NOTTINGHAM POLYTECHNIC
DEPARTMENT OF BUILDING AND ENVIRONMENTAL HEALTH

# BUILDING ENGINEERING SERVICES IN THE CONSTRUCTION PROCESS

**Raymond Archibald Bousfield**

**A thesis submitted in partial fulfilment of the requirements of the Council for National Academic Awards for the Degree of Master of Philosophy**

**March 1992**

To Katie

## CONTENTS

## LIST OF TABLES



## LIST OF FIGURES

## ABSTRACT

## BUILDING ENGINEERING SERVICES IN THE CONSTRUCTION PROCESS

Historically, the education of construction professionals has been dictated by the requirements of the professional institutions. In civil engineering there is a degree of autonomy because the education and training of both consultants, and contractors, is identical but in building there are many participants in the professional side of the construction process creating a division between design and contracting.

Although many professional building services engineers are members of either the Institution of Electrical Engineers, or the Institution of Mechanical Engineers, it wasn't until 1976 that a discrete professional identity was obtained by the evolvement of the Chartered Institution of Building Services Engineers from the Institution of Heating and Ventilating Engineers.

Building services engineering contracts are generally carried out as sub-contracts to main contractors and it is not unusual to find that services engineers have deficient knowledge of both contract and financial control. Equally, a major deficiency that occurs in the education of the other construction professionals is a competent knowledge of building services engineering.

Many construction professionals find it difficult to accept the importance of services engineering even though their total cost in many commercial contracts is often in excess of other construction sectors.

The multi-disciplinary nature of building engineering services is probably a major reason for the lack of recognition and until construction becomes multi-disciplinary at all levels of operation, the status quo will remain. The formation of the Construction Industry Council in 1990 was the first positive step towards unification and may probably lead to the formation of common first degree courses.

Recent developments in building procurement have resulted in Employers having a greater influence, and the advent of design and build contracts is an example which building services engineering contractors have generally welcomed as they are able to control both design, and installation.

This research was undertaken at Nottingham Polytechnic during the period January 1987 to March 1992 and is not registered for any other award.


## ACKNOWLEDGEMENTS

I wish to give special thanks to my supervisors, Professor Peter L Clark Ph.D., RIBA, Ch.Arch., FCIOB, Hon.FASI, and the late Professor Roger Smith Ph.D., for their help, advice, and encouragement. Before his untimely passing Professor Smith was extremely helpful and supportive and his academic help was sorely missed at the latter stages of the research. Professor Clark's help, advice, and encouragement, throughout the research and particularly at the writing and editing of this thesis has been incalculable.

I also wish to thank Mr Bryan Hunt, Hon.FASI, FFB, the Chief Executive of the Architects and Surveyors Institute for his help at the commencement of the research, and Professor T J Lane MSc, FCIOB, MAPM, for his encouragement at the latter stages of completion.

# INTRODUCTION

The latter part of the twentieth century has seen the emergence of a harsh competitive financial climate in the United Kingdom unparalleled since before the 1939-45 World War,[1] and nowhere has it been more pronounced than in the operation of new construction contracts.

The steady decline of the United Kingdom economy has been arguably due to the inability of industry generally to modernise equipment and operations because of poor management, an inflexible and inadequately trained work force, and the emergence of fierce competition from other countries, particularly those in the third world. To counter the more efficient competition, commerce and industry have had to reduce unit costs, initially by reducing the number of employees, secondly by obtaining higher productivity from the remaining workforce, and thirdly by demanding lower costs from suppliers and the services industries. In construction, client demands for a quick return on their investment has led to pressure on all members of the construction team to complete designs and construction on much shorter time scales than were previously acceptable.

Traditionally, main contractors were responsible for the whole of a particular construction or building project and employed the majority of the personnel carrying out the work. Modern construction practice generally sees the main contractors' role as being that of a manager ensuring that the various sub-contractors carry out their particular work on time, to the required quality, and within costs acceptable to the main contractor.

The supervision of sub-contractors allied to general construction techniques rarely create problems but the supervision of building engineering services sub-

contractors frequently does. The problems attributable to the supervision of building engineering services are usually because of the lack of services engineering knowledge by construction technologists, managers, and quantity surveyors.

In commercial buildings, building engineering services have become more complicated and expensive, and it is possible, with the more complex engineering services installations, for them to account for as much as 70% of the total construction costs. The realisation of the changing emphasis in construction costs has been a slow process and is still not appreciated by many of the parties to construction contracts. The complexity of building engineering services has arisen from the demand by both clients and building occupants for comfortable internal environments, plus, at the same time, the clients requirement to keep total building costs as low as possible. It follows therefore, that building engineering services installations can represent a major initial cost, be the dominant factor in operating costs, and be a vital aspect of user satisfaction.

Within the construction industry, economic decisions on the design of buildings have traditionally been based on a comparison of initial capital costs as these were classed as being the simplest to assess. If this method alone is used it ignores other important factors such as operating costs, maintenance costs, energy costs, and occupancy costs and therefore it is advisable to use the method of life cycle costs to assess the economic viability of a particular building. Life cycle costing can be defined as "the total cost of an asset over its operating life", and takes into account both initial and operating costs.

Whilst accepting that some designers use a crude form of life cycle costing when selecting equipment and materials, the Royal Institution of Chartered Surveyors[2]

suggest that all construction designers develop the necessary expertise to be able to provide clients with detailed life cycle costs of buildings and components.

The importance of building engineering services in any assessment of life cycle costs can be ascertained by considering major areas of continuing costs within buildings. Energy and water costs are two areas that add annually to the overheads of building operation, and poor selection at the design stage can create major problems for building owners. The use of life cycle costs techniques requires that all members of the design team are aware of the technical factors which lead to increased costs, particularly within building engineering services.

The number of disciplines within building engineering services are an enigma to many non-building engineering services personnel because whilst traditionally the sector comprised drainage, hot and cold water, and electrical installations, the requirements to provide comfortable internal environments in modern buildings has led to a far wider range of services. Mechanical ventilation, air conditioning, lighting, electronic controls, vertical and horizontal transportation, fire protection, and gaseous systems have to be added to the traditional services and it is these additional systems which raise the cost as a proportion of the total construction costs.

The creation of comfortable internal environments is a difficult process as rarely do a group of people agree on air temperatures, relative humidity, and air speed levels. Usually acceptable ranges are $18^{o}C$ to $24^{o}C$ for air temperature, 30% to 70% for relative humidity, and 0.1 metres per second to 0.4 metres per second for air speed, but all are relatively wide bands. The difficulties of creating acceptable internal environments are apparent with the problems of "sick buildings" and "legionnaires" disease, both resulting from designers and building owners trying

to either achieve comfort at economic costs, or cost reduction in engineering services operation and maintenance. "Sick building syndrome" is of great concern to employers as it results in occupancy illness but has no clearly defined cause, although lack of ventilation is suspected, whereas "legionnaires disease" has been traced to polluted water sources, particularly the cooling towers of air conditioning systems.

In the United Kingdom, the training and education of architects and builders has concentrated on the design, production and technical aspects of buildings with little reference to costs control and management.

From the mid 1970s the latter has been rectified in many building courses, but because of the short duration of the courses there has been a tendency to concentrate on management, at the expense of technology. This has followed a similar pattern to the training of quantity surveyors, where the concentration has been on the process of measurement to rigid rules, and also costing, and contract law at the expense of technology.

Flanagan (1980)[3] drew attention to the latter serious defect in quantity surveyors' knowledge, and also suggested that research in quantity surveying was at the stage of development that engineering had been one hundred years previously.

Education of the construction professionals is discussed in Chapter Two together with the implications of a united Europe.

Before understanding the relationship of the parties involved in the United Kingdom construction industry it is necessary to review the historical origins of United Kingdom construction and the way the various parties have evolved.

These relationships and their evolvement are discussed in Chapter One.

The social status of construction in the United Kingdom is also a major problem for recruitment into the industry. Historically, high social status has been achieved by professions able to promote a caring image, show a perceived need for extensive training and education, together with a social identity showing that their technical knowledge requires careful judgement in its application. A 1965 study by Higgins & Jessop[4] concluded that the construction industry was afflicted with ill defined responsibilities within the construction team with conflicts of interest and lack of rapport between professional disciplines. Higgins & Jessop also suggested that inequalities of prestige affects the patterned ways in which members of different occupational groups act towards each other and considered that inter-occupational status evaluations in the construction industry have an effect on performance and organisational relationships. The discussions in both Chapters One and Two aim to show how the different occupational evaluations have evolved and how the different attitudes between traditional building personnel and building engineering services have been created.

The necessity to conserve the use of energy has led to increased levels of thermal insulation to buildings, which in turn has meant reductions in heating load requirements, and reductions in the relative capacity and cost of heating installations. Where consulting engineers are paid on a fee scale related to the cost of the building engineering services, the reduced capacity of the installed system has resulted in lower fees even though the design work is of a similar nature. The introduction of fee competition amongst consultants has also contributed to reductions in fees, with the result that consulting engineers provide less detailed information to the sub-contractor, thus adding another factor to possible construction delays.

Quality Assurance to British Standard 5750:1979 is widely used throughout the manufacturing industry in an attempt to improve the quality of finished products and is slowly becoming an accepted requirement in construction, but research has shown[5] that faults arise on new building services engineering contracts in the following proportions:-

| | 1982 | 1988 |
|---|---|---|
| Product related | 10% | 26% |
| Construction related | 49% | 41% |
| Design related | 59% | 33% |

Faults due to workmanship remained fairly steady, whereas design related faults appeared to fall considerably, but this may have been due to an increase in workloads or the fact that more design was undertaken by sub-contractors. Manufacturing faults also increased, but again extra workloads may have been the cause.

Traditionally the role of co-ordinator for the building engineering services element of a contract was carried out by the Architect, but on modern contracts, main contractors generally undertake co-ordination. Unfortunately, main contractors have little more knowledge of engineering services than the Architects, and on many occasions fail to realise that different tolerances are required for the various components. A National Economic Development Office Survey found that two thirds of construction contracts were late on completion due to sub-contractors performance. Delays can be attributable to a variety of causes and these are discussed in Chapter 3. When building engineering services were less complex, and in many buildings virtually non-existent, as around the beginning of the 19th century, the early contractors (plumbing and heating), were found to be manufacturers marketing patent products and quoting prices for the design and

installation of systems involving their own products. The separation of manufacturer and installer did not commence until the middle of the 19th century and the process was gradual, with the manufacturer's using local labour to instal their equipment, and then sub-contracting the work on a more formal basis.[6] The specialist heating and ventilation contractor began to emerge when some of them withdrew from manufacturing and offered a design and installation service to the client. Equipment was obtained from those remaining in the manufacturing sector.

The introduction of design only by some of these contractors produced a further separation, and was the forerunner of the modern consulting engineer. The emergence of separate contractors had a profound effect on the marketing approach of the contractors who were no longer using their own products and they often had to convince a consultant or specialist designer that they could carry out an installation using the products of another company. Until the second decade of the 20th century there were generally only four parties involved in the building operation, namely the client, the architect, who was both designer and co-ordinator, the main contractor, who deployed the majority of the craft skills, and a few specialist contractors. It was common for the building services engineering contractor to have direct contact with the client, who both paid and appointed them. How this phenomenon has repeated itself to a lesser degree with the operation of modern construction management contracts and trade contracts is discussed in Chapter Four.

In modern construction there are numerous contractors all vying for space, and additionally there are consulting engineers, a quantity surveyor, an architect, a main contractor, and a client all wanting to input into the operation of a contract.

The changed influential position taken by clients in modern construction has caused a radical overall of construction contracts, with the insertion of onerous clauses, which overrule the clauses previously agreed in standard forms of contract, and this area is also discussed in Chapter Four.

The introduction of performance bonds, whereby if a sub-contractor fails to perform correctly the bond can be called in is a further complication for contractors, and requires more efficient management and supervision. Poor management expertise is an area frequently levelled at building services engineers.

Another difficult area for building services engineers is shown to be that of contract knowledge, and many of the criticisms by personnel interviewed, and discussed in the Chapter Five, relate to this lack of knowledge.

That there are problems between building services engineering and traditional construction cannot be denied and the aim of this thesis is to explore why there are difficulties, and to suggest how they could be alleviated.

## REFERENCES - INTRODUCTION


1) Beckman, R., "Into the Upwave" Milestone Publications

2) Flanagan, R., and Norman, G., "Life Cycle Costing for Construction" 60.003, QS Division Royal Institution of Chartered Surveyors,

3) Flanagan, R., "Tender Price Time Prediction for Construction Work", 1989, Doctoral Thesis, University of Aston

4) Higgins, G., and Jessops, I., "Communications in the Building Industry", 1965, Tavistock Publications, London

5) BSRIA Report, "Construction Midlands", p.4, July/August, 1990, Wealthstream Ltd., Manchester

6) Heating and Ventilating Contractors Association, "The Story of the Heating Engineers", 75th Anniversary, 1979, London

## CHAPTER ONE

## THE EMERGENCE OF THE CONSTRUCTION PROFESSIONALS

The approach to the construction process in the United Kingdom can generally be divided into Building and Civil Engineering, with the civil engineering approach having a higher degree of autonomy than that of building. Autonomy in Civil Engineering occurs because the design, management, and construction processes are usually undertaken by civil engineers, who have all received similar education and training. In building, several professions, each receiving differing education and training are involved in the construction process.

Bowley (1966)[1] and Hillebrandt (1984)[2], have chronicled the evolution of the construction process in the United Kingdom and both have drawn sharp distinctions between the building and engineering disciplines and state that in the building process, the main engineering discipline is usually that of the building services engineer.

The Banwell Committee Report (1964)[3], on the placing and management of contracts for building and civil engineering, stressed the need for collaboration between all participants in the construction process, whether they be client, professional, contractor, or sub-contractor.

Riley (1991)[4] describes how building services engineering sub-contractors have to endure unfair conditions imposed on them by main contractors. He cites examples of fixed price tenders for indefinite periods, the refusal of main contractors to provide contract programmes to sub-contractors, and the problems of obtaining payment even if stipulated in contract conditions. His allegation that contractors

are often in conflict with sub-contractors, and that both are in turn in conflict with suppliers, with reciprocal action, suggests that little has changed in construction since the publication of the Banwell Report.

Unlike other countries, particularly those of mainland Europe, education and training in the United Kingdom has been dominated by the professional institutions. During visits to both higher education institutions, and construction companies in mainland Europe by the author (1990/91)[5], the difference in approach was forcibly reinforced. It was stated repeatedly that the influence of professional institutions as perceived in the United Kingdom, would not be permitted. The State and Universities on mainland Europe appear to have had full control of syllabus content for a longer period than has occurred in the United Kingdom. Prior to the expansion of public sector higher education from 1964 in the United Kingdom, the main examining bodies for the construction industry professional were the professional institutions. They therefore could be seen as fulfilling a role not readily provided by State education.

The Construction Industry Professional and Higher Education Review Group Report (1988)[6], commonly known as the CIPHER Report, emphasised the urgency for the participants in the United Kingdom construction industry to unite to meet the increased competition from the European mainland after the creation of the single European Market on 1st January 1993. The Report also referred to the traditional historical divisions within the construction industry, and that the divisions rarely reflected the needs of a modern society or market economy.

CIPHER embraced all sections of the construction industry and was remarkable in that it was the first time that such a meeting had ever taken place. However, the Chartered Professional Institutions involved in building and civil engineering

and who had formed the Building Industry Council (BIC) in November 1988, were not content to allow a wider spectrum of construction interests to dictate the industry policy. Whilst participating in all the CIPHER meetings (of which the Author was in attendance), they attempted to denigrate the CIPHER proposals, by suggesting that as their Institutions had both educationalists and industrialists in membership, they could speak for the industry with one voice. This was unacceptable to the non-chartered professional institutes and trade organisations. The United Kingdom national Government also indicated through its Agencies, i.e. Training Agency and National Council for Vocational Qualifications, that financial support would not be provided for any industry consortium unless that industry was united.

The Author was a member of the working party that produced the CIPHER Report which was essentially a compromise between CIPHER and BIC.

A major problem was the choice of the term building or construction in the title. Initially, representatives from institutions such as the Chartered Institute of Building and the Chartered Institution of Building Services Engineers were adamant that the term "building" should be used, but eventually acceded to the term "construction".

The Construction Industry Standing Conference was formed at a meeting of CIPHER and BIC representatives in 1990 at the offices of the Institution of Civil Engineers. Its remit was to produce proposals for training and education in the construction industry. CIPHER and BIC effectively merged to become the Construction Industry Council and whilst many of the partisan problems affecting the industry emerged during preliminary meetings at least a concerted attempt at unification of the industry had begun.

The first professional institution in the construction industry was that of the civil engineers, with an initial meeting taking place in 1818. Seven engineers, who all had mechanical engineering backgrounds, decided to meet on a regular basis in London to discuss mutual engineering matters.[7] By 1820, only two extra members had joined the original seven, but they invited Thomas Telford to become the first president in the same year, and his influence, and enthusiasm resulted in a rapid increase in membership. Telford was adamant that the Institution should fulfil its role as a learned society and encouraged members to submit papers for discussion, thus paving the way for a Royal Charter which was eventually granted in 1828.[8] By 1989, world wide membership of the institution had grown to in excess of 70,000.[9]

During the 17th and 18th centuries, the generally accepted method of building organisation was for the client to employ people who were both architects and builders. As many building designs exceeded the competence of the average architect/builder it was inevitable that a separate institute, catering for architects only, would be formed, particularly as the architects were jealous of the reputation of other professionals such as the legal and medical professions.[10]

The Institute of British Architects was formed in 1834 and undertook to confine competition within the profession to achievement in design and competent supervision of work. A Royal Charter was granted in 1866, but the Royal Institute of British Architects (RIBA) aim for a fully professional system of architecture was slow to evolve. During the early years of the 20th century the vast majority of practising architects did not belong to the Institute, and the designation "architect and builder" was still commonly in use, although such people could not be full members of the RIBA.

In 1909, the RIBA decided upon a policy to seek legal powers to establish a register of architects which would exclude persons having an interest in contracting, and eventually, in 1938, the campaign was successful with the passing of the Architects Registration Act.

The Act specifies that anyone wishing to practice as an Architect must be registered with the Architects Registration Council of the United Kingdom (ARCUK), but they do not necessarily have to be a member of the RIBA, or any other professional body. The Architects Registration Council determine the level of examinations necessary for Architects. It also assesses the ability of Institutes of Higher Education to provide the examination standards required for registered architects.

Bowley[2] questions why architects should have taken such extreme steps but accepts that clients ought to be able to consult architects who do not have a financial interest in either building companies or materials suppliers. However, Bowley compares the architects decision with that of the civil engineers who have not considered such measures necessary and suggests that a differential register catering for the differing categories of architect would probably have been more realistic.

Hillebrandt[11] suggests that the poor public image of building as a career relates to the fact that, for many years, Architects and Chartered Surveyors were not permitted to participate in commercial activities such as contracting. Therefore, the directors of building companies were either people who had progressed from craft level, or civil engineers, and thus the only obvious source of well educated building personnel were not in the mainstream of contracting. Whilst this may be generally correct, the lack of recognition of the status of the Engineer in the

United Kingdom as compared to recognition on mainland Europe is probably a more pronounced factor. The Engineer's status in mainland Europe is equivalent to that of the Architect, although in countries such as France, an architect must be employed to obtain planning/construction approval. By prohibiting Architects from contracting involvement in the United Kingdom, Hillebrandt[11] suggests that they obtained little knowledge of construction management. By excluding such knowledge, the separation of design and construction was compounded.

In the early 1960s architectural education was broadened to include management whereas prior to this period the emphasis was on artistic creativity. Many practising architects were unhappy with their exclusion from commercial activity, and, in 1984,[12] changes in the rule of conduct by the RIBA allowed participation in commercial activity. This, plus the introduction of fee competition, produced a watershed in architecture, and professionalism began to vie with commercialism.

Thomson[13] suggests that architects have not profited generally from registration and includes this as one of the reasons why the Royal Institution of Chartered Surveyors abandoned the aim of a register for surveyors in 1952. However, he does not provide any firm evidence for this suggestion, and it is probably more correct to state that the many facets of surveying would preclude such a register.

Whilst the RIBA is the dominant professional institute for Architects, many Architects have been dissatisfied with what they saw as isolation from the rest of the construction professions. A minority of Architects have attempted to break down this isolation by becoming members of institutions having a wider membership.

The formation of two institutes, the Faculty of Architects and Surveyors (FAS) in

1924, and the Incorporated Association of Architects and Surveyors (IAAS) in 1926, were examples of attempts to breakdown barriers. After the passing of the Architects Registration Act, both institutes had to limit new Architect members to Registered Architects. In 1989 the FAS had 300 Architects in a total membership of less than 2,000, and in order to survive it had to merge with the Construction Surveyors Institute (CSI) to form a new body, the Architects and Surveyors Institute (ASI). The ASI is a multi-disciplined Institute embracing membership from every discipline in construction, but it is having to compete against the entrenched historical position of the larger chartered institutions.

The IAAS also had only limited success in attracting Architects into membership and in 1989 had a total membership of less than 4000. The vast majority of members being non-architects.

In 1986, Faulkner and Day[14] concluded that the Architect was still generally seen as the most eminent member of the construction team in the United Kingdom. However, it has to be recognised that this eminence is under attack with the use of new procurement methods, such as design and build. In this method the Contractor is the dominant member.

It could perhaps be argued that the differing training and education methods adopted by the various professions contributes to the lack of clearly defined leadership.

Hillebrandt[15] cites the lack of contact between students before commencing practice, coupled with a constant attempt to determine leadership, as a major reason for distrust between the various professions.

Before the formation of the RIBA the Architect often undertook the role of Measurer, whereby completed building work was measured in detail before payment was made. Burrows (1987)[16] indicates the necessity for architects, during the period before the formation of the RIBA, to be able to measure building work because of the system of contracting used, i.e. measure and value. In this system, the builder submitted prices for individual items of work, which were measured on completion to ascertain the actual amount carried out.

The Institute of British Architects on its formation precluded Architects from measurement activities. However, as Burrows (1987)[16] points out, only 9% of the architectural population was in Institute membership in 1841 so little change occurred. During the period 1750 to 1850 Burrows (1987)[16] states that measure and value contracts had to compete with contract in gross. In the latter system contractors submitted a lump sum tender and the use of measurers began to wane.

Measure and Value methods were weak in that employers had no idea of total construction costs before completion. Contracting in gross, however, required full detailed working drawings from the Architect. Unfortunately few Architects of that period were capable of producing drawings for the more complicated building. Measure and Value did, however, relate to the exact quantity of work carried out.

Thompson[17] describes how the Architects denigrated the Measurers of the 19th century in their aim for professionalism. By excluding the measurer from the architectural profession, the newly emerging quantity surveyors were also excluded.

