and they do not have any obligations to the appointing entity, regardless of whether they are paying for his services or not.

Such claims may relate to programme delays, disputes about whether the project is complete, cost of corrective work, additional costs suffered and dissatisfaction with the performance of a party.

12.3 Expert adviser

An expert adviser can be appointed by a party to assist and support in the formulation and preparation of a party's claim or defence. They have an overriding duty to the party appointing them. They do not need to have expert capability, just that of a competent person.

12.4 Dispute resolution

Building services engineers may provide their services as mediators, adjudicators or arbitrators.

Mediators assist parties to reach a mutually satisfactory resolution and settlement of their dispute in a non-legally binding process. There is no resolution between the parties until all the parties agree to their own settlement. Without everyone involved saying 'yes' there is no deal and the settlement is non-binding until a settlement agreement is written and signed. Only after it is signed does it become a legally binding contract. A party can unilaterally withdraw from mediation.

Adjudicators also assist parties to come to resolution themselves. Adjudication is slightly more formal than mediation, but still without resorting to lengthy and expensive court procedure. The decision is final and binding, providing it is not challenged by subsequent arbitration or litigation. The parties are obliged to comply with the decision of the adjudicator, even if they intend to pursue court or arbitration proceedings.

Arbitrators listen to and consider the facts and evidence presented by the parties, applying the relevant laws and issuing a final legally binding award, but still without resorting to lengthy and expensive court procedures. Arbitration is a procedure in which a dispute is submitted, by agreement of the parties, to one or more arbitrators.

Mediation, adjudication and arbitration are all consensual and can only take place if both parties have agreed to it and to not involve attendance at a court and a decision made by a judge. If none of these options is followed, disputes between parties are determined by a formal legal route involving expert witnesses.

Once the responsible party is clearly identified, there is the issue of proving and quantifying the resulting direct costs, indirect costs and any programme impact.

Summary

Building services engineers may be appointed to provide reporting and advisory services after the design deliverables have been completed. They may undertake roles as (first, second or third party) auditors, expert witnesses, expert advisors or as part of a dispute resolution process.

Feedback question

1 Do clients make the word 'claim' seem like a 'dirty word'? If a contractor believes that additional compensation, due to a particular situation, is justified then it should firstly formally advise the client. In your experience do you find that clients encourage or discourage this, assuring contractors of future satisfaction but no action until the notice period has expired and the contractor's rights are compromised?

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Building Services Engineering: After Design, During Construction, First Edition. Jackie Portman.

Companion website: www.wiley.com/go/portman/buildingservicesengineering