The Builder Journal, founded in 1842, was instrumental in enhancing the status of surveyors. Correspondence and articles in the journal during the period 1842

to 1870 was influential in uniting the various surveying disciplines. The Editor of the Builder was the sole press representative at the first meeting of the Institution of Surveyors in November 1868. Criticism of the education and training of surveyors had led to the formation of the Institution.[18] Remarkably, similar criticism of surveyor training in 1952 led to the formation of the Construction Surveyors Institute which will be described later in this chapter.

The Institution of Surveyors had a bias towards land surveyors with the founder members being more concerned with practical training than education. A founder member, William Sturge,[19] positively stated that "a university education was not a good thing for surveyors".

Central Government, in 1861,[20] classed civil engineers as professionals, whereas architects and surveyors were placed in the industrial class. However, by 1881 architects were reclassified as professionals, as were surveyors. The status of the engineer was therefore enhanced for the brief period associated with the engineering developments of the industrial revolution.

The first surveyors in the Institution of Surveyors were mainly land surveyors with a small mix of mining, valuation and quantity surveyors.

The Institution defined professionalism in a similar way to the Oxford English Dictionary in that they practised a calling, as distinct from trade or business.[21] It is perhaps at this time, that the lowering of the engineers status began, as against the so-called professionals. Quantity Surveyors belonging to the Institution of Surveyors, were not permitted by the Institution to be employed by building contractors. This bar to contractor employment was in force until 1967 with training and practice only being permitted inside the office of an independent

practising quantity surveyor.[22] (The Institution achieved chartered status in 1881 and became the Royal Institution of Chartered Surveyors in 1946).

One of the first building contractors willing to undertake the whole of the trades work in a contract (contracting in gross) was Thomas Cubitt in 1815.[23] Generally, architects were against this system in that they feared poor workmanship, the use of inferior materials, and disputes over claims for work not in the original specification. Thomas Cubitt's brother, William, argued that the system of measure and value created problems, in that there was no uniform system of measuring. He also criticised the fact that contractors had to pay for measurers, who had to be attended to by workmen from each trade. Whilst the arguments from architects and builders differed, they both agreed that a detailed specification was required from the architect. Architects did however fear that builders would take advantage of loosely drafted specifications.[24] This argument is still common and often prevalent in modern construction.

As described earlier, correspondence and articles in the Builders Journal were instrumental in enhancing quantity surveying. One such article in 1862[25] compared contracting in gross with the use of bills of quantity. It was suggested that quantity surveyors produced full and meticulous bills so as to protect themselves against claims from the builder, but at the expense of the client. The suggestion was that "quantities in full", as they were known, raised prices and the benefit of competition lost if the cost of the work was enhanced.

This statement has been repeated to the author by many building and civil engineering contractors over the past decade. It was also an argument used by the British Property Federation when they introduced their own form of contract in 1983, which was different from the Standard Form of Contract generally in use

for contracts.

A further letter to the Builder in 1863[26] criticised the abuses of some quantity surveyors who touted for any work that was advertised. The latter suggested that respectable surveyors should wait to be asked to produce bills of quantity from builders or architects. Such comments were instrumental in the formation of the first Institution of Quantity Surveyors despite the opposition of Architects and Civil Engineers.[27] Whilst the Architects and Civil Engineers disagreed as to the levels of competence required, they were united in their opposition to quantity surveying as a profession. They both saw it as being a narrow, boring process and not intellectually stimulating.

This is probably still true today for the production of bills of quantity but the profession has partially moved into a cost control role using more sophisticated methods of analysis. Production of bills of quantity are however still the basic source of income for many independent quantity surveying practices.

Many building contractors were concerned that quantity surveyors could not be admitted to the RICS if they were employed by contractors. In 1977[28] the RICS publicly stated that the training of Quantity Surveyors should be directed towards equipping him/her for the task of securing value for money for the client. John Laing[29] was one of the first building contractors to employ quantity surveyors, especially in contract negotiations with clients. Because these surveyors were barred from the RICS, the question of formal qualifications often arose. Eventually, with the assistance of John Laing, the Institute of Quantity Surveyors was formed in 1938. It accepted both contractors and independent surveyors into membership, although it was generally recognised as the contractors quantity surveyors Institute. Because of the John Laing influence, a succession of senior

personnel, employed by Laing, were actively involved in the Institute administration.

Several attempts were made, after 1967, to merge the IQS with the RICS, but were generally resisted. However, in 1983, a ballot of members in both institutions resulted in a merger, whereby the IQS disappeared into the RICS. All previous corporate members of the IQS became Chartered Quantity Surveyors within the RICS. Despite the inclusion of contractors quantity surveyors, the total quantity surveying membership of the RICS was shown in a survey in 1986[30] to be only 36% of the total surveying membership.

After the second world war (1945), many contractors were still employing unqualified contract surveyors. Correspondence in the Illustrated Carpenter and Joiner (1952), now Building Today, on this topic attracted replies from many experienced surveyors. They wanted an institute specifically for contractors surveyors which did not include clients quantity surveyors. A general meeting was held in Sheffield and the Building Surveyors Institute was formed.[31] Because of its limited appeal the Institute changed its name to the Construction Surveyors Institute (CSI) in 1969, so as to include surveyors in other disciplines.

Like other Institutions, such as the IAAS and the FAS, formed by disenchanted members from larger Institutions, the CSI membership remained fairly static around 4000. An attempt was made to merge with the Chartered Institute of Building in 1978. Agreement from 75% of the CIOB membership was required but this failed by 7%. With a static membership it was inevitable that other mergers would be sought and eventually the Architects and Surveyors Institute was formed in 1989, as described earlier, by an amalgamation of the CSI with the FAS..

The formation of general building contractors, able to undertake contracting in gross, in the early nineteenth century was instrumental in the formation of the Builders Society in 1834. This was the forerunner of the Chartered Institute of Building. Membership of the Builders Society was confined to London until 1884. It then became the Institute of Builders, and national applicants were accepted into membership.[33] The membership consisted of building contracting owners, and by 1867 had achieved a high level of respectability.[32] However, the Institute had little impact on the education of builders for the first seventy years of its existence.

Kelly[34] describes the social gap that existed between employers and the labouring classes in the early nineteenth century. He suggests that employers had little time for education other than technical training. The early master craftsman had to be able to read, write, interpret basic accounts, and their dependants shared the same levels of education. Apprentices of the same 18th and 19th century periods were also in a privileged position. However with eighty percent of pupils leaving elementary school before the age of twelve, the social gap was pronounced.[35]

Hillebrandt[2] suggests that because the Institute of Builders was perceived by the industry as being a social club, few people were attracted into membership. In 1955, with only 2000 members its very existence was in doubt. A change of name to Institute of Building was made, and its status enhanced, by the introduction of an academic examination structure.[36] Together, with concerted liaison with Colleges of Further and Higher Education, the new status resulted in a rapid expansion in membership. Membership is now in excess of thirty thousand, and although half its members are below corporate level, the Chartered status ensures that it is now accepted alongside the traditional Chartered Institutes.

The recognition of the mechanical and electrical services engineer (now professionally termed building services engineer) has been a slow process in the construction industry. This is despite the fact that many modern commercial buildings have a building services content approaching fifty per cent of the total contract cost. During the industrial revolution of the 19th century, heating boilers were introduced which were installed by engineers and ironmongers, who had diverted into heating apparatus manufacture.[37] Many public buildings of the 19th century were installed with heating systems, providing air temperature levels of 14°C which was classed as luxurious. During this period the separation from manufacturer and installer occurred, with the emergence of the specialist heating and ventilation contractor. These specialist contractors offered clients a design and installation service with equipment purchased from a manufacturer.

Until approximately 1920 the four main parties to a building contract were the Client, Architect, Main Contractor, and a few selected specialists such as the heating engineer. The latter was usually paid direct by the Client, who appointed him.

The first Institute catering for building services was the Institute of Sanitary Engineers founded in 1895.[38] In 1955 it became the Institution of Public Health Engineers. However the main interest of the Institute was in public authority services such as drainage and sewage disposal. The Secretary of the Institute proposed that members interested in heating should form another Institute and in 1897 the Institution of Heating and Ventilating Engineers was formed. Mr Luwee Harris from New Jersey, who described himself as a civil engineer, architect, and structural engineer, was the first Secretary.

The first President was an Ironmonger, Mr John Grundy. To cater for lighting

engineers the Illuminating Engineering Society was founded in 1909, by academics from Universities, with financial help from industry. This followed a visit to the United States of America by Mr Leon Gaster, who was sponsored by the English Holophane Company, to study illumination engineering in America.[39] It can be seen therefore that there was American influence in the founding of the two bodies who eventually formed the Chartered Institution of Building Services Engineers.

The path to the eventual Charter was long and difficult. Initially, Scott (1972) reported,[40] critics argued that the discipline of building services was too narrow. Secondly, it was then argued that it ought to be regarded as a cross-disciplinary activity, and therefore too broad for a university course. The initial argument seems fatuous when compared with the discipline of quantity surveying. The second argument was advanced by secular interests in mechanical, civil, and electrical engineering.

Scott argued that the scope of the IHVE was too narrow and the 1978 amalgamation with the Illuminating Engineering Society perhaps proved his point. He also argued that the name "Environmental Engineer", as against "Building Services Engineer" should be adopted. He suggested that the latter was too narrow and implied that such a term related to engineers servicing a building. However, the majority of engineers in the IHVE preferred Building Services Engineer as being more practical, and was also supported by national government.

The Chartered Institution of Building Services Engineers became a reality in 1976 and now has a membership in excess of 13000. Although small in comparison with other chartered institutions it is a member of the Engineering Council enabling qualified members to use the title "Chartered Engineer".

Whilst now accepted as a CEI member, it is ironic that in 1972, a CEI committee recommended that building services should be a post graduate study after a basic training in mechanical, electrical or civil engineering.

Another Engineering Council (formerly the Council of Engineering Institutions) member, the Civil Engineers, tried in 1971 to promote a Society of Building Services Engineers.[41] At the same time, the Institution of Mechanical Engineers suggested a merger with the then IHVE. All IHVE members would have been granted chartered status but would have lost their identity as building services engineers.

Whilst several people, including Scott in 1972, have defined the building services engineer as a person capable of designing several individual services, the industry's perception is still that of either a mechanical, or electrical engineer. Electrical services designers are usually members of the Institution of Electrical Engineers. It would appear therefore that the Chartered Institution of Building Services Engineers whilst catering for mechanical and electrical engineers is still predominantly a heating and ventilation institution. It probably follows that unless further growth can be achieved in membership, merger with one of the larger institutions may be necessary.

A general criticism of engineers is that their knowledge of costing and management contracts is secondary to their technical knowledge.

Sturla[42] considered that the building services engineering contractors required graduates capable of managing, whereas the educational content of building services engineering degree courses concentrates on technical and theoretical engineering. He also stated that many graduates have to undergo post graduate

conversion, which causes a culture shock. Whilst the introduction of a management subject into the Chartered Institution of Building Services Engineering membership syllabus is an acknowledgement of their deficiency in engineering education, there is still criticism that new members lack financial awareness. In discussions with senior personnel employed by main contractors, the author was told repeatedly that problems arose where engineers were in charge of services sub-contracts. Their lack of contractual, financial and management expertise created many of the difficulties that arose in contract operation.

The inter-relationship between the various members of the building team can be seen to be fraught with difficulties. These can be due to the respective professions jealously guarding their sectorial achievements, the lack of a coherent combined education policy, and an unwillingness by the state to impose a rational educational system for the industry.

## REFERENCES - CHAPTER ONE


1) Bowley, M., "The British Building Industry", 1966, Cambridge University Press

2) Hillebrandt, P. M., "Analysis of the British Construction Industry" 1984, Macmillan Press

3) The Banwell Committee Report, 1964 "The placing and management of contracts for building and civil engineering work", HMSO

4) Riley, N. T., Letter to Building, p.20, March 22, 1991, "Stop the Infighting"

5) Bousfield, R. A., STV-90-UK-1018, 1990-91, Erasmus Study Travel Grant, EEC Brussels

6) The CIPHER Report, Report to 3rd Symposium for Professional Bodies in the Construction Industry. December 1988, Centre for Educational Resources for the Construction Industry, London

7) Rolf, L. T. C., "Thomas Telford", pp 200-201, 1979, Penguin Books

8) Rolf, L. T. C., "Thomas Telford", p.202, 1979, Penguin Books

9) 1989 List of Members, Institution of Civil Engineers

10) Cooney, E. W., Construction History, Vol.3., 1987, p.119, "Innovations and Contracts in the Post War British Building Industry"

11) Hillebrandt, P. M., "Analysis of the British Construction Industry", p.154, 1984, Macmillan press

12) RIBA, 1984, Amended Code of Professional Conduct

13) Thompson, F. M. L., "Chartered Surveyors - Growth of a Profession", 1968, Routledge and Kegan Paul

14) Faulkner, A. C., and Day, A. K., Construction Management and Economics, pp 245-260, 1986, "Image of Status and Performance in Building Team Occupations"

15) Hillebrandt, P. M., ISBN, 0-333-34688-2, p.42, 251, 1988, "Analysis of the British Construction Industry"

16) Burrows, M., Trent Paper, No.2., Nottingham Polytechnic, 1987 "Modes of Obtaining Building Contracts During the Industrial Revolution"

17) Thompson, F. M. L., "Chartered Surveyors - Growth of a Profession", 1968, Routledge and Kegan Paul

18) Thompson, F. M. L., "Chartered Surveyors - Growth of a Profession", 1968, Routledge and Kegan Paul

19) Sturge, William., Transaction of the Surveyors Institute, Vol.1, p.51, 1868-69

20) Occupation Tables of the Census Record for England and Wales, 1861

21) The Oxford English Dictionary, p.1428, 1961

22) Laing, Coad R., ISBN, 0-340-23985-9, 1979, Hodder and Stoughton, London

23) Thompson, F. M. L., "Chartered Surveyors - Growth of a Profession", p.84-85, 1968, Routledge and Kegan Paul

24) Cooney, E. W., Construction History Society, Vol.3., p.119, 1987, "Innovations and Contracts in the Post War British Building Industry",

25) Builder XX, 11 October 1862, "Contract Operation"

26) Builder XXI, 3 October 1863, Letter

27) Thompson, F. M. L,., "Chartered Surveyors - Growth of a Profession", p.136, 1968, Routledge and Kegan Paul

28) RICS Pamphlet, May 1977, "The International Role of the Chartered Quantity Surveyor"

29) Laing, Coad R, ISBN 0-340-23985-9, p.143-144, 1979, Hodder and Stoughton, London

30) RICS Yearbook, p.xxxvii, 1987

31) QS Weekly, p.5, 16 August 1979, "The Construction Surveyors Institute"

32) Bowley, M., "The British Building Industry", p.335-336, 1966, Cambridge University Press

33) The Financial Times Supplement, p.30, July 1958, "Survey of the Building Industry"

34) Kelly, Thomas., "Adulty Education in Great Britain - Middle Ages to the 20th Century", p.30, 1970, Liverpool University Press

35) Gregg, Pauline., "A Social and Economic History of Britain 1760-1970", p.507, 1971, Harrap

36) Hillebrandt, P. M., "Analysis of the British Construction Industry", p.154, 1984, Macmillan Press

37) Heating and Ventilating Contractors Association, 1979, "The Story of the Heating Engineers 75th Anniversary", London

38) Institution of Public Health Engineers, Pamphlet

39) Chartered Institute of Building Services Engineers Information 1978, Leaflet

40) Scott, D. R., Building Services Engineer, Vol.40, May 1972, pp.38-41, "Some Current Problems Facing Environmental Engineering Education"

41) Watson, Gareth., "The Civils, Story of Institution of Civil Engineers", p.152, Thomas Telford, London

42) Sturla, J. D., Building Services Engineer, Vol.40, May 1972, pp.42-45, "Technical Education and the Contractor"

## CHAPTER TWO

## EDUCATION OF THE CONSTRUCTION PROFESSIONALS

The education of the United Kingdom construction professional has, throughout the twentieth century, been dictated by the requirements of the professional institutes. The unification of European countries into a single common market in 1993, and the European Economic Community Directive[1] on "diplomas" awarded in Universities has, however, caused a major re-appraisal.

The EEC classes all higher educational establishments, throughout its membership, as Universities, whatever title is allocated in each member country. Initially, the EEC directive only considered qualifications awarded after a three year period of full time study at a University. This effectively excluded the majority of professionals in the United Kingdom construction industry, and would have excluded such people from recognition. The professional institutions in the United Kingdom argued that their corporate membership examinations were University equivalent, and eventually the EEC accepted this argument in a Council Directive of December 21 1988.[2]

The EEC Directive named professional Institutes/Institutions that they considered as having equivalent examination arrangements to Universities, and included all the Chartered Institutes and Institutions in the United Kingdom construction industry. Professional qualifications on the European mainland are obtained by university study, and there is a growing trend in the United Kingdom for this method to be the route to professional recognition.[3]

Faulkner and Day[4] comment on the differences of prestige accorded to industry in

the United Kingdom, mainland Europe, and the United States of America. They suggest that the lack of involvement in vocational education by the United Kingdom central government, plus the leaving of regulation to individual professions, has not enhanced industry's reputation. Germany is cited by Faulkner and Day as an example of a country where industry has a high status because of the integral relationship between education, the State, and industry. Whilst this may be true for Germany, it is not the case in some other mainland European countries.

At a conference in Brussels (1991)[5] at which the Author was present, engineering graduates complained at the academic nature of Belgium University courses in construction, and the lack of involvement by industry. A general complaint by the students was that their five year degree course did not adequately prepare them for employment in industry.

United Kingdom courses in Universities and Polytechnics aim to combine academic and vocational studies as compared with the training and vocational nature of United Kingdom professional institute examination systems. The professional institutes have jealously guarded their methods of examination, but they have a tendency to be rigidly vocational. This can lead to narrow and discipline orientated preparatory studies, whereas academic institutions aim to examine a student's ability to adapt to alternative solutions by problem solving. However, over the past decade, due to the interaction between academic establishments and the professional institutions, there has been a considerable interchange of learning and teaching strategies, and associated assessment techniques. These have been to the benefit of both types of examining body.

Candidates who sit the examinations of professional institutions, carry out private,

individual, self-study and often miss the academic rigour of an academic institutions. This occurs because there are too few candidates to make courses in academic institutions economically viable. There is a noticeable trend now occurring whereby a lower number of candidates are sitting the examinations of professional institutes. At technician level, the examinations of the Business and Technician Education Council (BTEC), are accepted by all institutes, and at degree level, the majority of institutes accept the examinations of universities as partial fulfilment of professional academic competence. The Chartered Institution of Building Services Engineers require that the first degree be at honours level and that the degree has been validated by the Institution. This must also be coupled with two years structured training followed by two years post graduate responsible work experience.

For students entering a degree course direct from school at 18 years of age, the minimum period of practical training plus work experience is therefore 4 years in addition to the academic studies. Before corporate membership of CIBSE is granted a further professional interview to assess the suitability of the candidates experience is also required. Similar procedures before the granting of corporate membership are a requisite of all chartered institutions allied to construction and/or the Engineering Council.

Education and training are terms often interchanged and any difference becomes difficult to perceive when applied to many vocational courses.

Alderson[6] suggests that merging the United Kingdom government Department of Education and Science with the Department of Trade and industry would create a more unified approach. He also comments that the often apparent gap between education establishments and industry could probably be closed by such a merger.

The United Kingdom government have, however, attempted to stress the importance of industry through several training initiatives. These have been introduced through its Training Education and Enterprise Department (TEED) (formerly Training Agency), but many of the initiatives have concentrated on short term training, to fill voids created by previous lack of involvement.

A major TEED initiative in the higher education sector has been the award of Enterprise grants to Universities and Polytechnics.[7] These have resulted in a closer relationship between industry and education and the author has been closely involved in these initiatives. The construction industry have willingly allowed senior personnel to discuss live construction projects in the higher educational establishments with undergraduates, and the profile of construction has been raised considerably.

The proliferation of professional institutions, each holding their own examinations had led to the formation in the UK of the National Council for Vocational Qualification.[8] Through this Council, central government hopes to be able to rationalise the numerous qualifications and ensure that they are competency based. The NCVQ has produced various competency levels for qualifications with levels one to four relating to craft and technician qualifications. In 1991,[9] NCVQ announced that level five as a single stage, would apply to professional examinations. De Ville[10] reported in 1984 that less than ten percent of personnel in the construction industry had qualifications beyond the National Certificate level. Later, Lighthill[11] stated in 1986 that many building companies preferred to concentrate their training activities at craft and technician level. This was in the belief that some of the products of such training could be further developed into supervisors and managers. From the above, the gap between the education of architects, and builders becomes apparent. Building services engineers fall into

the same category as builders.

Farrow,[12] describes how, in the mid 1960s over seventy percent of the John Laing Construction Ltd site management had craft backgrounds, a further eighteen percent had technician background, and any graduates were usually civil engineers. Thompson[13] points out that during the same period of the 1960s the majority of Architects were graduates. Only a minority of Quantity Surveyors were graduates, with "on the job" training being the most common method of education, and academic competence being tested by professional institute examinations. Turner,[14] however, emphasises that the greater provision, from 1964, of higher education in the United Kingdom, meant that students, holding "A" level qualifications, began to follow vocational courses in institutes of higher education. This resulted in 1989 in the majority of quantity surveying entrants to the RICS being graduates.

Torrance (1989)[15] suggested that membership of a United Kingdom chartered professional construction institution would be a passport to practice in Europe. However, the original directive specifically stated that three years full time education post baccalaureate was necessary and the amendment to add chartered institutions was a United Kingdom and Ireland request. Articles 59 and 60 of the Treaty of Rome[16] state that no person must be disadvantaged by the harmonisation of markets and as non-chartered institutes had members operating in the same manner as chartered professionals they argued that their members should also be covered by the First Directive.

In 1991 the United Kingdom accepted that provided they had the requisite educational experience, Incorporated Engineers could be covered by the First Directive. As Incorporated Engineers are normally classed as Technicians in the

United Kingdom, it would appear that the original requisite of three years full time higher education is the main requirement. Presumably this will also allow non-chartered professional institutes in the United Kingdom to equate with chartered institutions, and therefore widen the recognition of UK professionals.

However, a second EEC Directive will be introduced in 1992 which will cover all qualified personnel not covered by the first EEC Directive. The Department of Employment state that National Vocational Qualification levels one to four will be embraced in the second Directive and they anticipate that NVQ level five will apply to the first Directive.

Prior to 1939 there was only one first degree course in Building in the United Kingdom, and none in Building Services Engineering.[17] The first Polytechnic to offer a degree course in Building was Brighton Polytechnic in 1962. Before this period, the Higher National Diploma in Building was the principal source of educated managers for the industry.

Bowley[18] points out that senior management of many building companies are not convinced that formal vocational training for management is necessary. She also suggests that higher education is regarded sceptically by many, who argue that time is better spent on site learning the practicalities, rather than on study in academic institutions. The problem with this philosophy is that it produces management who are unable to adapt quickly to changes, and efficiency is likely to fall. With increasing numbers of building graduates being produced, their particular skills in management are being acknowledged by building contractors. In the authors experience, many small and medium sized contractors still concur with Bowley, but all large contractors are moving towards degree or equivalently qualified management.

In Building Services Engineering, Sturla[19] chronicled the change of recruitment pattern for the same period as Turner[14] did for Quantity Surveying, i.e. 1964. The major difference they found being, that, whereas the Quantity Surveying profession began to attract the more able students, building services engineering had to adjust to a lower standard of recruit. The status accorded to the building services engineer appeared to be a major factor but Sturla does not quantify this.

Faulkner and Day[4] (1985) found that amongst the construction professionals i.e. Quantity Surveyor, Contractor, Structural Engineer, Services Engineer and Architect, the average rating of each other produced the lowest in social status for the contractor and Services Engineer. The education and training of services engineers was also perceived as being low. If this perception of the services engineer is the one seen by fellow professionals, the public reticence is not difficult to understand. The study by Faulkner and Day generally confirmed the findings of an earlier study in 1965 by Higgins and Jessop.[20]

Sturla[19] describes how the services engineering industry adopted to the changing recruitment pattern from 1964 by introducing a technician stream which allowed a new group of people to enter the industry. He also commented that specialisation in the building services engineering sector meant that fewer people had the capacity, or time, to master the total volume of knowledge, or skill, to design building services. The greatest single need, he suggested in 1972, of building services engineering contractors was for people who could manage the various processes in a contract. To substantiate this, Sturla commented that on a total project, ten percent of the time is for fundamental design, thirty percent for detailed design, and construction management the remaining sixty percent.

An analysis of these figures begins to clarify the reasons for some of the problems

relating to the conflict of understanding that occur, between services engineers, and other professionals. Management study is singularly absent in engineering undergraduate courses. An Engineering Council/Design Council (1990)[21] report accepted that engineering courses were insular in relation to other professions, and often failed to promote the realities of their own discipline in the workplace. In other words, engineering courses were too theoretical, and not vocationally practical. The same report also recommended that building services engineering should be multi disciplinary, and courses ought to have a greater content of cost analysis in relation to clients requirements.

The report highlights another area that is a significant problem in building services engineering i.e. that of being multi-disciplinary. Building designers are required to understand and manipulate the elements and components included in a building. It is rare, however, to find services designers who can embrace, for example, air conditioning, heating, electrical engineering, and lighting. The majority specialise in one area.

Smith[22] argued that contract management and administration were rarely appreciated by building services consulting engineers and poorly applied by services engineering contractors. He did, however, suggest that with the exception of research and development, there was little need for highly trained mathematicians and physicists as most work in consultancies and contracting was pedestrian.

This, coincidentally, was the same argument put forward by Architects against the emerging Quantity Surveying profession[23] in the 19th century.

From the authors experience, the majority of building engineering services

contractors do employ technicians both to design and operate contracts. Arguments for this practice tend to be that technicians qualified to Higher National Certificate level are more than competent to carry out normal day to day tasks. Perhaps more compelling is that they are usually less expensive in salary costs than professionally qualified Building Services Engineers.

In the area of technician employment, Turner[14] considered that whilst the quantity surveying profession from 1964 has attracted entrants with good academic ability, he suggests that it quite deliberately has lost the less able academic entrant whose technical skills after, suitable training, served the profession well. His argument centres on the expansion of higher education from 1964, whereby prior to 1964 entrants would obtain pupillage with Quantity Surveying practices, but were unable to study for degrees which were unavailable in sufficient number. When degrees in law and accountancy became readily available, Turner suggests that school leavers found them more attractive than quantity surveying. He also implies that in a deliberate attempt to make the profession degree only, technicians have been deliberately excluded from professional offices. Turner's comments imply that although it has become degree orientated academic ability in the quantity surveying profession is still lower than that of law and accountancy and appears to reinforce the comments of Hillebrandt et al on the lack of attraction by school leavers to construction professions generally.

A problem that can occur is where the dividing line between technician employment and technologist or professional employment becomes blurred. The more able technicians in all construction employment disciplines are often capable of carrying out some of the tasks which are generally regarded as the province of the professional. Design and estimating are examples of this. Alternatively there

are many cases whereby professionals are under employed and carry out technician work.

The production of bills of quantity for small and medium sized works are good examples of the latter. Because professionals command higher salaries than technicians the blurring of employment tasks can sometimes cause dissatisfaction.

In discussions with the Author, small to medium services engineering contractors have stated that technicians trained to Higher National Certificate level are quite capable of carrying out the design tasks they require. Any further education beyond HNC level is resisted because of the fear that higher salaries may be demanded. It logically follows that if building engineering service contractors employ technicians for design work, they will automatically look to use technicians for quantity surveying for exactly the same reasons. Whilst the use of quantity surveyors by services contractors is still not universal, the majority who do, tend to use people who have not followed the conventional building educational route for surveyors. Many transfer technician engineers into estimating and quantity surveying and whilst salary levels may be a compelling reason to exclude professionally qualified surveyors, there are other reasons.

In the authors experience very few chartered quantity surveyors are capable of or are interested in building engineering services. Lack of services engineering content in academic quantity surveying courses is often apparent. Ironically, a Royal Institute of Chartered Surveyors report (1981),[24] stated that quantity surveyors ought to have a better understanding of services engineering. This was because of its increasing cost ratio as compared to the rest of the construction costs. This increasing cost factor was highlighted by a report from the Building Services Research and Information Association (1990)[25]

Lansley[26] suggests that a major problem in recruiting more able school leavers into construction is that the rewards to be obtained from a career in construction are not fully explained by its leaders. He also comments that the individuals contribution to the construction process is not properly recognised, and therefore the industry provides an image which will not attract the more able school leaver and graduate. Graduates, he suggests, look for post-graduate training and early responsibility which the majority of construction companies do not provide. Dissatisfaction and rapid employment change often result. The author constantly receives complaints from building graduates and undergraduates on the lack of defined company training programmes and insufficient devolved responsibility. Companies, however, often complain that graduates believe they are capable of more responsibility than their age or experience warrants. The age factor can perhaps be attributed to the age at which the majority of United Kingdom students graduate. On the mainland of Europe, because of the imposition of one or two years military services, students enter industry at the age of twenty five years or older. In the United Kingdom graduates are usually twenty two or twenty three years of age.

The European perception of the United Kingdom construction industry was illustrated by Timmermans,[27] a Centre Parc director, who claims that main contractors in the United Kingdom lack capable middle management, have poor training schemes, and have poor relations with sub-contractors.

He also suggested that lack of competent management in the industry led to it being run by quantity surveyors rather than technologists. The adversarial relations with sub-contractors, he implied were because there was no attempt to

build up long term relationships. Timmermans comments reinforce the stance taken by Japanese construction companies who build up a long term relationship with sub-contractors. This eliminates the adversarial conflict which besets many United Kingdom construction contracts. The activities of the quantity surveyor, who is peculiar to the United Kingdom, must have some influence on the differences that are apparent in contract operation. Although the provision of bills of quantity led to contractors quoting for uniform items, the cost analysis used by quantity surveyors was shown by Flanagan[28] to be suspect.

Flanagan suggests that quantity surveyors use historical data from many sources which is often inadequate and unreliable. He also comments that tender times in documents are often derived, from knowledge of the performance from construction of similar buildings.

More significantly, he comments, on the poor knowledge of the construction process apparent from surveys he undertook. This reinforces the comments of the RICS report[24] discussed earlier in this Chapter.

Croome[29] argues, that because of the many changes now being required in building design and construction, it is essential for the professions to be inter-disciplinary rather than multi-disciplinary. He cites the example that Architects alone cannot determine the genetic imprint of a building, and the balance between art, engineering, and science is constantly changing.

Both Croome,[29] and Lighthill,[30] argue for a more educated professional, and yet the argument still persists in the United Kingdom that education is not always necessary to succeed. Ivens (1989)[31] criticised proposals for the creation of a Chartered Institute of Management, arguing that as no management criteria met

all company requirements, it was better for companies to construct their own management training. He described how a Tavistock Institute study of American entrepreneurs showed that there was a tendency for the successful entrepreneur to be an early school leaver without formal training.

Ivens argument fails to accept that the percentage success rate cannot be measured. Entrepreneurs both succeed and fail, with, or without, education and the failures are not recorded. The vast majority of employees have no entrepreneurial skills, and require training and education to provide sufficient skills to be successful.

In building services engineering contracts, a reliance on the financial control is often left to a services engineer having little or no financial training.

Lighthill[30] emphasised that effective management education was essential for graduates entering a modern construction industry. Without it, he argued, efficiency would decline and the effective use of labour and materials would be impaired. He suggested that building management be established as a discrete academic discipline which was intellectually demanding.

An analysis by the author has found that whilst there are several Construction/Building Management courses operating in 1991 in the United Kingdom and Ireland, this is not the case in the European mainland In Germany there is only one first degree course operating as Building Management (Karlsruhe) France appears also to have only one, and at first degree level there are only three in Denmark. The vast majority of courses operate as Civil or Building Engineering courses with management and finance treated as a subject within a diet of engineering subjects.

Young (1990)[32] suggested that in the skills and knowledge required for a construction management career, financial management was a major requirement. This item is generally given a low priority in all building services engineering courses and, as described above, it does not play a major part in mainland European first degree courses.

Observation of construction site operation in Germany and the United Kingdom by the author showed that engineers in Germany are highly respected and all personnel receive formal training as compared to the United Kingdom. More use of powered plant is made in Germany than in the United Kingdom, resulting in a lower labour requirement. There also appeared to be less conflict between main contractor and sub-contractor. The remoteness Young (1990)[32] found between senior managers and the workforce in the United Kingdom was not apparent in Germany.

Foster (1990)[33] commented that unless the United Kingdom construction professionals become more efficient, and skilled, the industry will begin to import management and follow the pattern set by the United Kingdom manufacturing industry. He cited as an example the complete takeover, in the United Kingdom, of motor car production by American and Japanese companies. From 1974 to 1986, Foster states that construction labour productivity increased by one percent per annum. Over the same period he quotes a German increase of one and a half per cent per annum and a French increase of two percent per annum. To increase from one to two percent per annum, he suggests, requires training and retraining. Foster commented that an average eight per cent cost for professional services on contracts was higher than in other European countries. He also stated that there are as many Architects in the United Kingdom as in the United States, where the construction industry is four times larger. This suggests that there are too many

qualified Architects in the United Kingdom and that many are doing work which is capable of being undertaken by technicians.

Foster, however, reiterates the findings of an Institution of Civil Engineers Working Party report[34] that the construction industry would be more influential if it acted together as an integrated body. His statement that an integrated system of professional training, cutting across existing boundaries, is essential for an increased industry efficiency, is being expounded from many sectors. However, the major problem will be overcoming the entrenched positions of the major institutions. For example, the Institution of Civil Engineers Report[34] suggested that services engineering education should be multi-discplinary. The Institution of Mechanical Engineers in 1972 proposed a merger with the Institution of Heating and Ventilating Engineers before it became the Chartered Institute of Building Services Engineers.[35] Both suggestions appeared at first to be admirable and yet the proposals would have seen the disappearance of building services engineering as a separate discipline.

The Institution of Civil Engineers has produced reports as described above and yet an analysis of the Institution membership[34] shows that above fifty percent were involved as builders, and a further twenty nine per cent stated over half of their employment was in building. The same report stated that twenty five per cent of Civil Engineering graduates do not enter the profession, and of the remainder, twenty per cent do not join the Institution of Civil Engineers. The findings of the Institution of Civil Engineers report are not confined to one Institution. Training Managers of construction companies have reported to the author that they find similar resistance to membership of the Chartered Institute of Building by building graduates. As described in Chapter One, many Architects are not members of the Royal Institution of British Architects, and therefore there are at least three major

professional institutions who appear unable to convince all people qualified in their discipline, that membership of the Institution is essential. Although no hard evidence is available, an analysis of technicians qualifying each year[36] compared to membership of Institutes suggests a similar resistance. This will inevitably bring into question the continuing influence of the professional institutes. As more young people enter degree, diploma, and certificate courses[37] in the United Kingdom, it would appear that there is a strong possibility that academic qualifications will replace Institute qualifications as the method of acceptable recognition.

Foster[33] suggests that professional institutions may find that they become the same as City of London Livery Companies and simply have libraries, hold dinners and provide fellowship i.e. become little more than select clubs. If the degree is to become the accepted academic standard for professionalism, comparison with mainland Europe is essential. In most European countries the bachelor or baccalaureate is not a higher education degree. In France, it signifies completion of secondary education and is essential for access to higher education, with the Licence being the traditional first degree. In the United Kingdom the bachelors was established as a first degree during the medieval period.[38]

The authority to award degrees varies in different countries. In the United Kingdom the Universities have Royal Charters and the Polytechnics have control by the Council for National Academic Awards. The latter have validation of their degrees either by the CNAA directly or are allowed self validation with indirect CNAA control.

In France students, lecturers and industrialists sit on a University council which awards the degrees or diplomates. The Universities are autonomous in

administration and financial control. Industry plays an important part in the course content, with industry being represented by both Trades Unions and Management.[39]

Hill (1991)[40] has also called for a move away from the present methods of educating and training building students. He suggests that present training is too narrow, the professional institutions too protective and too specialised, and that the European mainland university approach to engineering education of a common first two year syllabus followed by specialisation, ought to be used in the United Kingdom. Here again the European mainland approach to education is lauded and the word "engineering" is used. These mainland universities commonly have subjects such as Architectural Engineering and Construction Engineering. If the United Kingdom universities and polytechnics converted courses in Building to Building Engineering perhaps much of the resistance to engineers would dissipate.

If the influence of the institutions does reduce, the introduction of further training beyond academic achievement must be essential. A report by the United Kingdom Government (1989)[41] stressed the importance of further training in the form of Continuing Professional Development (CPD). The report showed that employers appreciated the necessity for CPD but the cost of courses may be a negative factor in implementation of a company CPD policy. The University Grants Committee (1983)[42] accepted that initial education cannot be sufficient for the whole of a persons career and formal CPD must be essential. Despite resistance to education from some sections as discussed above, the changes that will be required in construction operations will, of necessity, be based on education.

As discussed earlier, the building services engineer suffers from recognition by fellow professionals, recognition, amongst general engineering disciplines by school

leavers as a rewarding career, and a scarcity of financial and management expertise. All these factors must contribute to difficulties that arise in contract operation, but moves towards unification of the professions will involve sacrifice in prestige from all professionals.

The adoption of the title Euro.Ingeneur could be one way forward. To achieve this title in the United Kingdom, holders of a first degree have to be a member of a Chartered Institution. On mainland Europe, some engineering degree courses operate over five years. This enables the graduates to automatically achieve Euro-Ingeneur status. A compromise between United Kingdom courses and the courses described above could perhaps create equality, but it would be at the expense of the professional institutions.

The multi-disciplinary nature of building services is a difficulty for a sector wishing to achieve unitary recognition. The BSRIA report (1990)[25] stated that electrical installations accounted for forty six per cent of services engineering; heating, ventilation and air conditioning; for thirty six per cent; and plumbing, eighteen per cent.

If as stated in Chapter One electrical engineers generally aspire to the Institution of Electrical Engineers founded in 1871 then the Chartered Institution of Building Services Engineers is not the dominant Institution in Services Engineering. This, again, only helps to compound the problems that the CIBSE has in enhancing the status of building services as a discipline. Unification, under a general title engineer becomes more desirable if the above arguments are to be accepted. The confusion, caused by the diversification of engineers within building engineering services, only serves to reduce the impact of the claims of the Chartered Institution

of Building Services Engineer to be the professional institution for building services engineers.

## REFERENCES - CHAPTER TWO


1) EEC Brussels, 7 July 1988, "Council Directive on Higher Education Diplomas"

2) EEC Directive, (89/48, OJL 19) "General Directive on Professional Qualifications

3) Segal, A., Guardian, newspaper article, 13 June 1989, "Getting In and Getting On"

4) Faulkner, A. C., and Day, A. K., Construction Management and Economics, 1986, pp 245-260, "Image of Status and Performance in Building Team Occupations"

5) Conference, Brussels, 1991, "Higher Education in Europe"

6) Alderson, D., Youth Training News, Issue No.48, July/August 1988, "Time is Right to Merge Education and Training?", Training Commission

7) Training, Enterprise and Education Department, "Enterprise in Higher Education", Sponsored Initiative and Education Department

8) White Paper, Department of Employment, December 1989, "Education and Training Working Together"

9) The National Council for Vocational Qualifications, June 1991 "The NVQ Framework"

10) Deville, H. G., "Review of Vocational Qualifications in England and Wales", Department of Education and Science, 1986

11) Lighthill, Sir James., BEC/CIOB Report, August 1986, "Degrees in Building Management"

12) Farrow, J., CIOB Paper Vol.2., 3 November 1987, "Fundamental Research Needs in Construction Management"

13) Thompson, F. M. L., "Chartered Surveyors - The Growth of a Profession", Routledge and Kegan Paul, London, 1968

14) Turner, A., Chartered Quantity Surveyor, p.17, May 1989, "Going Technical"

15) Torrance, V., Building Technology and Management, pp.5-6, April/May 1989, Presidential address, Chartered Institute of Building 1989

16) EEC, Treaty of Rome, Articles 5 and 6

17) Croome, D. J., "The Emergence of Environmental engineering in British Universities"

18) Bowley, M., Building Services Engineer, Vol.40, p.33, May 1972, "The British Building Industry", Cambridge University Press

19) Sturla, J. D., Building Services Engineer, Vol.40, pp.42-45, May 1972, "Technical Education and the Contractor"

20) Higgins, C., and Jessops, I., "Communications in the Building Industry", 1965, Tavistock Publications, London

21) New Builder, p.5, 26 July 1990, "Engineering Course Design Content" Report,

22) Smith, T., Building Services Engineer, Vol.40, p.48, May 1972, "The Use of Building Services Engineering Graduates in Consultancy"

23) Thompson, F. M. L., "Chartered Surveyors - The Growth of a Profession", 1968, Routledge and Kegan Paul

24) Royal Institution of Chartered Surveyors, 1981, "Surveying in the Eighties", QS Divisional Council Report

25) Construction Midlands, p.4, July/August 1990, BSRIA Report, Wealthstream Ltd., Manchester

26) Lansley, P., Chartered Builder, p.9-10, March/April 1990, "Trends in Graduate Education for the Construction Profession"

27) Timmermans, J., Construction Weekly, p.8, 19 July 1989, "UK Skills Shortages"

28) Flanagan, R., "Tender Price Time prediction for Construction Work" Thesis, April 1980, University of Aston

29) Croome, D., Building Research and Practice, No.3, pp.174-182, 1990, "The Impact of Technological Innovation on the Construction

30) Lighthill, Sir James, BEC/CIOB Report, August 1986, "Degrees in Building Management"

31) Ivens, M., Sunday Telegraph, 11 June 1989, article, "Proposals for a Chartered Institute of Management"

32) Young, B. A., and Duff, A. R., Building Research and Practice, No.3, 1990, pp.183-192, "Construction Management Skills and Knowledge"

33) Foster, Sir Christopher, Chairman NEDO Construction Group, 13 February 1990, Speech to Building Industry Council, London

34) Institution of Civil Engineers Report, January 1989 "The Future Manpower Needs of the Construction Industry"

35) Scott, D. R., Building Services Engineer, Vol.40, p.39, May 1972, "Some Current Problems Facing Environmental Engineering Education"

36) Business and Technician Education Council, Annual Reports, London

37) Times Higher Education Supplement, "Expansion of Higher Education"

38) Guiton, J., and Halls, W. D., UNESCO, "World Guide of Higher Education"

39) Bousfield, R. A., Erasmus Study Grant, 1990, Interview with French University Academic Staff

40) Hill, Sir Brian, Construction Weekly, p.8, 27 February 1991, "Education Far Too Narrow", Report on Higgs and Hill plc, Annual Business Lecture

41) New Civil Engineer, p.8, 22/29 August 1985, Report - Education Refreshers, Department of Education and Science

42) "Continuing professional Development" Report to the Universities Grant Committee, p.2, December 1983

## CHAPTER THREE

## FINANCIAL AND MANAGEMENT CONTROL OF BUILDING ENGINEERING SERVICES

Despite the high cost of the building services engineering content on some building projects, only rarely is a services engineering contractor appointed as the main contractor. On most contracts, therefore, the services engineering contractor operates as a sub-contractor.

Gray (1990)[1] states that sub-contractors in the United Kingdom are now a major factor on construction sites carrying out ninety percent of the work and employing the largest proportion of the labour force. Gray also explains that a healthy sub-contract sector will include large companies providing a high quality service. In turn these companies will be supported by many other sub-contractors, in effect sub-sub-contractors. He also suggests that one of the attractions of foreign sub-contractors to United Kingdom clients and main contractors, is that they are managed by qualified engineers who have the authority to make decisions for the whole company. Gray also points out that United Kingdom management in sub-contracting is often highly skilled technically, but lacks the ability to use and implement these skills to the full benefit of efficient contract organisation. He also suggests that the perceived lack of managerial skills from United Kingdom engineers, particularly those in services engineering is in stark contrast to the ability of engineers employed by foreign sub-contractors.

Gray's use of the word foreign, relates to mainland European countries but from 1993 onwards the majority of these countries will be partners with the United Kingdom in the European Common Market.

Foster (1991)[2] urged British construction companies to create a pyramid of management with clearly defined responsibilities at each level. He suggests that such a system would provide clear decision making, and eliminate the existing proliferation of personnel who have to be consulted before decisions are made. He also criticised the proliferation of contract document forms as being a cause of fragmentation.

The use of Project Managers having overall control is an attempt to eliminate the management problems cited by Foster and is a method the author has seen operating successfully in France. Its use in the United Kingdom is open to criticism from the vested interests of professionals unwilling to accept control from other disciplines. However, the project manager can be from any discipline and the personality of the individual will usually be the deciding factor on appointment. Whilst Standard Contract Forms, such as the Joint Tribunal Contracts Form'80, are the commonest in use, their amendment, by clients and main contractors, creates a proliferation, as cited by Foster, and assists in creating disunity.

Barber (1991)[3] suggests that a method of creating unity in the construction industry would be for designers to understand the requirements of contractors. Contractors, he adds, want building design that can be efficiently constructed and with sufficient information provided to allow purchasing and construction to proceed in accordance with the programme of work. The problem of hierarchy, highlighted by Faulkner and Day[4] is also reiterated by Ohly (1991).[5] Ohly suggests that the British are too keen on establishing rank and working to a hierarchial system. He also comments that the participants in a contract ought to communicate first to see if a particular item is permitted before referring to the contract.

The problems of relationship referred to by Ohly in 1991 are not dissimilar to the earlier Higgins and Jessop findings in 1965[6] and confirmed in the 1984 study by Faulkner and Day.[4]

It is here that the academic research of the two studies and the practical assessments from industry by Barber and Ohly respectively are seen to merge.

Beazer (1990)[7] added his voice to other industrialists by inferring that construction contained too many individual professions which naturally provoked and stimulated divisions within the industry.

Bell (1991)[8] appears to support the mainland European concept of construction by suggesting that too much time is spent on contractual administration. He infers that many of the contracting disputes would disappear if personnel performed more effectively and to higher standards. Without doubt it can be argued positively that the use of traditional contract methods and fixed fee scales for the professionals has produced a system whereby the individual professionals have remained in comparative isolation, each from the others. The professional consultancy side of construction was effectively isolated from the harsh competition that contractors faced. The introduction of fee competition as described in Chapter Two has changed the concept of professionalism, but has also created further difficulties. Less detailed information is being provided to contractors by consultants because of the reduction in fees arising from competition. In interviews with both main and services engineering sub-contractors the author was repeatedly informed that lack of detailed design information was a major cause of delay in contract completion.

Cecil (1983)[9] probably foresaw the problems that fee competition would create by

suggesting that the conventional building procurement process through competitive tender had outlived its usefulness for commercial developments. He criticised the Joint Contracts Tribunal Contract documents (JCT 80) and bills of quantity produced under the 6th edition of the Standard Method of Measurement (SMM 6) as requiring too much detail before work actually commenced.

Flanagan and Norman (1985)[10] examined the theory and practice of competitive tenders by sealed bids and concluded that careful selection of contractors was of paramount importance. They found that specialisation of certain classes of building by contractors produced lower costs to clients. Tenders could also be made more competitive by improving the quality of information made available to tenderers. Their research also found that the maximum number of tenders should not exceed five.

The lack of information at tender stage was cited by the British Property Federation (1983)[11] as a reason for them producing an alternative contract document. In the BPF contract, bills of quantity are eliminated, as they were perceived to be a source of over detailing and required unnecessary detail from designers. At the time of the BPF contract document introduction the extra detail required from bills of quantity could, it was suggested, lead to additional professional fees. Fee competition has now probably curtailed any excessive increases in fee costs. In practice, the BPF form of contract is simply an amended JCT form which attempts to counteract problems of design, supervision and communication.

Riches (1991)[12] suggested that the confrontation that occurs in the construction industry is because of lack of professionalism from the professionals involved in the building process. He cited examples of bills of quantity that were often in his

terminology "bills of fiction" and also the lack of detailed drawings and specifications at the tender stage of the building process.

In an attempt to overcome the friction that can occur between building services engineering and building, a new joint venture procurement method has been used by two contractors in the United Kingdom; Drake and Scull Ltd and Fairclough Building Ltd.[13] A new hospital contract was awarded as a common contract with Drake and Scull carrying out the services and Fairclough Building Ltd the building construction, as equal partners. Fairclough Building Ltd. provided the main project manager, with a deputy project manager from Drake and Scull having equal line control. As the services content of the contract increased, the deputy project manager effectively became project manager, but both had direct control of all aspects of the contract.

Davis[14] suggests that the system will work efficiently if the services content exceeds thirty percent of the total contract.

Pylbo[15] suggests that whilst the system can operate efficiently for both parties, there is a necessity for financial management to become a major part of an engineers training. By equal partnership, each partner is responsible for the other partners debts thus providing additional protection for the client. Without doubt much of the friction between Building Contractors and Services sub-contractors can be alleviated by the use of this system of procurement, but it requires a conciliatory approach from main building contractors, as compared to traditional procurement methods.

An important change in ownership of United Kingdom building engineering services companies may prove to be one way forward in reducing confrontation.

Figure 3.1 refers to the ownership of the largest thirteen building engineering services companies and shows that six of the thirteen are owned by construction contractors.

Lindon (1991)[16] argues for the use of quantity surveyors by building engineering services companies, but accepts that many quantity surveyors provide a poor service. He suggests that too many quantity surveyors cost to design, when building procurement would be more economic if designed to cost.

Wilson Large (1990)[17] in a review of requirements of quantity surveyors by clients found that only half of the clients interviewed received warnings of financial problems. Of the projects referred to, only thirty eight percent were found to use quantity surveyors for the building engineering services content. Of those that did sixty per cent found the utilisation of the quantity surveying services only acceptable or, in some cases, poor. As described in Chapter One, there is often a lack of services engineering knowledge by professional quantity surveyors. The survey by Wilson Large also produced evidence from quantity surveyors admitting to only having a peripheral knowledge of services engineering. Lindon[16] suggested that building projects often run out of allocated money before services engineering is installed, and, that early involvement of the quantity surveyor could prevent this. The evidence, from the Wilson Large survey, suggests that quantity surveyors need to improve their knowledge of services engineering before Lindon's suggestion can be taken seriously.

Many building engineering services contractors now employ quantity surveyors as contract surveyors. The majority of these are not chartered quantity surveyors and are usually specialists in engineering services, unlike the professional or

**Figure 3.1**

**The Largest United Kingdom Building Engineering Services Contractors and their Ownership**

| Company | | Ownership |
|---|---|---|
| Matthew Hall Ltd. | Amec plc<br>Fairclough Building Ltd. | Amec plc |
| Balfour Kirkpatrick Ltd. | Balfour Beatty Building Ltd. | BICC |
| Haden Young Ltd. | Balfour Beatty Building Ltd. | BICC |
| Drake and Scull Ltd. | | JWP Inc.(USA) |
| How Engineering Services Ltd. | | How Group Ltd. |
| Crown House Ltd. | Tarmac Construction Ltd. | Tarmac plc |
| Lorne Stewart Ltd. | | BET |
| N G Bailey Ltd. | | N G Bailey Ltd. |
| James Scott Ltd. | Amec plc<br>Fairclough Building Ltd. | Amec plc |
| William Steward Ltd. | | William Steward Group plc |
| T Clarke Ltd. | | Credit-Suisse |
| Andrews Weatherfoil Ltd. | | Powell Duffryn Ltd. |
| Rosser and Russell Ltd. | Norwest Holst Ltd.<br>Sogea de France | SGE (France) |

(Ref. Building Services Research and Information Association, 1991)

clients quantity surveyor. Many contractors surveyors have moved from engineering roles and specialise in estimating or post contract measurement. A major part of their role is producing monthly accounts, claiming for variations, and liaising with main contractors and professional quantity surveyors. All major services contractors employ contract quantity surveyors but many medium sized small contractors often rely on engineers for financial control.

Lack of financial and management education by these engineers often creates difficulties. In an interview with a senior professional quantity surveyor, the author was told in commercial confidence how an engineer employed by a sub-contracting services engineering company failed to claim for £50,000 of extra work. This is an example of both conflict and lack of knowledge. It also emphasises the lack of financial and management experience of engineers.

The reluctance of services engineering contractors to use quantity surveyors is highlighted by the lack of educational courses for services quantity surveyors. Only one course operates in higher education in the United Kingdom and that is a Higher National Diploma Course at Nottingham Polytechnic. The student numbers attracted can be seen from Table 3.1 to be low and hardly economic. The only professional institute which caters specifically for services surveyors is the Architects and Surveyors Institute. Despite their efforts over a period of fifteen years (1975-1990) no other course for services surveyors has operated.

Noblett (1986)[18] suggested that evidence received by the Heating and Ventilating Contractors Association, from many of its members, showed that, if thought necessary, qualified quantity surveyors could be employed to administer contract details. Post contract measurement, management and supervisions could be undertaken by engineers. This, however, is at variance with evidence discussed

**Table 3.1**

Student numbers on the final year of the Higher National Diploma (Building Engineering Services Quantity Surveying) at Nottingham Polytechnic.

| Academic Year | Enrolment |
|---|---|
| 1979-80 | 4 |
| 1980-81 | 10 |
| 1981-82 | 7 |
| 1982-83 | 10 |
| 1983-84 | 15 |
| 1984-85 | 10 |
| 1985-86 | 11 |
| 1986-87 | 9 |
| 1987-88 | 10 |
| 1988-89 | 10 |
| 1989-90 | 9 |
| 1990-91 | 9 |

earlier in this and previous Chapters in that services engineers have little knowledge of either financial control management, or contract operation.

Culmer (1987)[19] explains how building engineering services surveyors emerged during the period of the second world war (1939-45) in that there was a necessity for the measurement of large plant, pipeline, and electrical installation owned by National Government. Of the staff that were recruited, Culmer describes how they were ex-estimators and engineers who were able to understand the details of such large constructions. The profession of quantity surveying emerged at the end of the 19th century as described in Chapter One and developed and established recognisable educational route to pass on techniques and procedures. As services engineering was low in content in buildings it was inevitable that concentration was on building procedures rather than engineering. It is only relatively recently that the services engineering content of buildings has reached the levels of forty to fifty percent of the total construction cost. It is perhaps, therefore, understandable, but not acceptable, that quantity surveyors have concentrated on the building process rather than engineering services.

Culmer compares the lack of services engineering knowledge of quantity surveyors with an equal lack of commercial awareness by services engineers. He comments that the inevitable outcome is that technically the two disciplines found it difficult to relate to each other.

He also states that whilst building contractors and professional quantity surveyors have attempted to overcome the technical language barrier by acquiring engineers, as surveyors or estimators, few engineering contractors have employed building quantity surveyors to overcome contractual problems. Here, again, the lack of educational awareness in either technical, or management areas is highlighted and

relates to findings of other commentators and researchers.

Within the building services disciplines Birkby (1987)[20] found that the most common communication problem is the result of the various disciplines operating independently of each team member. Drawings development becomes difficult if incompatible scales and notation are used. An example quoted is where a services engineer represents a pipe run by a single line which fails to state space allowance for insulation and fittings. Whilst the engineer and installer understand this fact it will not be immediately apparent to members of other disciplines causing a clash of services.

Production of bills of quantity does mean that detailed design has to be completed before the tender period. Rarely is detailed design available at this stage and therefore traditionally prime cost sums are usually included in a bill for building services.

Martin (1982)[21] supports the view that building quantity surveyors ability to measure engineering services is unsatisfactory. He suggests that whilst the quantity surveyor in general practice is able to provide a unique service for building works there are very few practices who are able to apply the same skills to building engineering services.

Without doubt the provision of bills of quantity for engineering services by quantity surveyors lacking the requisite technical skills has helped to undermine the confidence of tenderers and clients in such documentation. Birkby suggests that the interests of the client would best be served if quantity surveying duties for engineering services remained under the control of the consulting engineer, but dealt with by experienced surveyors. Whilst this method could cover the technical

difficulties that may occur it is probable that it would increase consultancy costs.

Meopham (1981)[22] contrasts the function of client and contractors quantity surveyors by commenting that only rarely will a contractors surveyor be required to produce a bill of quantities. He also commented that graduate building services engineers are rarely equipped to be project managers for installation work. Whilst these comments were made in 1981 similar statements have been made both before and after this date as described in earlier chapters. In building services engineering contracting it is unlikely that quantity surveyors will perform similar roles to those in building or civil engineering apart from in the largest companies.

It is common to find no bills of quantity for general building services engineering installations. The quantity surveyor, therefore, has to make use of the tender document provided by the estimators and supply advice to project managers on payment applications, variations, claims and final accounts.

Meopham adds that where engineers are in control it is common to find over-valuation of work in progress. These valuations, he suggests, are often expressed as an appreciation of the work in progress and the payment application is then prepared by taking from the accounts the cost of materials and adding to it the value of the labour element of the contract. It is then expressed as the percentage completion of the total labour value. Over expenditure on materials is often missed until after it has occurred with labour costs being expressed as a percentage of the costs that have been incurred. The result is that high early valuations have to be offset against the high costs that arise during the latter stages of the contract.

Meopham stated that quantity surveyors in building engineering services often

work in isolation surrounded by engineers, and he suggests that the presentation of advice rather than detailed skills is more often the pre-requisite.

Davis[23] argues that in the United Kingdom, specialist engineering services contractors are poorly served by bills of quantities. He adds that the Standard Method of Measurement calls for bills to "fully describe and accurately represent the quantity and quality of the works to be carried out". He adds that where bills of quantity are used for engineering services contracts, rarely is a true SMM adopted, and, under no circumstances, could they be said to fully describe the works.

The resistance to the use of bills of quantity from building engineering services sub-contractors is highlighted by Ryding (1982).[24] She suggested that the production of bills of quantity for building engineering services contracts, in accordance with SMM 6, is often unnecessary. Ryding points out that the SMM 6 calls for detailed measurement of equipment which varied little in cost, resulting in the common practice of tenderers allocating identical prices. Labour constants, she also suggested, are often similar, and variations in price generally relates to market price factors, plus the individual sub-contractors percentage mark-up for profit. Ryding's study also found that the need to understand engineering calculations deterred many building quantity surveyors from undertaking building engineering services measurement.

A discussion paper produced by the Heating and Ventilating Contractors Association (HVCA) (1978)[25] stated that the use of bills of quantity for engineering services would necessitate a frozen design. The HVCA argued that modifications to original designs are common at the post tender stage, and that the use of bills of quantity would mean that more detail would have to be provided on drawings.

Schedule of rates, the HVCA suggested, are a more practical aid for dealing with inevitable variations, because the items can be confined to operations on which variations are likely to occur. Whilst the HVCA accepted that quantity surveyors wanted bills of quantity for the production of elemental costs, and to enable them to produce budget pricing in detail, the HVCA suggested that design efficiency and site factors made it impossible to arrive at elemental costs which are comparable between contracts. The HVCA also commented that provided a client used selective tendering by limiting invited contractors, to no more than five, there would be little saving in total tendering costs by preparing bills of quantity. The HVCA suggested that the best way to reduce costs was to improve the design of engineering services, and the Royal Institution of Chartered Surveyors (RICS)[26] in reply to the HVCA paper, agreed with this statement.

The RICS argued, however, that the absence of detailed design at the tendering stage is more important to the architect than the quantity surveyor. Quantity surveyors, should, they stated, be able to judge likely cost effects and include provisional items as necessary. The RICS suggested that quantities are essential to most classes of tendering and can be prepared by quantity surveyors, consulting engineers, or contracting engineers. The RICS argued that, whilst contractors called their own quantities, cost sheets, rather than bills of quantity, and despite the lack of standardisation, the differences are quite narrow. The RICS also reminded the HVCA that quantities prepared by contractors may be rough, lacking in detail, and that inaccuracies will be at the contractors own risk. Who is best to prepare engineering services quantities, the RICS admitted, was a difficult question to answer, but they suggested contractors are probably the best for small contracts, contractor design, and negotiated contracts. In other cases, such as large contracts, client designs, and remeasured contracts, then, the RICS suggested, a bill of quantities prepared by a quantity surveyor would be preferable.

Turner (1981)[27] stated that cost control of engineering services by quantity surveyors was poor, and was due to the lack of understanding of the responsibilities of engineering services and contractors.

Chelmick (1981)[28] suggested that apathy to building engineering services in quantity surveying practices was because they believed that there was little profit to be obtained. He also criticised the training of quantity surveyors in engineering services and suggested that it should be a post graduate discipline.

Meopham (1981)[29] argued that an experienced engineer should be able to prepare a bill of quantities more effectively than a quantity surveyor. The quantity surveyors, he suggested, would be better employed in engineering services by assessing risks, development of cash flow projections, and ensuring receipt of financial settlements.

Nisbet (1979)[30] commented that engineering consultants often argued that engineers should prepare bills of quantity as only they had sufficient knowledge to be able to interpret drawings and specifications. Nisbet argued that this did not reflect favourably on the information the consultants provided. He also suggested that as, traditionally, the services engineer had not been involved in measurement, any measurement work, and valuation would be subsidiary to the engineers function of design and supervision. Nisbet also argued that the preparation of bills of quantity is not only a matter of measurement, but also preparation of contract documents. The services engineer, by his training, Nisbet suggested, had insufficient knowledge to evaluate the costs incurred in contract preparation and operation. Therefore, he added, because of the cost and contract implications, only the quantity surveyor should prepare the bills of quantity for engineering services. Nisbet accepted that there was an argument for accepting

that quantity surveyors had insufficient technical knowledge of engineering services, but countered that this assertion is closely linked to the amount of information available at the tender stage. He suggested that he had doubts as to whether the basic construction of engineering services changes quite so rapidly as building systems had, during the period after the second world war ended in 1945.

Nisbet appeared to put engineering services into the category that the author has found in discussions with many professional building quantity surveyors. These perceive engineering services as simply being a few pipes and cables, and whether they are conveying hot or cold fluids, low or high voltages, they are all the same.

Whilst, if more information was provided at the tender stage, interpretation would be easier, measurement, if used, and as Meopham suggests, does require knowledge of the various engineering services.

Ryding, Turner, and Meopham, all imply that the training of quantity surveyors has not provided them with the detailed knowledge necessary to undertake the measurement of engineering services.

The production of drawings schematically, with no indication of exact positions of pipe runs can cause confusion. It is therefore essential that any person taking off measurements for a bill of quantities, should have adequate technical knowledge to interpret the engineering services drawings.

A common method of initial budget costing by professional quantity surveyors is to relate these to cost per unit of floor area. Ryding argued that this method is inappropriate for engineering services and could lead to inaccuracies of plus or minus 50 percent. The HVCA (1978)[25] discussion paper stated that to produce

budget prices for engineering services that were more accurate than plus or minus ten percent was impossible. They argued that to contend otherwise would be to underestimate the complexities and invariables that were inherent in engineering services systems. The RICS replied (1978)[26] that they could not agree to this figure of plus or minus ten percent as any margin of accuracy depended on previous designs and on the quality of cost analysis and cost planning. The HVCA suggested that closer budget prices could only be achieved by forcing the cost of the final system down to the budget price at the expense of excessive operating costs.

Ryding's research is at variance with both the HVCA and the RICS papers although the RICS were vague as to what is an acceptable figure. Flanagan (1980)[31] in his doctoral thesis also questioned the general accuracy of quantity surveyors cost predictions and related it to the quantity surveyors lack of detailed knowledge of the construction process. He added that very few quantity surveyors have an appreciation of the technology of design problems. Flanagan argued that if a construction project did not proceed because of the difference between contractors tender prices, and the quantity surveyors price prediction, the implications for clients, the construction industry, and the allied professions would be serious. Abortive costs and work will have been undertaken by all parties. Flanagan also stated that bills of quantity are not accurate in providing information for budget forecasting, and that more research is necessary to produce more accurate price models. On the need for more research, Flanagan suggested that academic research in quantity surveying in 1980 was probably at the equivalent stage of development that engineering research was in 1880!

The comments by the HVCA on design certainly refer to the fact that engineering services design is determined by engineering parameters. Ryding's study probably went some way to defining the apparent difficulties in understanding building

services engineers by building technologists/building quantity surveyors. However, whilst the use of floor area as a basis for preliminary engineering services costs is of doubtful value, the use of approximate calculations, either related to floor area, or building volumetric measurement, can often provide a commencement point for feasibility discussions.

The problems of forecasting the costs of engineering services were also described by McCaffer (1975).[32] He found that in one particular study, the co-efficient of variation (CV) accuracy between forecast and actual cost was 26 percent for heating and ventilation contracts, and 34 percent for electrical contracts. These compared to a CV of 15 percent for constructing office buildings, in the same study.

The C.Vs. which have been used by the Researchers were obtained from the following formula:-

$$CV = \frac{s}{x}$$

where

s = the standard deviation for the set of estimates being considered

x = the mean of the set

Research by Ogunla and Thorpe (1990)[33] showed that CVs were below 6.5 percent for building contractors and 13 percent for professional quantity surveyors' estimates. The CV for quantity surveyors budget estimates were compared with the lowest acceptable tender price submitted by contractors. The CV for contractors were obtained by comparing the contractors submitted tender against final construction costs. The information available at the initial feasibility stage will determine the accuracy of the quantity surveyors figures. However, contractors will have access to more detailed information at the tender stage.

Both clients, and the design team, seek accurate estimates of costs from the quantity surveyor, but it is difficult to see how improvement on the general co-efficient of variation of 13 percent can be made, because of the historical nature of the data available to them. The figures for engineering services, from both Ryding and McCaffer, certainly call into question the budget estimating methods used by quantity surveyors, since they are not only historical, but also relate to the previous discussions on their lack of engineering services knowledge. Flanagan's general criticism of cost prediction follows the same argument.

Felstead (1984)[39] highlighted the lack of co-ordination in engineering services as being a major cause of delays and conflicts. The lack of adequate provision for services, he suggested, resulted in the various sub-contractors trying to get their particular services in first. This often resulted in installed works that may have to be altered causing increase in costs. Felstead referred to the same problem as Birkby, whereby where services were shown as single lines on drawings, the space requirements were often forgotten. Whilst Felstead's comments may still be true for many contracts, the majority of large building contractors in the United Kingdom now employ services engineering co-ordinators who attempt to ensure that the problems expressed by Felstead do not arise. However, where detailed information is not provided by consultants, the co-ordinators work can become difficult.

McPherson (1991)[35] suggests that if trade contractors produced finalised designs in preference to consultants; economies in installations could be made. However, Williams (1991)[36] also argues that cost control of services engineering is poor because on many contracts, services engineers, and not quantity surveyors, control the contract. Davis (1991)[37] comments that the early involvement of services engineering contractors in the design process would reduce costs.

Taymech Limited (1990)[38] pioneered the use of a services engineering contractor as a main contractor on a Design and Build Contract. They were fortunate to be a subsidiary of a major building contractor (Taylor Woodrow Ltd) and were able to form an in-house design team comprising Architects, Structural Engineers and Quantity Surveyors. The main difficulty that Taymech found was that the form of contract was a hybrid of the standard Joint Contracts Tribunal contractors with design form and was not really suitable for work where the services contractor was the main contractor. This particular contract appeared to be successful however, due to the monolithic design team being from one company, albeit separate units within that company. Where co-ordination and co-operation of the professional design team occurs successful contract operation should be possible.

Fisher (1981)[39] stated the necessity of creating a building team which worked together in design, pre-planning and programming. He emphasised that delays occurred due to incomplete design and lack of pre-planning at the tender stage. However he also cited indecision, or changes by clients or their advisers, as contributing to delays and increased costs.

Horsburgh[40] advocates the use of two stage tendering as a means of improving communications and relationships on contracts. In this system the services engineering sub-contractor is involved at pre-contract state with the design team and then negotiates a contract sum at the second stage. Design of buildings cannot be handled by one person and both Fisher and Horsburgh argue for interactive teams to enable economic and satisfactory installations to be achieved.

The use of specialisation in United Kingdom engineering is criticised by Geysen, Belmans, and Findley[41] as being detrimental to the needs of Europe when the Common Market is formed after 1992. They also found that engineering education

in the USA and mainland Europe uses a broad based approach which it is suggested is only achievable by a five year academic study programme. This is in direct contrast to the United Kingdom approach as discussed in Chapters One and Two.

The five year academic study programme is not universal throughout mainland Europe. The author found, from personal experience, that in Denmark, France, Germany and Portugal, three year academic study for a first degree in engineering is common. Five year courses of academic study in mainland Europe generally award Masters degrees. As described in Chapter Two a Masters degree awarded in mainland Europe enables the student to obtain the title Euro-Engineer, whereas in the United Kingdom the normal route to Euro-Engineer is through membership of a Chartered Engineering Institution.

A study by Morice (1990)[42] reiterates that recruitment to engineering academic courses in the United Kingdom declined rapidly from 1984 to 1988. Morice suggests that to young people in the UK, engineering academic courses appear to be dull, old fashioned, and too crowded with studies. He also comments that despite these suggestions, engineering is a discipline demanding hard work, and longer, not shorter, courses may be necessary in the future. This is in contrast to a view at present under consideration by the Department of Education and Science in the United Kingdom that, because of the high cost of academic courses, two year first degrees should be available.

An IPRA report (1991)[43] on the future skill needs of the construction industry stated that only 2.5 per cent of construction students studied building engineering services in 1990 at graduate level. The same report suggested that many technicians with multi skills were required by the construction industry, which was

supported by Smith (1991)[44] who argued that more technicians were needed than chartered engineers in building engineering services.

Smith however argued that common first degrees for engineers are required by the construction industry but neither the IPRA report or Smith appear to acknowledge that financial and management expertise are necessary for engineers.

## REFERENCES - CHAPTER THREE


1) Gray, C., Chartered Institute of Building, Report, 1990, "Specialist and Trade Contractors"

2) Foster, C., Chairman, NEDO Construction Group, Building, p.10, 5th April 1991, "Pyramid Proposal"

3) Barber, C., Construction Weekly, p.14, 27 March 1991, "Teamwork"

4) Construction Management and Economics, 1986, "Image of Status and performance in Building Team Occupations"

5) Ohly, M., Air Conditioning and Refrigeration, p.11, February 1991, "Poor Communication"

6) Higgins, G., and Jessops, I., "Communications in the Building Industry", 1965, Tavistock Publications, London

7) Beazer, B., Architects and Surveyors Institute Dinner, Speech at the House of Lords, November 1990

8) Bell, P., Builder, p.22, 5 April 1991, Letter to the Editor

9) Cecil, R., Building, p.25, 19 August 1983, "Keep the Professionals"

10) Flanagan, R., and Norman, G., Construction Management and Economics, pp.145-161, 1985, "Sealed Bird Auctions: An Application to the Building Industry"

11) Manual of the British Property Federation Contract Form, 1983

12) Riches, J., Architects and Surveyors Institute Conference, April 1991, "Claims in Construction" Norwich

13) Caines, C., Building Services and Environment Engineer, pp.16-17, April 1991, "Parnters in Success"

14) Davis, M., Building Services and Environmental Engineer, April 1991, Article

15) Pylbo, M., Contracts Director, Drake and Scull Ltd., Interview, April 1991

16) Lindon, D., Building Services and Environmental Engineer, p.19, April 1991, "Costing the Future of Construction"

17) Wilson Large and Partners, Coventry, QS Client Needs, Report, November 1991

18) Noblett, A., Heating and Ventilation Contractors Association, Interview, Education Secretary, November 1986

19) Culmer, M., Confederation of Construction Professionals Year Book, 1987, "Building Services Surveyor"

20) Birkby, C. J., "Co-ordination of Building Services", 1982, (Hons) BSc (Hons) Building Thesis, Trent Polytechnic

21) Martin, P., Building Services, Vol.4., No.1., p.55, January 1982, "Conditions of Engagement"

22) Meopham, B., Chartered Quantity Surveyor, pp.35-36, September 1981, "Contractors QS in Engineering Services"

23) Davis, M. K., CIOB Technical Information Paper, No.32, 1984, "The Sub-Contractors Dilemma"

24) Ryding, H., Chelmick, D. G., Building Cost Research Conference, 1982, "Cost Control of Building Services" Portsmouth Polytechnic

25) Heating and Ventilation Contractors Association, 1978, "Bills for Heating and Ventilation?"

26) Royal Institution of Chartered Surveyors, Engineering Services Committee Review, 1978, "Bills of Quantity for Engineering Services"

27) Turner, A., Chartered Quantity Surveyor, p.283, March 1981, "Engineering Services and the QS"

28) Chelmick, D., Chartered Quantity Surveyor, p.283, March 1981, "Engineering Services and the QS"

29) Meopham, B., Chartered Quantity Surveyor, p.284, March 1981, "Engineering Services and the QS"

30) Nisbet, J., Chartered Quantity Surveyor, p.10, August/September 1979, "Who Prepares the Bill of Quantities?"

31) Flanagan, R., Doctoral Thesis, 1980, University of Aston

32) McCaffer, R., Quantity Surveyor, Vol.32, pp.81-86, December 1975, "Some Analysis of the Use of Regression as an Estimating Tool"

33) Ogunla, O., and Thorpe, T., International Journal of Construction Management, Technology, 2, 4, p.34, "Design Phase Cost Estimating - The State of the Art"

34) Felstead, J., Electrical Contractor, Vol.82, Part 1, p.20, January 1984, "Added Responsibilities of Multi-Service Contracts"

35) McPherson, I., Building, p.54, 22 February 1991, "Cost of M and E Services"

36) Williams, B., Building, p.54, 22 February 1991, "Cost of M and E Services"

37) Davis, M., Building, p.54, 22 February 1991, "Cost of M and E Services"

38) Robertson, M. E., Taymech Ltd., Letter to the Author, February 1990

39) Fisher, D., HAC Journal, p.27, 27 October 1981, "The Changing Role of Building Services Contractors"

40) Horsburgh, P., Chartered Building Services Engineer, pp.40-41, February 1989, "A Contracting View"

41) Geyson, W., European Journal of Engineering Education, Vol.15, No.4, pp.314-315, 1990, "The Classical Engineering Studies Pipeline"

42) Morice, P. B., European Journal of Education, Vol.15, No.4, pp.357-360, 1990, "Recruitment of Engineering Students in the United Kingdom"

43) IPRA Report, "Future Skills of the Construction Industry" IPRA Ltd., Brighton 1992

44) Smith, T., Chartered Institution of Building Services Engineers, 1992, Presidential Address

## CHAPTER FOUR

## BUILDING ENGINEERING SERVICES IN THE CONTRACT PROCESS

The Confederation of Associations of Specialist Engineering Contractors (CASEC) have listed the main causes of delay on construction contracts encountered by their members (Figure 4.1) but delays in completing construction contracts can be attributable to many factors that are inter-related between participants.

Azzaro (1987)[1] suggests that the major causes of delay in the construction process are due to unclear or missing project information, and suggests that poor design co-ordination is a contributing factor. The design, and management, of construction projects could be improved, Azzaro adds, if the "Common Arrangement", produced by the Co-ordinating Committee for Project Information (CCPI) was widely employed. The "Common Arrangement" introduced in 1987, is based on common groupings of works in construction and relates to contemporary work practices, rather than trade groupings.

Gordon (1984)[2] explains how contract claims, arising from inadequate information at the tender stage, are commonplace because drawings, specifications, and bills of quantity are prepared in an unrelated manner. He described how, in 1984, it was decided to structure the 7th edition of the Standard Method of Measurement for building works (SMM 7) so that it was consistent with the "Common Arrangement". The SMM 7 (introduced in 1988) permits optional use of descriptions, with abbreviated headings being permitted. Contractors estimators, therefore, have to fully understand the measurement rules set out in SMM 7, otherwise they may fail to price for items necessary to carry out an installation. The term, "deemed to be necessary", is widespread in SMM 7 and

**Figure 4.1**

**Delay Factors identified by CASEC**

Failure to identify the needs of the client and to produce a clear brief

Deficiencies or lateness in design

Poor buildability in design

Lack of integration between building design and engineering design

Deficiencies or lateness in the supply of information

An unstructured site organisation

Poor site management

Poor co-ordination of the building programme

Failure to identify long lead times

Changes of mind and multiple variations

Late delivery by suppliers

Contractors chosen solely on price

information. The earlier 6th edition of the Standard Method of Measurement (SMM 6, introduced in 1979) provided for detailed descriptions of all measured items in a bill of quantities.

The Banwell Committee (1964)[3] highlighted the problems of specialist installations and recommended, that where work was to be carried out by specialist sub-contractors they should have early involvement in the design process.

Chilvers (1990)[4] points out that the role of the engineering services consultant in design is often misunderstood, and argues that failure by architects, and clients engineers, to understand the limitations of a consultants responsibilities and the duties of a sub-contractor, can lead to expensive defects, or delays, on site. He describes how, unless a consultants commission is for full design, building engineering services sub-contractors are obliged to produce working drawings which will dimensionally co-ordinate with other systems. Chilvers accepts that the production of working drawings is expensive and that many sub-contractors avoid them as much as possible. He also suggests that such avoidance can lead to construction delays, and cites as an example, items of plant that were too large for accommodation into a plant room, because working drawings were not provided when the room was constructed.

The author saw a similar example whereby a plant room had been constructed on verbal information supplied by an engineering sub-contractor. On delivery of the hot water storage calorifiers, it was found that the overall dimensions of the calonfiers were too large to fit into the plant room. In this particular case the sub-contractor faced a claim for the costs of altering the plant room dimensions.

Barton (1976)[5] compared the differing agreements between client and architect,

and client and the engineering services consultant. He described how an architect, under the Royal Institute of British Architects (RIBA) "conditions of engagement", has responsibility to integrate any work produced by consultants. Barton compared this requirement to the Model Form of Agreement produced by the Association of Consulting Engineers (ACE) which does not give any recognition to the necessity for co-operation within the design team. This, he argued, could lead to less enthusiasm by the engineering services consultant to teamwork, and co-ordination, since it is a service that the consultant was not required to provide.

The Barton study agrees with Chilver on the problem of engineering services drawing production. Barton compares the production of plans, sections, and elevations, by architects and structural engineers, to the schematic drawings of pipes and ductwork produced by engineering services consultant. Whenever the Author has produced engineering services drawings for contracts, isometric layouts of pipe runs have been provided. These have been appreciated by estimators and installers alike as showing exactly how the installation should be completed. It is rare, however, for isometric drawings to be provided by either consultants or sub-contractors, with the result that estimators over, or under, price and installers often have to guess the designers intentions. Whilst it must be accepted that drawings production is expensive, lack of detailed information can increase construction costs due to delays, which may be in excess of initial drawing production.

Davis[6] suggests that as engineering services are not always fully designed at the tender stage, problems of co-ordinating the pipes, ducts, cables and equipment within the structure are inevitable. Without a technically able person to co-ordinate all the construction processes, Davies argues, the contract operation cannot flow smoothly. He adds that to avoid delays, engineering services design

should be carried out in parallel with the architectural design. Lack of information through drawings can therefore be seen as a problem which generally relates to cost restraints. Both fee competition between consultants, and the sub-contractors desire to reduce initial drawing costs, are added contributory factors which reduce information flow, and increase construction delays.

Horsburgh (1990)[7] adds to the discussion by suggesting that it is important that there must be a good working relationship between contractor, architect, structural engineer, and services engineer. He comments that on every contract, there should be a design team leader, who will take responsibility for overall co-ordination between the three main disciplines. Details proposed by design sub-contractors should, Horsburgh adds, be checked and evaluated, and information should be presented in detail with all necessary material schedules.

Gray and Flanagan (1988)[8] compared the operation of sub-contracting in Europe, the USA and Japan. They found that in the USA, all design work is usually completed before site work commences, and that the sub-contractors site management is of a high quality. In Japan, sub-contractors tended to work for one contractor only, with the main contractor determining contract price. Essentially the system in Japan is to provide labour only sub-contracting facilities.

Sub-contractors dominate in France and Germany in that they carry out virtually all the work. In Germany, they have responsibilities for design, and construction, but in France, they are usually responsible for construction only, with design being carried out by Bureau d'etudes (BET). Gray and Flanagan reported that in none of the countries they studied were bills of quantity, or quantity surveyors used. Engineering processes dominated the construction process, and the author found similar attitudes on visits to European construction companies and sites.

Birkby (1987)[9] suggests that the majority of variations that occur in services engineering contracts arise from incomplete designs from services engineering consultants. This suggests that consultants are responsible for full design, whereas in practice, they are, in the majority of contracts, only responsible for outline design and supervision. Specialist sub-contractors are commonly responsible for detailed design. A National Economic Development Council (NEDC) Research Report (1988)[10] highlighted delays in the design of engineering services, and commented that these were often caused by the break in design progress whilst the specialist contractor was appointed. The research also emphasised that inadequate space, and location allowances, made by consultants during the earlier stages in design, had to be revised once the true dimensions were known. The division of design between engineering services consultants and specialist contractors was criticised by the NEDC report and suggested that either one, or the other, should be responsible. Where both were involved, the report stated, recriminations and delays occurred, but where only one party was involved in the design, problems of demarcation were avoided. In the worst example cited by the report, changes in design resulted in an enlarged services duct, which in turn meant new planning approval had to be sought. These, and Birkby's comments, probably are in agreement with the discussion in Chapter Two, which related to the reduction in information provided by consultants due to the introduction of fee competition and reduced fee scales.

Earlier, Fisher (1981)[11] had also blamed incomplete design for delays and variations. He also argued that incomplete design, rather than the use of nominated sub-contractors, was the main cause of conflict between engineering sub-contractors and main contractors. Fisher's argument was based on design delays by architects, or consultant engineers, and emphasised the importance of producing a good, complete design in a similar manner to the HVCA report.

The practice of using nominated sub-contractors had developed over many years, but became more common after the introduction of the Joint Contracts Tribunal Standard Form of Contract 1980 edition.[12] Fisher [11] suggests that nomination enables the engineering services contractor to tender with confidence against competition that is thought to be fair. Baccarini (1989)[13] stated that the most frequently nominated sub-contractors were building engineering services contractors because of the increasing sophistication, and specialised nature, of the engineering services content of buildings.

The Heating and Ventilating Contractors Association (1983)[14] cited research studies in Australia to support their argument that the use of nominated sub-contractors could lead to contract cost savings of 10 percent or more. The use of nominated sub-contractors was discussed by Cutting (1985).[15] He argued that the most vociferous critics of nomination have been the quantity surveyors who suggest that nomination, under the JCT 80 form of contract, constitutes an open invitation, to main contractors, and nominated specialists, to blame each other for any contract delays. Cutting argues that instead of tackling the basic causes, i.e. the contractual framework, quantity surveyors propose billing of engineering services and the use of domestic sub-contractors from a specialist list of contractors.

Whilst Cutting criticises the quantity surveyors for antagonism towards nomination; clients, and main contractors, have been equally critical. Nomination of sub-contractors under the Joint Contracts Tribunal Form of Agreement 1980, falls into two categories i.e. the "basic" method of nomination and the "alternative" method.

Nomination of a sub-contractor by either method will be because either the Architect, or client, or both, wish to have the final selection of a particular sub-

contractor. This may be because of a particular specialisation that the client, or architect, knows that the sub-contractor possesses. The procedure for appointing a nominated sub-contractor is set out in Figure 4.2 Much of the criticism of the nominated sub-contractor selection centres around the time consuming administrative processes involved before the sub-contractor is officially appointed. Four sub-contract forms have to be completed as set out in Figure 4.3 if the "basic" method is used. This method is for use where the sub-contract works are substantial. It also ensures that the sub-contractor agrees with the main contractor, the programme of work, and that both parties enter into an amicable contract. With the "alternative" method, only one form of sub-contract is required (Figure 4.4) and programmes of work may have to be settled after nomination. The "basic" method of sub-contract also ensures protection for the client by the necessity for the sub-contractor to enter into a "collateral warranty" with the client which does not involve the main contractor. In effect, these are insurance policies to protect the client if the sub-contractor defaults in any way.

The problems of liaison between the various parties where nomination occurs were highlighted by Porter (1978).[16] He insisted that where an architect had early discussions on a design and construction timetable with a nominated engineering services sub-contractor, then there must also be liaison with the main contractor. Without such liaison, Porter argued, problems could arise whereby the programme of work planned by the sub-contractor, could be out of sequence with the programme of the main contractor.

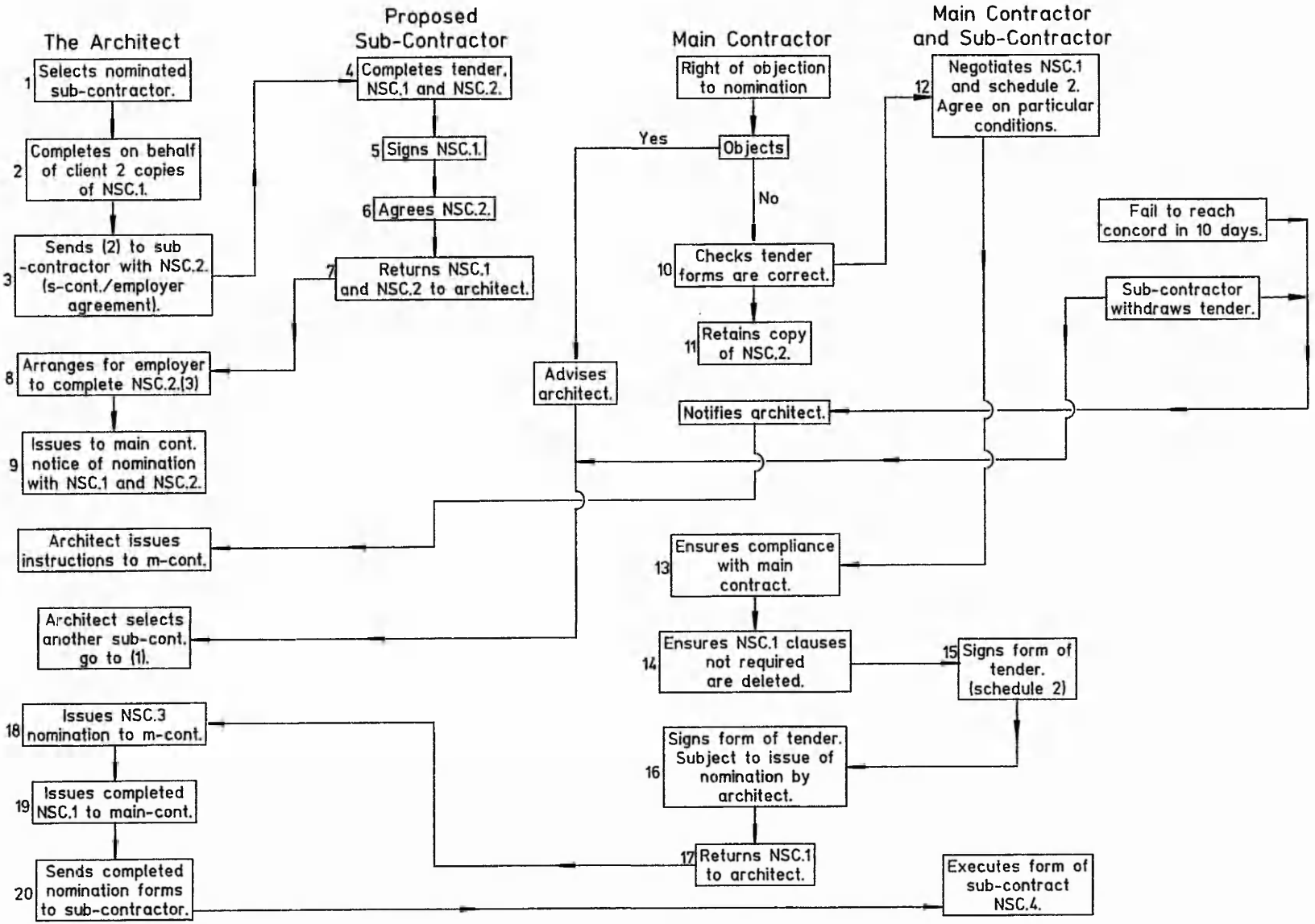


Fig. 4.2

Contractural Procedure for the Nomination of Sub-Contractors (JCT '80 Standard Form)

**Figure 4.3**

**Standard Forms Used in the Basic Method of Sub-Contractor Nomination**

1) Standard Form of Tender and Agreement NSC/1

2) Standard Form of Employer/Nominated Sub-Contractor Agreement NSC/2

3) Formal Nomination instruction NSC/3

4) Nominated Sub-Contract NSC/4

(Binding agreement after stages 1, 2, 3, which concludes the Basic Method of Nomination)

**Figure 4.4**

**Standard Form Used in the Alternative Method of Sub-Contractor Nomination**

1) Standard Form of Employer/Nominated
Sub-Contractor Agreement NSC/2a
(Not always required)

2) Nominated Sub-Contract NSC/4a
(Binding Agreement adapted from NSC/4 and used where Tender Form NSC/1 has not been used)

Commonly NSC/4a only used.

Essential information MUST be an appendix to this form.

Jones (1980)[17] described how, in his opinion, the JCT 80 contract document would eliminate unfair contract conditions that had previously been imposed on sub-contractors. By inference, he also suggested that the problem of liaison, highlighted by Porter,[16] would be solved.

The introduction of the 1980 edition of the JCT form of contract was generally welcomed by sub-contractors and nominations by architects became common.

Whilst the Banwell Report[3] had earlier agreed that nomination of sub-contractors was advantageous where specialisms, such as building engineering services occurred, the report also suggested that main contractors should be responsible for the appointment of sub-contractors.

Two associations representing sub-contractors the Federation of Association of Specialists and Sub-Contractors (FASS), and the Confederation of Construction Specialists (CCP), both produced reports (1991)[18] criticising the use of onerous, and unfair, contract conditions, by main contractors against sub-contractors. From the introduction, in 1980, of an agreed revised standard form of contract, to within a period of ten years, the standard conditions were therefore not being complied with. Banwell's concerns, expressed in 1964, and partly ignored by the introduction of the JCT 80 are, from the above, seen to be valid. The basic problem with the nomination of sub-contractors is that there is a danger that they will have mixed loyalties to the design team, and main contractor. Not only main contractors were concerned at nomination of sub-contractors. Clients also expressed concern at nomination and some of them decided to challenge the established traditional procedures for building procurement.

In 1983, the British Property Federation, which comprises major private sector

clients, produced its own system of procurement and contract documentation.[19]

The BPF system specifically excludes the use of nominated sub-contractors and passed responsibility for much of the building design to the main contractor. The BPF system allowed for sub-contractors to be named in the contract documents and this was followed by similar procedures in the Intermediate Form of Contract (ICF 84) introduced by the Joint Contracts Tribunal in 1984. The adversarial approach of the JCT contract forms, and lack of clear duties for each party to a contract, are cited, as reasons by the British Property Federation for the introduction of their contract form.

John Sainsbury plc, the United Kingdom grocery company, were also discontented with the Joint Contracts Tribunal 1980 Edition standard form of contract. They had continued to use the 1963 Edition of the Standard Form until advised by their legal advisers that continued use of the form could lead them into conflict with the Courts in the event of litigation. Sainsbury's then introduced their own form of building contract for use on all building contracts operated by them.[20]

A further criticism by Sainsbury's refers to the constitutional make up of the Joint Contracts Tribunal (Figure 4.5) in that the private employers have one representative in the form of the British Property Federation. Before any tribunal decision is binding it has to be agreed by all the members. As the British Property Federation have also introduced their own contract form, as described above, Sainsbury's criticism probably has some validity, if looked at from the private clients position.

**Figure 4.5**

**Constituent Members of the Joint Contracts Tribunal**

Royal Institute of British Architects

Building Employers Federation

Royal Institution of Chartered Surveyors

Association of County Councils

Association of Metropolitan Authorities

Association of District Councils

Confederation of Association Specialist Engineering Contractors

Federation of Association of Specialist Sub-Contractors

Association of Consulting Engineers

British Property Federation

Scottish Building Contract Committee

Sainsbury's were also unhappy with the method of using nominated sub-contractors in the manner laid down by the JCT standard form of contract, but still wanted to use specialist sub-contractors they were familiar with. They therefore favoured the system of using named sub-contractors, whereby they can indicate the sub-contractors they wish to use, but at the same time the main contractor has complete control of the management of such contractors. Main contractors can ask for sub-contractors of their own selection to be added to the tender list, but details of the contractors selection have to be circulated to the original named sub-contractors. The alternative to the use of named and nominated sub-contractors is to use domestic sub-contractors who are generally selected and appointed by the main contractor. The client, (or client's adviser), will have usually provided an original list of three sub-contractors, but commonly the main contractors add sub-contractors of their own choice to create extended tender lists.

Beurain (1989)[21] argued that whilst the use of domestic sub-contractors gives more flexibility of choice to main contractors, there is much abuse of the system. There are many examples, he argued, where tender lists of sub-contractors were initially as high as ten, then reduced to six, and subsequently. Reduction of the original tender prices were then achieved by "dutch auctioning", which set one sub-contractor against another. It was not unknown in this system, Beurain suggested, to re-invite new tenders after this process. All costs in producing tenders have to be borne by the sub-contractors who will inevitably seek to recoup these costs during the contract operation. Producing fewer detailed drawings as described earlier is one method used by sub-contractors to reduce costs but this often leads to contract delays.

Whilst CASEC[22] argued strongly for the use of nominated sub-contractors, their use has declined because of the objections raised by Clients, their advisers, and

main contractors. The Named sub-contractor procedure considerably reduces administration prior to contract commencement whilst still giving clients control over who will carry out specialised work such as building engineering services. Management control rests with the main contractor. Named sub-contractors were introduced into the Joint Contracts Tribunal Form of Intermediate Contract in 1984 which was designed to be used for contracts not exceeding £250,000 in value and for contracts not exceeding 12 months in length.

Griffiths[23] suggests that there is doubt as to whether or not this particular form was designed for use where the building engineering services content of contracts is extensive. The named procedure was attractive to clients and their advisers and for this reason it is not unusual to see the intermediate form used on larger contracts than originally intended. The problem with the use of the intermediate form is that there is no provision for design and where contractors design is specified the risks of problems with design may inconvenience the client, or his adviser, who will have no redress. It is also essential when using the JCT 80 Standard Form that where contractor design is specified, the design supplement of the form is used. Sainsbury's use of the named procedure is an example of the welcome this method received, but is also an example of how clients have exerted influence on the way that building contracts operate. The use of named sub-contractor procedures enables architects or clients advisers to indicate to the main contractor the sub-contractors they wish to be employed.

If, however, sufficient information on design requirements, contract duration times, and site availability are provided to sub-contractors, many of the delays and conflicts that occur could perhaps be eliminated. In an ideal world a quantity surveyor would look to a contract that would provide the client with least risk, an

architect would look to a contract that would perhaps provide the least grief, and a contractor would look for a commercially sensible contract, hence the contractors favourable reaction to JCT 80.

The University of Reading report, "Building Britain 2001",[24] concluded that the standard forms of contract used for building contracts are too detailed and flexible, which is a similar criticism to that of J Sainsbury plc. An argument put forward by "Building Britain 2001" was that the standard forms allowed design to be incomplete at the tender stage, and permitted clients to change their mind during construction. This flexibility it was suggested is frequently the source of conflict.

However, Gray and Flanagan, argue that on lump sum contracts as specified under the standard form JCT 80, design is assumed to be complete prior to the invitation to tender, but as Harding (1991)[25] states this is never the case. Gray and Flanagan also suggest that modern construction processes are not really amenable to lump sum contracts and these contracts also fail to recognise the extensive input into the design process by building engineering services sub-contractors.

Gray and Flanagan also cite as an area of probable conflict the division of responsibility between building engineering services sub-contractors and building engineering services consultants, whereby the division of responsibility appears to have no meeting point.

Gray and Flanagan appear to overlook the fact that on many of the lump sum contracts, building engineering sub-contractors effectively are employed on a design and build basis. The virtual elimination of nominating sub-contractors has placed management responsibility for building engineering services design onto the main

contractor, but for this to be successful sufficient time must be allowed for interaction between the various members of the design team. Wood (1990)[26] describes how the JCT 80 standard form, and the JCT Intermediate Form of Contract, expressly state that the Standard Method of Measurement, 7th Edition (SMM7) should be used for measuring work to produce bills of quantity. He also suggests that the area of largest contention in tendering is in the specialist work, such as building engineering services. Wood also argues that, whilst traditionally, building engineering services have tended to be included as "design and build" packages within the main contract with many complicated contractual problems ensuing, he could not see any significant changes occurring to this process. This is, Wood suggests, due to tradition, shortage of time, and clients finding it economically favourable, but cites insufficient pre-tender planning and design as factors creating difficulty.

Simac (1990)[27] described how the business activities of consulting engineers, civil engineers, and building services engineers, often create similar contractual relationships which led to the creation of the FIDIC international contract document. FIDIC is the acronym of the French name of the international association of consulting engineers "Federation Internationale des ingenieurs conseils".

Comparing building engineering services to other engineering works, such as civil engineering, Simac suggests, shows differences in areas of supply of equipment and size and bulk of operations. Because of these differences, a separate contract document is available which was originally based on the Model Form B3 produced in 1963 by the Institute of Electrical Engineers and the Institution of Mechanical Engineers. A simplified form was updated by FIDIC for building engineering services work in 1987. Whilst the documents are based on English law, Fidic,

according to Simac, found it necessary to update the traditional old fashioned language used in English law so as to make it understandable to international consulting engineers.

Kennedy (1985)[28] stated that compared to France and Germany, law in the United Kingdom is much less centrally regulated and had developed in a "piecemeal" way. This resulted, she argued, in a lack of clarity about the respective rights and obligations of the parties to a contract and a proliferation in litigation and arbitration in the United Kingdom construction industry. Kennedy also suggested that the standard forms used by the construction industry had a tendency to distort the contractual position of the various parties to a contract. The increase in the proliferation of standard forms since 1965, she argued were proof that the standard forms have not proved to be satisfactory at one time or another.

Cottam (1987)[29] had earlier put forward similar comments to Simac in that the FIDIC contract for Electrical and Mechanical Works was a move forward in contract documentation whereby simple English language was used in place of the legal language so favoured by the English legal system. However, Cottam concedes that even in the updated document there are anomalies, particularly where the engineer has to approve contractors drawings. In contracts such as design and build, the sub-contractor is responsible for the drawings and design, and it is an impossible task Cottam suggests for the engineer to check and approve every drawing that is produced.

Hamilton (1990)[30] forecast that the design and build method of building procurement, common to building engineering services sub-contracts, will become an accepted way of construction for all type of contracts, and quotes the Royal Institution of Chartered Surveyors as concluding "that it is a cost effective way of

procuring a building where speed of construction is important."

Campbell[31] considered that there were five cost implications of design and build contracts:-

i) Buildability

ii) Quality

iii) One off buildings

iv) Motivation and conflict

v) Competition

Buildability is in effect the practicality of a design to be implemented into a building, and Campbell suggests that if the contractor is involved in the design process then his expertise should produce a better design particularly relating to speed and ease of construction. Griffiths (1989)[32] stated that the traditional design process, embodied in traditional contracts, depended upon a steady flow of information but ignored the skills, and information, that a contractor could contribute. Buildability, involving the creation of a multi-disciplined design team can reduce costs, he suggests. However, Williams (1983)[33] had earlier warned that whereas good site management will always overcome an inadequate design, good designs will not always overcome inadequate management.

Quality can be variable on design and build projects, according to Campbell,[31] but where the contract design is carried out under the JCT 80 standard form, with contractors design, then both design and site work are subject to supervision by the "employers' agent:. Subject to cost restraints, quality can be assured if adequate independent supervision is provided. A contractor wanting further work will ensure that the whole contract is both cost effective and well designed.

One off buildings can create problems, but as the majority of designs fall into this category, then the prospect of future work will create the same incentives as for quality.

Motivation and conflict are both related to relationships between individual departments in a company carrying out the design and build contract. In both cases if the aims of all departments are the same, then costs will be reduced and it is the aim of good company management to ensure this. Competition is the way that the client is provided with value for money, but it is essential that the number of contractors' tendering are kept to a sensible minimum (as earlier described by Beurain) because the costs of design have to be added to the traditional estimating costs.

All the five factors above can be applied to design and build contracts of any size, and equally relate to building engineering services sub-contracts.

Carpenter (1987)[34] described how, in the United States of America, contracts were commonly carried out with multi-disciplinary design teams, the use of an owner project manager, and with buildability the main theme of all construction. He also suggested that USA contracts were often completed in 18% less time than comparable United Kingdom contracts. One particular feature Carpenter highlighted, was that sub-contractors produced their own working drawings and are effectively design and build contractors using their specialist and practical experience to produce economical buildings. Quantity Surveyors are not used on USA contracts, with cost control being undertaken by the architect and contractor. Engineers and the project manager handle all payments during construction. Sub-contractors bid for works packages on a lump sum basis and are paid monthly

for the proportion of work that they have completed which eliminates the necessity for measuring the lengthy payment calculations which are a feature of traditional United Kingdom contracts.

Fenn (1990)[35] wondered whether the use of the quantity surveyor was the major cause of conflict on United Kingdom contracts and suggested recent increases in civil engineering case law were the result of increasing use of quantity surveyors on civil engineering contracts. Fenn accepts that to date there is no firm evidence to support this but if quantity surveyors are increasingly used on building engineering services contracts, a similar result may follow.

However, Turner (1991)[36] commented that a significant number of United Kingdom contracts specifically excluded the use of bills of quantities with the increasing use of design and build.

Gray and Flanagan stated that in Japan, the majority of building work was undertaken by specialist trade contractors who had a "paternalistic" relationship with the main contractor. The sub-contractors depended upon the main contractor for future work and had generally worked for particular contractors for many years. Gray and Flanagan reported how at tender stage the main contractor stipulated the contract price, rather than let the specialist sub-contractor estimate for the contract. The Japanese philosophy is one of trust, which is singularly lacking in many traditional United Kingdom Contracts. Quantity Surveyors are also absent from the Japanese contract scene, outside the United Kingdom, with payments being negotiated weekly with the project manager.

Management of sub-contractors is undertaken by the main contractors who also evaluate the performance of their sub-contractors at least twice a year.

Gray and Flanagan state that the contracting system in the majority of countries they had assessed, was designed to harness the full production capabilities of sub-contractors so as to reduce interference in their operations to a minimum. They suggested that if United Kingdom construction productivity is to increase then the attitude that persists that the sub-contractor is seen as a facilitator of design and subservient to the design team must be reconciled with the practice they had observed in other countries.

From the Author's observations of the French method of construction contracting, the common system is that of letting contracts on a trade by trade basis - "lots separes". The co-ordination is undertaken by a "pilote" who may be a specialised pilotage company or more commonly one of the trade contractors. The system is similar to the one that commonly operates in the USA which has been imported into the United Kingdom under the heading of Construction Management.

Margrave[37] describes how his building engineering services company found that its status was raised to that of other contractors by the client when they operated under a construction management contract. He did, however criticise the lack of co-ordination between contractors and stated that no one in the construction management team was designated to act as co-ordinator resulting in damage to installed services. A clause in the contract "protection to practical completion" effectively passed the responsibility to the sub-contractor from the Construction Manager. Margrave suggests that whilst a good construction management contract is fairer to building engineering services sub-contractors; poor management personnel, and poor drawing detail from consultants, both create the same difficulties as for traditional contracts. The speed of such contracts, he suggests, requires building engineering services engineers who are able to adapt to clients requirements, and be able to anticipate problems before they arise, i.e.

be good managers.

Margrave reiterates the concerns of Sturla and Pilboe on the management deficiencies of building engineering services engineers that were discussed in Chapter Three.

Whilst Margrave is positive, generally, about the operation of construction management contracts, there is, as Franks (1990)[38] indicates a problem of cost control at the outset of the contract as compared to design and build contracts. This is because although the management contractor is appointed early to control costs, full cost control cannot be undertaken until all the various sub-contractors have submitted their tenders.

Huxtable (1990)[39] also argues that management contracting is an expensive way of procuring contracts and that specialist sub-contractors often receive unfair treatment. He suggests that too often on management contracts the specialist sub contractor is treated as an appendage to be added onto a contract rather than be treated as a major part of the design and construction process. Huxtable considers that construction management, rather than management contracting, is fairer to the specialist sub-contractor, which is the same argument put forward by Margrave. Spackman[40] an advocate for management contracting suggests that an advantage is the separation of design from construction in management contracting. This argument however is at variance with virtually every other advocate of alternatives to management contracting, and the separation of design from construction is generally cited as the main problem in the inefficient operation of contracts in the United Kingdom, and the reason why design and build has received such favourable comment.

Construction management and management contracting are essentially systems whereby a company is employed to manage the contract on a fee basis. The main difference is that in construction management, the construction manager is employed to manage the contract and the sub-contractors enter into direct contracts with the client. In management contracting the sub-contractors are in contract with the management contractor and are paid by him. A further refinement of the management process has been the introduction of project management.

Franks[38] explains how the British Property Federation introduced the term "client's representative" which is used in many countries. Project management is the term used to describe the client's representative in the majority of United Kingdom systems and can be employed in any procurement system. Franks also suggests that the project management system has developed in response to a demand from clients for better management on contracts. The Chartered Institute of Building in a Technical Paper (1988)[41] stated that the role of project manager is developing throughout the world but originated in Sweden. The project manager is another independent adviser appointed to have complete control of the management of the contract and be the client's representative with full authority to make decisions.

The proliferation of differing forms of contract have created difficulties for all participants in the construction process. As described earlier, clients have wanted a greater say in the design and construction of buildings and many have been dismayed at the conflict that occurs in the traditional process of procurement in the United Kingdom.

Gillingham (1991)[42] argues that the continuing trend to obtain lower unit costs by

buying from the cheapest source wherever it comes from avoids innovative measures which would secure the long term future of the industry. He suggests that the United Kingdom approach of cut-price costs is at variance with practice in both the United States and Japan where quality and time take precedence. He could have added Germany where profit margins on contracts are larger. On visits to German construction sites the Author found that quality was uppermost and time secondary. Profit margins were regularly in the area of ten per cent as against United Kingdom figures of four per cent and less. Gillingham describes how building services engineering is growing in importance as a proportion of first and life cycle costs and suggests that letting contracts for such works in fragmented packages is unrealistic for modern construction.

Knowles (1990)[43] describes how as many as one hundred separate trade contracts can be formed with employers on construction management contracts and if any single contractor fails to perform correctly, then the employer may suffer financially, particularly if the contractor has left the site after being fully paid, apart from retention. The case referred to by Knowles relates to the use of a non-standard contract form, but employers can have more protection if tried and tested case law documentation is used.

Moss (1991)[44] considers that many of the problems creating conflict can be blamed on modern contractual frameworks using the old concept of professionals carrying out the design, and "the rest" doing the work. He states that this is not generally the way that modern contracts operate, but suggests that even where it does, specialist building services engineers are not regarded as part of the construction team. Moss also suggests that a major re-appraisal of contracting in the United Kingdom is required, and that there should be less involvement by the legal profession, who are commonly employed to draft non-standard contract forms of

great complexity.

Roberts (1991)[45] chronicles the changes that have occurred in building services engineering over the last twenty five years and explains how they have created conflict in the construction process. He suggests that the introduction of cheap energy and expensive money were the major factors that created difficulties. The former caused building design to change so as to introduce deep plan buildings with high illuminance, which in turn created heat that had to be combated by air conditioning. The ensuing dove-tailing of engineering services into buildings, Roberts suggests, led to inevitable delays with sub-contractors and main contractors blaming each other. He also suggests that as engineering services sub-contractors did not have expertise in the use of bills of quantities they did not know how to show why delays impinged on their tender price and lost out contractually. Main contractors, Roberts explains, were used to bills of quantities, particularly with separately identified preliminaries, and so could justify cost increases. Because of the rapid evolution of building engineering services over the past twenty five years, Roberts believes that, compared to architecture and structural engineering, the learning curve has been dramatic. Expensive money means that clients have to keep a close watch on expenditure and look for procurement methods which will do this. Roberts states that in his opinion, which agrees with others, that the process of design and build is the way in which the majority of buildings will be procured in future.

Kwakye (1991)[46] explains how the concept of fast track building requires designs that are buildable, including the designs of building engineering services. By using prefabricated packages for engineering services, delays Krakye suggests, can be reduced to a minimum. He also recommends that the lead services of mechanical and electrical should be used as the guideline for the remainder of the

installation teams with all works contractors being encouraged to communicate each with others. Kwakye also suggests that works or sub-contractors should have good managerial capabilities which is the same suggestion put forward by Margrave earlier (1989).[37]

On fast track construction contracts, designing occurs at the same time as construction and sub-contractors may have problems balancing expenditure against income, causing them to divert into other work to raise cash and at the same time, creating delays on the fast track contract. Where set-off clauses are incorporated into contracts by the management, or construction management contractor, they may create enormous difficulties for the sub-contractor. Set-off clauses were introduced to enable construction managers to claim compensation from sub-contractors if they were alleged to be responsible for any delays in construction progress. Problems can also arise if the contract programme is accelerated without warning by the main contractor but any accelerated programme will create difficulties for building engineering services contractors because of the probable delays in obtaining manufacturers equipment. This factor is not often recognised by other members of the design and construction team.

Huxtable (1990)[39] expresses concern that there are too many open ended set off clauses which allow management contractors to deduct money from sub-contractors arbitrarily. He also added however that construction management contracts were better for specialist sub-contractors as they undertook more of the design and have an increased management role. Huxtable also forecast that large contracts in the future would only be taken on in the United Kingdom by five or six specialists employing their own sub-contractors. In effect he is implying that the United Kingdom will follow the Japanese method of contracting. Huxtable's forecast has partially occurred with the take over of the major building engineering services

sub-contractors by major building contractors as described in Chapter Two.

The consensus of written and verbal opinion relating to building engineering services is that contractors prefer to produce their own designs and want a greater say in how contracts are managed. Lack of management and financial experience by the majority of building services engineers is a major stumbling block to such ideals but the continuing growth of design and build contracts will probably see a change in attitudes towards management and financial control in the building engineering services sector.

## REFERENCES - CHAPTER FOUR


1) Azzaro, D., Building Services Journal, p.39, June 1987, "Talking a Common Language"

2) Gordon, A., Building Services Journal, p.55, October 1984, "Getting Together on Project Information"

3) Banwell Report, 1964, "The Placing and Management of Contracts for Building and Civil Engineering Work", HMSO

4) Chilvers, H. D., Architect and Surveyors Institute Year Book, p.103, 1980, "The Design and installation of Building Services"

5) Barton, P. K., "The Co-ordination of Mechanical and Electrical Engineering in Building Production", 1976, MSc Thesis, Salford University

6) Davis, M. K., CIOB Technical Information Paper, No.32, 1984, "The Sub-Contractors Dilemma"

7) Horsburgh, P., Building Services Journal, "A Contracting View"

8) Gray, C., Flanagan, R., "The Changing Role of Specialist and Trade Contractors, Reading University, Published by CIOB

9) Birkby, C. J., "Co-ordination of Building Services", 1987, BSc (Hons) Building Dissertation, Trent Polytechnic

10) National Economic Development Office, ISBN 07292 0941 5, "Faster Building for Commerce", November 1988

11) Fisher, D., Heating and Air Conditioning Journal, pp.27-28, October 1981, "Engineering Services Review"

12) RIBA, 1980, "Guide to the Joint Contracts Tribunal Standard Form of Contract"

13) Baccarini, D., Architects and Surveyors Institute Yearbook, 1989, "The Question of Nomination"

14) HVCA Commercial and Legal Circular, Sheet No.10, 1983

15) Cutting, G., Chartered Institute of Building, "Nomination - the Myths and the Realities", Technical Information paper No.56, 1985

16) Porter, R. W., National Builder, p.174, May 1978, "Main Contractor and Nominated Sub-Contractor Working Together"

17) Jones, A., Electrical Times, pp.5-6, 29 August 1980, "Publication of JCT, Forms Eases Sub-Contractors Lot"

18) FASS, May 1991 and CCP, July 1991, "Onerous Contract Conditions"

19) Manual of the British Property Federation System for Building Design and Construction, BPF Ltd., 1983, ISBN 0900101 083

20) Sainsbury Building Contract, John Sainsbury plc

21) Interview with A Beurain, Contracts Director, Alfred McAlpine Ltd., 1989

22) CASEC, April 1985, "Nomination and the Building Process"

23) Griffiths, P., "Building Engineering Services Contract Administration Manual", 1990, Nottingham Polytechnic

24) Building Britain 2001, University of Reading, Report for Building Employers Confederation, ISBN 07049 0942 1

25) Harding, C., Building Journal, p.11, 22 November 1991, "BEC Discussion Document"

26) Wood, A., International Council for Building Research Studies Conference, Zagred, September 1990, "Procurement Procedures for United Kingdom Building Works and Relationships Between Bills of Quantities and the for of Contracts"

27) Simac, S., International Council for Building Research Studies Conference, Zagreb, September 1990, "Fidac Contract Documents"

28) Kennedy, J., Construction Surveyors Institute Year Book, 1985, "Law of the Construction Industry"

29) Cottam, G., Construction News, 23 July 1987, "Arguing the Case for Simple Contract English"

30) Hamilton, N., International Council for Building Research Studies Conference, Zagreb, September 1990, "A Review of the United Kingdom procurement Methods"

31) Campbell, C., Construction Surveyor, pp.16-18, January 1985, "The Contractor and the Design Process"

32) Griffiths, A., Science and Research Council Research Paper, 1984, "Buildability - A Case Study"

33) Williams, A., Architects Journal, No.6, Vol.177, 1983, "Buildability - A QS View"

34) Carpenter, T., Chartered Builder, pp.4-5, 26 May 1987, "USA Building"

35) Fenn, P., International Council for Building Research Studies Conference, Zagreb, September 1990, "Settling Disputes on Construction Projects"

36) Turner, A., Chartered Quantity Surveyor, p.23, October 1991, Article

37) Margrave, R. M., Russell & Russell Building Services Ltd., 1989, ICE Fast Build Conference

38) Franks, J., CIOB, 1990 ISBN 1 85380 014 7, "Building Procurement Systems"

39) Huxtable, J., Building Journal, p.27, 23 March 1990, "Management on Trial"

40) Spackman, C., Chairman, Bovis Construction, Building, p.27, 23 March 1990, "Management on Trial"

41) CIOB, August 1988, "Project Management in Building", Technical Paper

42) Gillingham, D., Building Journal, p.22, 2 August 1991, "Industry Strategy"

43) Knowles, R., Building Journal, p.39, 13 July 1990, "Construction Managers Lose Their Appeal"

44) Moss, T., Building Journal, p.IX, November 1991, "The Sub-Contractor"

45) Roberts, M., Building Service and Environmental Engineer, p.8, July 1991, "Beyond Capital Costs"

46) Kwakye, A. A., CIOB, 1991, Occasional Paper No.46, "Keeping up with Fast Track"

## CHAPTER FIVE

## INTERVIEWS

During the period that this research was undertaken, interviews were carried out with senior personnel in the construction industry to ascertain the position, and problems associated with building engineering services within the industry, and also how the provision of these services were perceived by such personnel. Originally it had been intended to undertake twenty to thirty company personnel interviews using specific questions. Unfortunately, the majority of people contacted insisted, that because of commercial restraints, they required anonymity and many refused to give firm comment. The reticence of these personnel is understandable, given the severe recession which began to affect the construction industry from the latter period of 1988, and it has meant that no firm conclusion could be obtained from the interviews.

Those personnel that were willing to be interviewed have added to the discussions in earlier Chapters and in some cases have consolidated the work of earlier researchers. Their opinions, therefore, have been included, both for interest, and to show how some of the comments discussed earlier are still prevalent in the construction industry.

On one particular construction management contract at Bishops Gate in London, Bovis Ltd. were the contractors. Mr J Broderick, the Construction Manager,[1] described how the use of Trades Contracts created problems for the sub-contractors who initially found difficulty in accepting responsibility for their work. The building engineering

services contractors were the most seriously affected as they were used to being told what to do on traditional style contracts, and were used to making claims for problems they encountered. Mr Broderick also described how on a traditional contract, undertaken by his company at Kingston-on-Thames in London, the main cause of delay by the building engineering services contractors was due to lack of information from the building engineering services consultant.

Mr J Dunster, the Vice Chairman of Taylor Woodrow (Scotland)[2] described how he found that generally, building engineering services sub-contractors run by engineers were seriously lacking in knowledge of contract documentation. Engineers, he suggests, like to think they understand contracts, but when serious disputes arise, a contractors quantity surveyor is often called in. Usually they arrive too late but being quantity surveyors try to defend their company which prolongs the dispute.

Dunster also stated that his company often encountered more problems from the mechanical engineering side of services engineering than from electrical engineering. A major problem on mechanical engineering contracts, he suggested, was the poor quality of manufactured components of which the sub-contractor had no control. The lack of cost expertise by both Architects and Engineers was highlighted by Dunster, and he stated that as they both have a major influence on contracts it was essential for their knowledge to be improved in this important area.

At the date of the interview, Dunster commented that the majority of building engineering services contracts with his Company were Domestic sub-contracts under JCT Standard Form 1980 edition and for Government Contracts,

GC Works 1 Standard Forms. He also said that whilst many building engineering services contractors blamed consulting engineers for delays, it is often the case that the sub-contractor has not produced adequate working drawings as required by the contract documents.

On the contentious issue of building engineering services quantity surveyors, Dunster argued that specialisation is unnecessary until after a general course has been studied. He also suggested that lack of services knowledge is not a hindrance to a trained quantity surveyor who has good contract knowledge.

Dunster, as a building contractors surveyor, highlighted the differences that arise frequently between builder and engineer, and builder and professional quantity surveyor. He sees the main role of the professional quantity surveyor as controlling costs and claims during contract operation and having no other main role on the majority of contracts. He also said that whilst the profession of quantity surveyor does not exist in Japan, the USA, or mainland Europe; in these countries the contract role is undertaken by Engineers or Architects and is not "pigeon holed" as it is in the United Kingdom.

On a £40 million contract in Birmingham, the Contract Manager[3] of Tarmac Construction described how the contract was a Standard JCT 80 Contract with nominated building engineering services contractors. The use of nomination, he stated, caused delays in two areas. The first was insufficient labour provision by the sub-contractor, and secondly, the acceleration of the main programme without acceleration by the nominated sub-contractor. These two items highlighted how conflict can occur when insufficient thought had been given to the preparation of contract documentation.

A contracts manager of a major Midlands based contractor[4] suggested that building engineering services engineers should only specialise after studying a basic construction course. He also thought that the same should apply to quantity surveying and could not see any validity for a pure building engineering services quantity surveying course. This perception of building engineering services is followed in two United Kingdom Universities, Loughborough and Manchester Institute of Science and Technology. In the former, students specialise in the final year of their course after two years of Civil Engineering studies and in the latter, specialisation occurs at Master of Science level after undergraduate studies for a BSc (Hons) Building.

From other discussions with building professionals, including Senior Quantity Surveyors, the same perception of building engineering services emerged. The general opinion was that problems that did arise were because the engineering services sub-contractors had insufficient knowledge of contract operation. No one was prepared to admit that there were differences between building and engineering requirements.

A building engineering services contractor's Director, based in Nottingham[5] suggested that most engineering services contractors liked the use of bills of quantities because they used the imperfections of the bills to make money by claiming for variation. This particular engineering services company was one of the first to employ quantity surveyors.

A partner of a civil engineering consultancy in the Midlands, suggested that the Civil Engineering Form of Contract was more suitable for building engineering services contracts than the standard building contract forms such as JCT 80. He explained that the latter form was more akin to building whereas the Civil

Engineering Form was designed to cater for engineering practices. He also described how the simplicity of the Intermediate Contract Form (ICF 84) had led to it being used for larger contracts.

An associate of a chartered professional quantity surveying Practice, Mr M Whitt of Gleeds,[7] suggested that the lack of engineering services knowledge could be a hindrance to a quantity surveyor when dealing with variations and billing, but not from a contractual viewpoint. There were, he suggested, definite skill shortages in the area of bills of quantity production. When interviewed, (1988) Mr Whitt stated that clients were beginning to become annoyed at delays in contract operation and he suggested that in many cases lack of design details from consultants was a major difficulty. He also described how many of the services surveyors that were employed by both professional quantity surveyors and contractors were educated to Higher National level only, with many undertaking engineering courses before transferring to quantity surveying.

The Partner of a Manchester based consultancy described how it was not uncommon for the building engineering services content of a contract to be the dominant part as far as time was concerned, but because the Engineering services sub-contractor appointment was generally after the main contractor, sub-contractors were usually given insufficient time to complete works. This often occurred because at the tender stage the time allocation for engineering services would be set before the main contractors tender was agreed. Lack of adequate pre-contract programming in cases such as this led to conflict and delays.

A contract manager controlling a major contract in the Midlands (1988) stated that trying to obtain drawings from Architects and Consultant Engineers took up more

time than controlling the sub-contractors. He had encountered this problem on many contracts, even when standard building contract forms were used which usually required all requisite drawings to be available before work commenced.

Another contract manager, with Rush and Tompkins ltd (1989), a company which has now ceased trading, implied that the use of design and build contracts enabled the main contractor to assert more control over both architects and consultant engineers.

The Chairman and Managing Director, Mr F Jaques of Jaques (Building) Ltd., a medium sized building and civil engineering contractor repeated the views expressed by Dunster that in his experience, building services engineering contractors had little contractual or arbitration knowledge.

The experience of working with Japanese clients was described by one contracts manager. He said that variations were agreed as the work progressed and they were able to submit a final account on the final day of the contract. Delays in payment of the final account were caused, he stated, by the professional quantity surveyor appointed by the Japanese client.

A sub-contractor site agent working under a Management Contract on a large contract in the South East of England (1988) stated that delays were often caused by late decisions from the management contractor. Delays of up to seven days were common because of indecision and ineffective management by the management contractor.

A common complaint by many of those interviewed was the increase in meetings and administration on management contracts.

Another common complaint from many contractors and quantity surveyors was the differing ideas of responsibility that arose from building services engineering contracts. This was because of the numerous sub-contractors that were often employed in the various services engineering disciplines.

An independent quantity surveyor, Mr J Holden, who specialised in services engineering contractual claims, stated that he found the knowledge of services engineering by the average professional quantity surveyor to be extremely poor.

Many of the comments that emerged from the interviews confirmed the discussions in earlier Chapters. Sub-contractors criticised the lack of detailed information available to them but as Dunster points out, many of these criticisms are ill-founded as it is often their own contractual responsibility. There was a diversity of opinions, but a common thread of criticism from the interviewees was that of a lack of contract and financial knowledge by many building services engineers when controlling contracts, and the rare involvement by sub-contractors at the planning stage of contracts.

## QUESTIONNAIRE USED FOR VERBAL INTERVIEWS

1) Which contract is commonly used for main contracts.

2) Which sub-contract is commonly used for services engineering contracts.

3) Do building engineering services sub-contractors have services surveyors?

4) If not who does the negotiating?

5) Are there problems in interpreting sub-contractors requirements by main contractor?

6) Are problems due to lack of information from designers?

7) Is there interpretation of information by sub-contractors?

8) Were any delays solely due to sub-contractors?

9) Were any delays to sub-contracts caused by main contractors?

10) Were any delays attributable to client?

11) Which part of contracts causes the greatest problem?

12) Which particular trade causes greatest trouble?

13) Is lack of services knowledge a hindrance to a QS?

14) Would better pre-contract meetings assist?

15) Are skill shortages a major contributor to delays?

16) Any adverse reaction from clients to delays?

17) Was the client QS helpful or a contributor to delays?

## REFERENCES - CHAPTER FIVE


1) Mr J Broderick, Construction Manager, Bovis Construction, 30th January 1990

2) Mr J Dunster, Vice Chairman, Taylor Woodrow (Scotland), 6th March 1988

3) Contract Manager, Tarmac Construction, 27th October 1988

4) Contracts Manager, Wiltsier plc, October 1991

5) Contracts Director, Hilton Building Services Ltd., November 1989

6) Mr J Pike, Joynes-Pike Associates, March 1990

7) Mr M Whitt, Building Services Associate, Gleeds, October 1988

8) Partner, Building Design Group, Manchester, November 1989

## CONCLUSIONS

Croome describes how, in 1989, he found that out of a total United Kingdom construction workforce of 1.6 million personnel, 250,000, or 15 per cent, were employed in building services engineering. The same research also found that the corporate membership of the Chartered Institution of Building Services Engineers was 7,000. This was in comparison to a combined corporate membership of 250,000 in the Royal Institute of British Architects, the Chartered Institute of Building, the Institution of Civil Engineers, the Institution of Structural Engineers, and the Royal institution of Chartered Surveyors.

At a total corporate membership of 7,000 the professional component of building services engineers in construction appeared to be only 2.8 per cent. These figures omit the building services engineers who are members of either the Institution of Mechanical Engineers, or the institution of Electrical Engineers. Whether these figures are too low relatively to the other construction professionals, or are correct in terms of industrial requirements, is difficult to quantify.

It is possible that the construction industry does not require the large numbers of people that are qualifying in the other professions and clarification of the industry's requirements could probably be the basis for a major research initiative. As discussed throughout this thesis, the monetary value of building engineering services on many commercial and industrial building contracts exceeds that of other areas of construction and yet, as Croome records, the number of professionals in the industry, as compared to other professionals, is low. Figures are not available as to how many engineers are corporate members of either the Institution of Mechanical Engineers or the Institution of Electrical Engineers, but it is doubtful if they would add significantly to offset the overwhelming totals of the

other institutions in construction.

Building engineering services, in the form of the Institution of Heating and Ventilating Engineers, was established, as described in Chapter One, in the 19th century at a similar time to all the major professional institutions, but 6the establishment of professional recognition has been a slow, difficult process.

Morice's suggestion, as described in Chapter Three, that engineering is not attractive to many young people in the United Kingdom is a commonly held view. There is, in the United Kingdom, a social attitude to engineering which will be difficult to change but there has never been a major difficulty in attracting undergraduates to civil engineering courses.

Building engineering services has a lesser attraction, as evidenced by the number of undergraduates on degree courses. Why one area of engineering is attractive is difficult to ascertain, but it may be that civil engineering is preferred because its finished projects can be seen, whereas building engineering services are invariably hidden within the building.

The numerous disciplines associated with building engineering services, as described in the introduction, is a major problem and is a microcosm of the building industry as a whole. The number of disciplines in building engineering services has increased with the increasing complexity of installations, but there was evidence in 1991 that efforts were being made to reduce the number of disciplines. Air conditioning installers complained that packaged air conditioning systems were being installed by plumbing contractors, who in turn argued that the installation of simple packaged units was well within their capabilities. The plumbing contractors also argued that the employment of multi-skilled craftsmen

HERIOT-WATT UNIVERSITY LIBRARY
INTER-LIBRARY LOANS
**********

VE41172

From:
INTER-LIBRARY LOANS
LIBRARY

01 JUL 1998

RESTRICTED ACCESS

The following item has been lent to us on the condition that it is consulted only in the LIBRARY. Please call at the ILL DESK with this notification before 08 JUL 1998. Also, bring this notification on each subsequent visit.

DUE BACK: 06 AUG 1998 (CAN NOT BE RENEWED)

BOUSFIELD, R.A.
BUILDING ENGINEERING SERVICES IN THE CONSTRUCTION PROCESS
M.PHIL THESIS, NOTTINGHAM TRENT UNIV.
1993

AJ EBRAHIM $
POSTGRADUATE
DEPARTMENT OF BUILDI
ENGINEERING AND
SURVEYING

NO RENEWAL

HERIOT-WATT UNIVERSITY LIBRARY
**********

AJ EBRAHIM $

RECEIPT FOR RESTRICTED ACCESS MATERIAL VE41172 Due: 06 AUG 1998

I acknowledge receipt of: BOUSFIELD, R.A.
BUILDING ENGINEERING SERVICES IN THE CONSTRUCTION PROCESS
M.PHIL THESIS, NOTTINGHAM TRENT UNIV.
1993

and I understand that this must NOT BE REMOVED FROM THE LIBRARY. I will en
that it receives all reasonable care whilst in my possession and I will re
it to the ILL DESK not later then 15 minutes before closing time or, at an
earlier time if requested to do so.

| DATE & TIME OF ISSUE | READER | TIME OF RETURN | RETURNED TO | FIN WITH |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

is the way the construction industry should be progressing if efficiency is to be improved. The largest items in many building engineering services installations are the manufactured packaged units, and it therefore follows that a modern craftsman ought o be capable of connecting the various pipes, cables, and ducts between these units.

Professional building services engineers are educated and trained in multi-disciplines within services, and it follows that services engineering contractors should be capable of multi-service installations. By being multi-disciplined a major source of conflict could be removed, but additionally both engineering services contractors, and professionals, should have greater financial and management skills.

The increasing use of life cycle costing will make building owners aware of the high costs associated with both the provision, and operation, of services engineering and will inevitably add to the debate. Throughout the thesis, reference has been made to the criticisms of the lack of management and financial skills by services engineers, and it is an area that must be rectified if their status is to be enhanced. The problems of the building services engineer being accepted as an equal in the industry are aptly illustrated by the comments of Scott and Sturla in Chapter one and by the research of Faulkner and Day described in Chapter Two.

As described in Chapter One, the first major professional construction institution was that of the civil engineers and it is ironic that the first secretary of the ICE, James Forrest assisted in the formation of the Royal Institution of Chartered Surveyors. As both institutions have headquarters in close proximity in central London, they are ideally placed strategically and historically to combine their resources. The major difficulty, and probably insurmountable in the short term,

would be that of sectarian interests. This was a major reason for the failure of the attempt to create a building engineering services section in the Institution of Civil Engineers in 1972. Smaller non-chartered institutes have merged due to economic necessity and it can only be a matter of time before the same harsh realities apply to the chartered institutions.

The two major professions in construction in continental Europe are Architects and Engineers. In the United Kingdom, the Institution of Civil Engineers and the Royal Institution of British Architects are arguably the dominant professional institutions and are therefore likely to enhance their position over the next decade.

To have any influence on European Government policies, consideration will have to be given to grouping of the professional institutes under these two main headings. The emergence of the construction professional institutes, as described in Chapter one, was in response to the necessity of the various professions to group together to safeguard their interests. In effect, the professional institutes are described by John Parris in his book "Companies for Construction Professionals" as private clubs, having no real authority apart from on their individual members. The institutions can argue, with justification, that they are learned societies and that their influence extends beyond that of their members.

The European Economic Community Directive 89/48 EEC on higher education will probably have more impact and influence on the education of construction professionals from 1993 onwards than the not inconsequential influence that the professional institutions have had over the previous one hundred years. As described in Chapter Two, the first Directive relating to three year full time education, or its equivalent, will become the mandatory requirement for all construction professionals wishing to work within the EC. This Directive will

exclude architects who have their own Directive 85/384. A second Directive Com/90 389 File 5YW 209 to be introduced in 1992, will have a similar requirement for full time education of two years duration, i.e. effectively at technician level. Both Directives in the United Kingdom will relate to National Vocational Qualification levels, with level 5 covering the first Directive, and levels 1 to 4 covering the second Directive, at which time the influence of the Construction industry Council will become important.

The impact of NVQs on professional institutions is still unclear, but if central government's determination to see their implementation is maintained then the effect may be considerable. The overall aim is to reduce the number of differing examining bodies and produce a system of vocational or competency testing. The formation of Occupational Standards Councils to supervise the quality of standards will ensure that the competence levels are maintained. It is possible therefore that the professional bodies may either have to produce their own approved occupational standards; select occupational standards from a central core produced by the Construction Industry Occupational Standard Council; adapt, or obtain exemption for, their present system of examinations.

The Construction Industry Council has been the first forum whereby all construction sectorial interests can communicate and produce a united voice. There are likely to be sectorial dissents for the first few years but eventually, and inevitably, there must be some form of unity if the industry is to speak with one voice.

A major impetus towards unanimity could be given by the educational system. The education of the professionals in construction is based on the pattern of professional institutions which were formed in the 19th century, and many of the

industry divisions are compounded by this system. The tendency of the United Kingdom Governments to leave vocational education to the professional institutions and industry has created fragmented education. Conflict within Government Departments has not helped and perhaps closer co-operation between, or merger of, the Departments for Education and Science, Trade and Industry, and Employment would create a more practical approach to education. However, as late as 1992, there are signs that integration is still not occurring. The Author was told by the Department of Employment that two separate Departments are dealing with the two EEC Directives on qualifications, and these do not include the Department for Education and Science. Education is, it appears, being covered by three separate Departments.

The perception of the building services engineer by fellow professionals is that of having a lesser education and training. When comparing syllabus content of education courses it is difficult to justify such a perception. The mathematical content of building engineering services courses equates with those in civil engineering, and exceeds those in most building and quantity surveying courses.

Whilst management as a subject is included in building engineering services degree courses, and also in the professional examinations of the Engineering Council, there does not appear to be a great emphasis placed on construction contract management in the form of contract awareness and financial control. It may be that this deficiency in practical financial control and management contributes to the perception of building engineering services education by other professionals in construction.

In many mainland European countries the status of the engineer is high and the author found that in Portugal, engineers had the highest status in the construction

industry. Although Portugal has a small population, the status accorded to professional engineers is not dissimilar to that in other mainland European countries. As the single European Market strengthens, the influence of engineers will probably be enhanced and a trend is discernible in the United Kingdom whereby higher educational degree courses in building are beginning to attach the title engineer to become degree courses in building engineering. Building engineering services will be included in Building engineering studies together with structural engineering and foundation engineering. This will probably enhance the status of building engineering services as a subject but may weaken it as a discrete profession.

Because contract management and administration is rarely appreciated by building services engineers, it shows up a weakness in their education. Although services engineers seldom require expertise in mathematics and physics in industrial employment, the majority of United Kingdom degree courses in building engineering services to place great emphasis on such subjects. This anomaly requires careful consideration but it is a fact that the average building engineering services designer or engineer will never have to apply, or use, complex mathematics.

However, the academic study of mathematics, and physics, does enable a wider appreciation, and analysis, of design areas, particularly if employment is in consultancy. It also has to be accepted that any engineering degree course that excluded mathematics and physics could not be considered to be academically rigorous. Whilst these subjects may have limitation in routine application, the laws of both studies govern the whole area of building engineering services and must be retained.

A further complication is the use of technicians by contractors to both design, and control, building engineering services contracts. Quantity surveying would probably have the same difficulty in recognition were it not for the fact that until 1973 chartered quantity surveyors were in consultancies and were not allowed to operate as chartered quantity surveyors in contractors offices. By requiring degree level competency, the quantity surveying profession was able to build up the status of the profession despite the initial criticism by many architects that quantity surveying was a pedestrian occupation. Whether the dividing line between technician and professional employment will become more clearly defined will depend upon the status accorded to the first Directive on qualifications throughout the EEC.

If the subject of building engineering services is made compulsory in all construction degree level courses then more prestige will be accorded to the subject and probably also the profession. Flanagan's comments on the serious gap in building engineering services knowledge by quantity surveyors coupled with those of Lansley, Timmermans, and Beazer suggest that there are serious deficiencies in the education of construction professionals.

Croome's argument that the construction professions should be inter-disciplinary, not multi-disciplinary, is one way forward but probably would still maintain sectarian professionalism. Much debate at present is centred around the possible future role of the construction professional institutions but suggestions of their demise are probably premature.

However, if the higher education three year full time diploma becomes the accepted route to professionalism, together with national vocational qualification accreditation, then many professional institutions may have less than a decade to

survive in their present form. Despite claims to grandeur, all professional institutions rely on subscriptions from their members to survive. Any large reduction in membership subscriptions would see an inevitable demise of a professional institution and therefore, some form of unification may become of paramount importance.

The professional institutions have considered making continuing professional development (CPD) a condition of continued membership. They formed the CPD in Construction Group, which in 1992 merged into the Construction industry Council. In practice the impact on membership of CPD is likely to be minimal as only one, the Royal Institution of Chartered Surveyors, has made it mandatory as a condition of continued membership and the probability of this being strictly enforced is remote. The Institution of Civil Engineers has recommended that CPD be undertaken, but the majority of institutions have made compliance obligatory. Figures C.1 and C.2 show the intentions of institutions towards CPD in 1992.

Major changes in the way construction projects are procured, and operated, have, over the past decade, highlighted the contribution of sub-contractors, particularly those in building engineering services, to the construction process. Sub-contractors employ the majority of the labour force and added to this, in the case of building engineering services, is the fact that they may also have responsibility for the largest financial content of the contract. Where services engineering is the dominant area there is no reason why the services engineering contractor should not be the main contractor. There are cases where the services engineering contractor has operated as joint main contractor but the lack of management and financial skills by the services engineering contractor is still a major problem. These two skill areas will need urgent attention from building services engineers if they are to continue to supervise large contents of construction contracts.

There is an increasing trend towards the employment of design and build contracts. This trend should counteract some of the criticisms attributed to the provision of drawings on contracts because the services engineering contractor will generally have to provide both outline and detailed drawings.

Delays that occur on design and build contracts can generally be attributed to the contractor causing the delay and with penalty clauses being punitive, the services engineering contractor has to have firm financial and management control. Whilst both Foster and Horsburgh argue in chapter 3 for interactive design teams, the emergence of multi-disciplinary services contractors is now apparent. The acquisition of major building engineering services contractors by multi-national United Kingdom construction contractors, as described in chapter 3 has resulted in multi-disciplined companies which are able to tender for and carry out all work on particular contracts. This approach is one way of taking the Japanese method of paternal employment of sub-contractors one stage further.

The problems of conflict within the construction industry have been discussed throughout this thesis and the research referred to shows that the causes are not confined to one particular area. Sectarianism by the professional institutions, the individual professionals desire for dominance, poor organisation on site, numerous contract forms, financial and administrative incompetence, and late payments are all seen as areas which exacerbate the problem. In chapter three, the isolation of design from construction is also seen as a source of conflict.

That these problems are not new is evident from the thesis, which shows that common comments spread from the Barnwell Report of 1964 to researchers and commentators of the present day.

In chapter three, reference is made to Flanagan and Norman who suggest that careful selection of contractors is of paramount importance. Any system of open tenders without scrutiny is bound to create difficulties if contractors inexperienced in certain types of work are allowed to submit tenders.

The use of Bills of Quantities is under scrutiny and in Chapter Three both Riches and the British Property Federation are shown as two examples of the mounting criticism of this method of procurement. If the use of Bills of Quantities is under attack on the general construction side of the industry it is fair to assume that they will never become common for building engineering services contracts.

Geysen, in chapter three, is reported as criticising the specialisation of engineering in the United Kingdom and advocating a broad based approach. In construction, specialisation is common and is reflected in educational courses. Prior to 1960 broad based education was common in United Kingdom construction courses other than Architecture. The Construction Industry Council are proposing that broad based courses be reintroduced and Hill, in Chapter Two, advocates a similar approach. The use of broad based courses should effectively reduce the potential for conflict within the industry, but if the professional institutions remain each in isolation then the process will be difficult.

The increasing use of design and build contracts will probably be a major factor in co-ordinating the various professions under the control of a main contractor. Ironically, this will be a repetition of the role the first main contractors undertook when they combined the resources of trade contractors to offer "contracting in gross". Unfortunately, at present it appears that construction education is in general behind the way that modern industry is progressing. Horsburgh's comments, discussed in Chapter Four, that there should be a design team leader,

can also be extended to the contract operation. Dissatisfaction by both contractors and clients with the traditional leadership role of the architect has resulted in the increasing use of design and build contracts, and the emergence of project managers. The latter is employed by the client to oversee all financial and managerial control of a contract and is, effectively, the clients' representative. As described in chapter four, the emergence of the project manager has again led to further conflict in that several professions are laying claim to be the most able to undertake the role. In practice as stated in chapter four the role could be undertaken by any competent professional.

The proliferation of contract forms is another source of conflict highlighted in chapter four. Sub-contract forms create dissatisfaction for many sub-contractors but the research shows a willingness by building engineering services sub-contractors to accept trades contracts as operated under construction management contracts. The fact that on this type of contract the majority of the specialised design is undertaken by the sub-contractor is shown to assist in smooth contract operation. Without doubt, where the contract, either at sub-contract or main contract level, is under the control of the contractor, smoother operation appears to occur, which in turn leads to less problems for the client.

It was unfortunate that the results of the interviews were not as detailed as envisaged at the commencement of the research, but the author found that comments received from a wide variety of sources confirmed those of researched sources. Whether it was lack of knowledge, or type of contract, the same comments were constantly repeated.

During the period that the research was undertaken (1987-1991) the construction industry underwent a tremendous change. An unprecedented work load in 1987/88

was followed by a deep depression. The use of standard contract forms changed to an increased use of non-standard forms produced by both clients and main contractors and including severe penalty clauses for sub-contractors who contravened them. Increasing delays in payments to sub-contractors also created severe financial difficulties.

The changing role of the professional quantity surveyor has also been a major difficulty for that profession in that there has been a decline in the use of bills of quantities. For many quantity surveyors, these were their main source of income, and a demand for more financial advice in forms such as life cycle costing was, and is, an expertise beyond the skills of the average quantity surveyor. Quantity surveying will also be directly affected by the influence on construction from mainland Europe in that at present there is no role for them as a professional. By changing their role to financial adviser they may be able to adapt, and there is evidence that there may be a demand for their services in Germany. However, the danger for quantity surveyors is that their role may be undertaken by Engineers.

Building services engineers may also find that their specific title may change in that they may simply become engineers. The difficulty of remaining a discrete profession has been described earlier, and added to this is the pressure to include engineering services into building engineering so as to produce a more generalised professional engineer, able to specialise in any one field of operation.

Unless building services engineers become more proficient in both contract management and financial control their influence will diminish and they may be overtaken by building engineers who will have a broader based knowledge.

As described in chapter three the control of six of the major United Kingdom building engineering services contractors has passed to main contractors by the nature of financial take-overs and this could lead, eventually, to a different approach to the operation of construction contracts.

This thesis shows that conflict within the construction process is not new and that there are attempts being made to counteract the problems that are apparent. Building engineering services as a profession has had to try and achieve recognition as an equal to other professions within this framework but has suffered from:

1) the difficulty other engineering institutions and professions have in recognising it as a discrete profession.

2) the dilution caused by the multiplicity of disciplines and fragmentation into other engineering institutions, such as the Institution of Electrical Engineering, which are outside the mainstream of construction.

3) The difficulty building engineering services contractors have in accepting that they need professional engineers in preference to technician engineers.

4) the failure of construction education to emphasise its importance by making it a mandatory subject in construction professional and degree courses.

5) the lack of managerial and financial knowledge of its professionals.

6) the failure of consultants to supervise contracts, and provide adequate detailed information to contractors thus exacerbating the suspicion other disciplines have of building engineering services.

7) the problems created by 'sick building syndrome' and 'legionella bacteria' which relate to poor design and maintenance.

8) the undue sophistication of services engineering installations with respect to both installation and operation.

It will be difficult to counteract the negative aspects of many of the above points, but it is recommended that an attempt is made by:-

1) the creation of multi-disciplined craftsmen/women; for example, in house-building the work of plumbing, heating, electrical installation, gas fitting, and glazing could easily be combined. In larger installations, heating, plumbing, gas fitting, ducted air installations could be incorporated into one with electrical and refrigeration work being similarly combined. The advent of competency based NVQ's will determine the individual's capabilities.

2) the creation of multi-disciplined degree courses having common early years with specialisation left until the final year. This format could be achieved by a study of the basic engineering, physics, financial control, management, and aesthetic requirements of buildings, followed by specific detailed study in the final year.

3) ensuring that contract management, financial control and forecasting is a major part of ALL construction courses. An example of how a building engineering services degree course could incorporate these extra subjects is given in Figure C.3.

A suggested format for a common degree covering all the construction professions with specialisation in the final year is given in Figure C.4.

In the operation of construction contracts it is essential that a building engineering services co-ordinator is appointed on all contracts having a large proportion of engineering services.

It is also of paramount importance that consideration be given to simplifying construction contract documentation so as to eliminate expensive delays and litigation.

The difficulties seen in building engineering services are a major cause of concern but are only one of several areas within the building process where there are problems. Because civil engineering contracts tend to operate autonomously as described in Chapter One, perhaps they could be used as a base for further investigations into the building process.

**FIGURE C.1**

**CPD IN CONSTRUCTION GROUP**
**CPD IN PROFESSIONAL INSTITUTIONS IN CONSTRUCTION**

MEMBERS OF THE GROUP

| Institution Members | CPD Status | Minimum CPD per year | Record Provided | Monitoring (see note) | Accreditation | Assistance with CPD (see note) |
|---|---|---|---|---|---|---|
| CIOB 32,270 | Obligatory | 20 hrs | A5 card | (a) (b) | CPD Study Centres Firms Courses | (c) |
| CIBSE 15,250 | Obligatory | 20 hrs | A4 ring | (b) | Recognition of course providers | (c) |
| ICE 77,000 | Recommended | 5 days | A5 booklet | (b) | No | (c) 'Courses Guide' 'Bulletin Board' |
| IStructE 20,000 | Obligatory | 20 hrs | A4 ring binder | (b) | No | (c) 'CPD Handbook) |
| RIBA 28,000 | Obligatory January 1993 | 35 hrs | Being prepared | No | No | (c) CPD Newsletters |
| RICS 89,000 | Mandatory | 60 hrs in 3 yrs | Filofax card | (a) (b) | No | (c) Branch Newsletter |
| RTPI 17,400 | Obligatory June 1992 | 50 hrs in 2 yrs | Record sheet | (a) (b) | No | (c) 'Practice Advice Note' Note' |

Notes:
Monitoring
(a) Sample Surveys (b) Requirement for membership upgrading
Assistance with CPD
(c) Provision of library: journals and other publications; course provider (courses/conferences/seminars); distance learning material; advice.

**FIGURE C.2**

ASSOCIATE MEMBERS OF THE GROUP

| Institution Members | CPD Status | Minimum CPD per year | Record Provided | Monitoring (see note) | Accreditation | Assistance with CPD (see note) |
|---|---|---|---|---|---|---|
| ASI 5,500 | Obligatory | 20 hrs | A5 card folded | (b) | | (c) |
| BIAT 6,200 | Voluntary | 35 hrs | A4 card folded | (a) Certificate of Compliance | | (c) |
| IAAS 4,200 | Obligatory | 20 hrs | A4 ring binder | (b) | | (c) |
| IMBM 2,400 | to be Obligatory | 20 hrs | A5 card | | | (c) |
| ICES | Obligatory | 25 points varying with activity | A5 booklet | (a) (b) | No | (c) |
| Information Subscribers | | | | | | |
| Landscape Institute 3,500 | Obligatory | 20 hrs | A4 sheet folded | | | (c) |
| Institute of Clerks of Works 4,150 | Voluntary | 20 hrs | Under investigation | | | (C) |

**FIGURE C.3**

**SUGGESTED SUBJECT AREAS FOR A BUILDING ENGINEERING SERVICES DEGREE COURSE (30 week year)**

| Year 1 | Study/Hours | Year 2 | Study/Hours | Year 3 | Year 4 | Study/Hours |
|---|---|---|---|---|---|---|
| Mathematics | 60 | Mathematcis | 60 | Industrial Placement | Air Conditioning | 30 |
| Thermodynamics | 100 | Acoustics | 60 | | Heating | 60 |
| Fluids | 60 | CAD | 45 | | Contract Law and Management | 120 |
| Materials Science | 30 | Heating | 90 | | Electrical Services | 30 |
| Computing | 30 | Contract Finance | 90 | | Design Project | 120 |
| Heat Transfer | 60 | Air Conditioning | 45 | | Dissertation | 120 |
| Building Services Systems | 60 | Drawing | 30 | | | |
| Communication and Administration | 60 | Controls | 90 | | | |
| Drawing | 30 | | | | | |
| Controls | 30 | | | | | |
| Building Technology | 90 | | | | | |
| Totals | 670 | | 600 | | | 480 |

**FIGURE C.4**

**SUGGESTED COMMON DEGREE COURSE STRUCTURE**

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 |
|---|---|---|---|---|---|---|
| Architect | C | $C_2$ | Industrial Placement | $S_1$ | $P_1$ | $P_2$ |
| Building Services Engineer | C | $C_2$ | (Flexible for the Architect) | $S_1$ | $P_1$ | |
| Builder | C | $C_2$ | | $S_1$ | $P_1$ | |
| Civil Engineer | C | $C_1$ | | $S_1$ | $P_1$ | |
| Quantity Surveyor | C | $C_2$ | | $S_1$ | $P_1$ | |
| Structural Engineer | C | $C_1$ | | $S_1$ | $P_1$ | |

C - common studies in all subjects

$C_1$ - common studies but with introduction of specialism

$C_2$ - common studies but with introduction of specialism

$S_1$ - study of specialism with specialism input to a common project

$P_1P_2$ - specialism into post-graduate years (only mandatory for the Architect to equate with existing education requirements)

## BIBLIOGRAPHY


1) Ashworth, A., Building Economics and Cost Control, 1983, Butterworths, London

2) Ashworth, A., Cost Studies of Buildings, 1988, Longmans, harlow

3) Beckman, R., Into the Upwave, 1988, Milestone Publications, London

4) Bonny, J. B., Handbook of Construction Management and Organisation, 1980, Van Norstrand Reinhold, New York

5) Bowley, M., The British Building Industry - Cambridge, 1966, University press, London

6) Brandon, P. S., Building Cost Techniques, 1982, E&F Spon, London

7) Cartlidge, D. P. and Mehrtens, I. N., Practical Cost Planning, 1982, Hutchinson & Co., London

8) Coad, R., Laing, 1979, Hodder & Stoughton, London

9) Cooke, B. and Jepson, W. B., Cost and Financial Control for Construction Firms, 1979, MacMillan, Basingstoke

10) Cormican, D., Construction Management - Planning and Finance, 1985, Construction Press, Harlow

11) Fellows, R, Langford, D, Newcombe, R, and Urry, S., Construction Management in Practice, 1983, Longman, Harlow

12) Ferry, D. J. and Brandon, P. S., Cost Planning of Buildings, 1980, Granada, London

13) Flanagan, R. and Norman, G., Life Cycle Costing for Construction, 1983, Surveyors Publications, London

14) Franks, J., Building Procurement Systems, 1984, CIOB, Ascot

15) Gregg, P., A Social and Economic History of Britain 1760-1970, 1971, Harrap, London

16) Hillebrandt, P. M., Analysis of the British Construction Industry, 1984, MacMillan Press, Basingstoke

17) Kelly, T., Adult Education in Great Britain - Middle Ages to the 20th Century, 1970, Liverpool University Press, Liverpool

18) Mudd, D. R., Estimating and Tendering for Construction Work, 1984, Butterworths, London

19) Major, W. T., Cases in Constract Law, 1983, MacDonald and Evans, Plymouth

20) Oxford English Dictionary, 1961 Clarendon Press, Oxford

21) Parrish, J., Companies for Construction Professionals, 1987, Collins Ltd., London

22) Ramus, J. W., Contract Practice for Quantity Surveyors, 1989, Heinemann-Newnes, Oxford

23) Robinson, C. and Ruddock, L., Quantitative Methods for Surveyors.

24) Rolf, L. T. C., Thomas Telford, 1979, Pelican Books, Harmondsworth

25) Skidmore, M., Contract Bidding in Construction, 1989, Longman, Harlow

26) Smith, R. C., Estimating and Tendering for Building Work, 1986, Longman, Harlow

27) Thompson, F. M. L., Chartered Surveyors; The Growth of a Profession, 1968, Routledge and Kegan Paul, London

28) Watson, G., The Civils, 1987, Thomas Telford Ltd., London

**REPORTS AND PAMPHLETS**

29) Architects and Surveyors Institute Year Book, 1987/88/89, Chippenham

30) Barnes, M., Institution of Civil Engineers Report. "New Style Contract for Civil Engineering", 1987, London

31) Barton, P. K., "Co-ordination of Mechanical and Electrical Engineering", MSc Thesis, 1976, Salford University

32) Birkby, C. J., "Co-ordination of Services" BSc Thesis, 1987, Nottingham Polytechnic

33) Banwell Committee Report, "The Placing and Management of Contracts for Building and Civil Engineering Work", 1964, HMSO, London

34) Burrows, M., "Modes of Obtaining Building Contracts during the Industrial Revolution" Trent Pager No.2, 1987, Nottingham Polytechnic

35) BTEC Annual Reports, 1985-1991, London

36) British Property Federation Contract Manual, BPF Ltd., London, 1983

37) Casec, Guide to Sub-Contracts, 1982, London

38) Cipher Report - 3rd Symposium for Professional Bodies in the Construction Industry, Centre for Educational Resources, 1988, London

39) CPD in Construction, Department of Education and Science, 1989, London

40) Cotterrell, G., "The Builders Quantity Surveyor" IOB Paper. No.1., 1979-80

41) Cooney, E. W., "Innovations and Contracts in the Post War British Building Industry", Construction History, Vol.3., 1987

42) Census Records for England and Wales, HMSO, 1861

43) Cutting, G., Technical Information paper No.56, CIOB, 1985

44) CIB, international conference proceedings, Zagreb-London, 1990

45) DeVille, H. G., Review of Vocational Qualifications in England and Wales, Department of Education and Science, 1986, HMSO, London

46) Davis, M. K., Technical Information Paper No.32., CIOB, 1984, Ascot

47) Department of Employment, Education and Training Working Together, White Paper, 1989, London

48) EEC Directive on Professional Qualifications - 89/48 OJL19, HMSO, London

49) EEC Treaty of Rome Declaration, 1957, HMSO, London

50) Farrow, J., "Fundamental Research Needs in Construction Management", CIOB Paper, Vol.2., 1987 Ascot

51) Faulkner, A. C., and Day, A. K., "Image of Status and Performance in Building Team Occupations", Journal of Construction Management and Economics, 1986, London

52) Flanagan, R.,"Tender Price Time - Prediction for Construction Work", Doctoral Thesis, 1989, University of Aston

53) Guiton, J. and Halls, W. D., World Guide to Higher Education, UNESCO, 1976, paris

54) Gray, C., Specialist and Trade Contractors, CIOB Report, 1990, Ascot

55) Gaskin, M. Prof., Construction to 1990, National Economic Development office, 1984, London

56) Griffiths, P., Building Engineering Services Contract Administration Manual, 1990, Nottingham Polytechnic

57) Higgins., G. and Jessops, I., Communications in the Building Industry, 1965, Tavistock Publications, London

58) HVCA, The Story of the Heating Engineers; 75th Anniversay, 1979, London

59) IPCA Report, The Future Skills of the Construction Industry, 1992, Brighton

60) Institution of Civil Engineers yearbook, 1989

61) Institution of Civil Engineers Report - Future Manpower Needs of the Construction Industry, 1989

62) JCT 180 Guide, RIBA, 1980, London

63) Kwakye, A. A., Keeping up with Fast Track, Paper No.46, CIOB, 1991

64) Lighthill, James Sir, Degrees in Building Management, BEC/CIOB Report, 1986

65) Morice, P. B., "Education of Engineers", European Journal of Education, Vol.15 No.4., 1990

66) ministry of Public Buildings and Works - Professional Collaboration in Designing Buildings, Management Handbook 5, HMSO, London

67) NEDO Report, Faster Building for Commerce - National Economic and Development office, 1988, London

68) NEDO Report, The professions in the construction industry, 1976, London

69) RICS Report, The International Role of the Chartered Quantity Surveyor, 1977, London

70) RICS Yearbook, Members, 1987, London

71) RIBA, Amended Code of Professional Conduct, 1984, London

72) RICS, Engineering Services in Building Report No.1, 1970, London

73) Spiers, G. S., "A Recognised Standard of Competence" CIOB Paper, 1980, Ascot

74) Sturge, William, "The Education of the Surveyor", Transaction of the Surveyors Institute, Vol.1., 1868-69, London

75) Universities Grant Committee, CPD Report, 1983, London

**ARTICLES**

76) Chilvers, H. D., "Design and Installation of Building Services" Architects and Surveyors Institute Year Book, 1990, Chippenham

77) Baccarini, D., "A Question of Nomination" Architects and Surveyors Institute Year Book, 1989, Chippenham

78) Ohly, M., Air Conditioning and Refrigeration, February 1991, London

79) Foster, C., "Pyramid Proposal", Building, p.10, 5 April 1991, London

80) Cecil, R., "Keep the professionals", Building, p.25, 19 August 1983, London

81) Building Technology and Management, CIOB, Presidential Address, pp.5-6, April 1989, Ascot

82) "Contract operation", Builder, XX, 11 October 1862, London

83) Letter, Builder, XXI, 3 October 1863, London

84) Scott, D., Article, Building Services Engineering Journal, Vol.40, pp.38-41, May 1972, London

85) Sturla, J., Article, Building Services Engineering Journal, Vol.40, pp.42-45, May 1972, London

86) Martin, P., Article, Building Services, Vol.4 No.1., p.55, January 1982, London

87) CIBSE Presidential Address, Building Services and Environmental Engineer, February 1992, London

88) Caines, C., Article, Building Services and Environmental Engineer, pp.16-17, April 1991, London

89) Croome, D., "Impact of Technological Innovation on the Construction Industry", Building Research and Practice, No.3., pp.174-182, 1990, London

90) Meopham, B., Article, Chartered Quantity Surveyor, pp.35-36, August 1981, London

91) Turner, A., Article, Chartered Quantity Surveyor, p.283, March 1981, London

92) Nisbet, J., Article, Chartered Quantity Surveyor, September 1979, London

93) Article, "A Contractors View", Chartered Building Services Engineer, pp.40-41, 1989, London

94) Turner,.A., Article, Chartered Quantity Surveyor, May 1989, London

95) Chartered Institute of Building Services Engineers, Information leaflet on the institute, 1978, London

96) Lansley, P., Article on graduate education, Chartered Builder, pp.9-10, March 1990, Ascot

97) Culmer, C., Article on building engineering services quantity surveyors, Confederation of Construction Professionals Year Book, 1987, Chippenham

98) BSRIA Report, Construction Midlands, p.4, July 1990, Manchester

99) Kennedy, J., "Law of the Construction Industry", Construction Surveyors Institute Year Book, 1985, London

100) Timmermans, J., "UK Skills Shortages", Construction Weekly, p.8, 19 July 1989, London

101) Hill, B., "Construction Education Too Narrow", Construction Weekly, P.8, 27 February 1991, London

102) Barber, C., "Construction Teamwork", Construction Weekly, p.14, 27 March 1991, London

103) Jones, A, "JCT Forms and Sub-Contractors", Electrical Times, pp.5-6, 29 August 1980, London

104) Felstead, F., "Multi-Service Contracts", Electrical Contractor, Vol.82, Pt.1., p.20, June 1984, London

105) "Survey of the Building Industry", Financial Times, p.30, July 1958, London

106) Segal, A., Article, The Guardian, 13 June 1989, Manchester

107) Fisher, D., "Building Services Contractors", Heating and Air Conditioning Journal, p.27, 27 October 1981, Barnet

108) Discussion Paper - Bills for Heating and Ventilation, Heating and Ventilating Contractors Association, 1979

109) Ogunla, O., Research Paper, "Design Phase Cost Estimating", International Journal of Construction Management

110) Parker, R. E., "Main Contractors and Nomination", National Builder, p.174, May 1978, London

111) National Vocational Qualification Council, Booklet, NVQ Framework, June 1991, London

112) News item "Education Refreshers", New Civil Engineer, p.8, 22 August 1985, London

113) McGaffe, R., "Regression as an Estimating Tool", Quantity Surveyor, Vol.32, pp.81-86, December 1975, London

114) "The Construction Surveyors Institute", QS Weekly, p.5, 16 August 1979, London

115) RICS, Pamphlet, The International Role of the QS, May 1977, London

116) Sainsbury Building Contract, 1990, John Sainsbury plc, London

117) Ivens, M., "Chartered Institute of Management" Sunday Telegraph, 11 June 1989, London

118) Griffiths, A., Research Paper "Buildability", Science Research Council, 1984, London

119) Enterprise in Higher Education, Training Enterprise and Education Department, 1989, London

120) Alderman, D., "Training and Education", Youth Training News, Issue 48, p.4, July 1988, Sheffield