BUILDING SERVICES AND REFRIGERATION VITAL TO BUILDINGS IN INTERNATIONAL COMMUNITIES

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INTRODUCTION

This paper is based on personal research and observations of construction processes in the United Kingdom and North America and other parts of the world. It is based on Prof. Rooley's construction experience, together with contributions and research from cross industry boards and committees in USA and the UK and worldwide. A number of the hypotheses in the paper have been presented to audiences of experienced construction professionals worldwide who have been challenged to correct statements made in those hypothesis. Many of the comments made are therefore personal opinions which has been exposed to critical assessment by his peers and verified by their agreement to the hypotheses.

The comments in this paper are directed to the entire construction industry. The best performers in major projects have little effect on the great majority of small projects. This paper addresses best, normal and worst practices.

THE CHANGING WORLD

The world of owning, constructing and using buildings is constantly changing. The world of science, mathematics and engineering is also in a state of change. There have been occasions in history when there has been a dramatic change at a far greater rate than normal evolution. Two examples are the change to our cities by the introduction of The Clean Air Act in the 1930s and the mushrooming growth in air conditioning in London around the year 1970.

DRIVERS OF CHANGE

In 1975 engineers were changing from slide rules to simple calculators. In the year 2000 all calculations are carried out using computers. On the assumption of increasing rate of change, the developments between 2003 and 2015 should be greater than that between slide rules and computers. This change will impact the entire construction industry. There are already indications of changing methods of working. These changes however are developments of the present process. Perhaps the change will be a step change from a quite different perspective.

The change however from slide rule to computer around the year 2000 can be argued to be less significant than the change in 800AD when Al-Khwarizmi introduced the zero to calculations. The step change from using Roman numerals to Arabic numerals with the introduction of zero and negative numbers enabled an extraordinary rapid development in science. A possible lesson from this however is the remarkable reversal of progress as Europe entered the Dark Ages some 500 years later.

There was a separation of theory and practice which occurred in building services about 1950. Pressures from servicemen returning from the Second World War and universities establishing a large number of new degree courses and the institutions' drive towards higher academic levels in charter contrasted with the movement away from combined design and contracting toward installation alone. This change was not reflected in the food refrigeration industry to the same extent. Between 1950 and now the separation has remained. It is hypothesised that it will not come together until perhaps 2020.

Until 1980 it was strongly argued that the solution to this separation was better education on installation, commissioning and maintenance operatives. To a large extent this was abandoned at that time. Until 2003 I have argued that the solution to the division was training of designers to ensure that all systems could be commissioned and maintained. It has been comprehensively proved to me that no significant efforts on a large enough scale are being made to achieve this. It can therefore be assumed that the HVAC designer alone will not redress the problem.

BUILDING DEMOGRAPHICS

The ASHRAE report on Homeland Security issued in January 2003 shows that in 1999 there were 4.7 million commercial buildings in the United States comprising 67.3 billion square feet of space. 95% of those buildings were smaller than 10,000 square feet and only 2% were larger than 100,000 square feet. One third of all workers worked in the large buildings. The mean age of buildings was 30.5 years.

The ratio of large design and construction firms to those employing less than 10 people is in a similar ratio as large buildings are to small buildings. UK figures indicate similar ratios. The Construction Industry Board and other innovation-driven bodies established in the late 1990s a triangle of innovation.

A pyramidical structure is observed, where the upper or pointed part with a small number of practitioners are leaders in developing thought. The

second group will also innovate and develop as soon as they see others with successful applications. The third and larger group follow the new trend when instructed by their client. The fourth level will continue to work as they always have. This group can be compared to those in about 1900 who continued to work in the horse transportation industry while all the others turned to motor transportation. The horse industry ended.

There have been many initiatives to improve the efficiency of construction in the United Kingdom. These have had a significant effect on the best performers, but have they helped the whole industry?

THE EDUCATION PROCESS

American students who spend part of their course in Britain have problems. The American student is given an assignment and works closely with teaching staff throughout that assignment. When they visit a UK university they are usually left to their own devices to establish their methodology for the project and their own deadline. Similarly the British student used to setting their own programme have difficulty in subjecting themselves to the discipline of the American student. When visiting a British university, discussion with professors will quickly come round to research, but in America will stay on teaching.

Large portions of the American university staff are devoted exclusively to teaching. The British model requires funds to be raised through research to supplement teaching in contrast to higher fees in America. These are subjective findings and it is noted that there are exceptions to the model on both sides of the Atlantic. This has led to a "check box" approach to design in America. Design methodology is clearly set by the employer and followed rigorously by the workforce. This is further enforced by the use of the professional engineer's stamp. There will be a relatively small number of registered engineers, but all design drawings must be stamped by one of those engineers. There is no such legal requirement in the UK where quality assurance techniques have been introduced possibly as an alternative.

On both sides of the Atlantic the best engineers have great lateral thought based on deep technical knowledge. In the model developed by Monty de Philistone in the 1970s the upper 1% of engineers are comparable. In the Philistone model of the second and third tiers of 10 and 100 the engineering leaders have greater control of the design process in the American model.

STANDARDS

In the USA, ASHRAE writes Standards which are developed using a consensus process. Public comment is central to this. Each state then writes its own Building Codes often based on ASHRAE Standards. The UK Building Regulations and British Standards are written by the Government and by the British Standards Office with input from individuals in the industry. In Europe the technical representatives from each nation make recommendations, but final decisions are made at a political level.

In principle, ASHRAE Standards are prescriptive using "check box" procedures. In the UK they are principally generic or performance based.

In energy conservation in Europe and the UK, Standards have generally been for building fabric performance and structural safety. Building Service elements have been an adjunct to safety considerations.

In America energy standards issued by ASHRAE are system based giving specific instructions on the efficiency of components, but are weak on overall building performance.

Comments on the education process above have led me to find that European countries with a similar education process to the British favour the European or British model. Other countries, including Germany, countries in the Eastern part of Europe and the majority of the developing world where ASHRAE has a number of Chapters and significant technical influence, favour the American model.

Both the British and the American systems are seriously flawed. Each method has advantages worldwide, but rationalisation, unless there is a step change in the construction process, is unlikely. One of the principal constraints of Standards writing is the time commitment of the participants. Those who write Standards must be practitioners and are often those with a commercial interest in the balance of that Standard.

REHVA has reported on the differences in Standards throughout Europe. The difference in approach is significant. At a time when construction is an international industry faced with the constraints of global warming and the need for more efficient operation, health problems recognised in many buildings in the absence of an international basis for Standards should be noted. ASHRAE is working closely with the Green Building Council to address cross disciplinary Standards in the conservation area. The ASHRAE Standards required for indoor air quality, including mould, and energy Standards requires development in the ASHRAE approach. This is built on the traditional prescriptive Standards, but is developing towards performance requirements. The industry worldwide must examine what Standards are appropriate in what countries, acknowledging, as in Europe, the independence of each sovereign state in writing Standards. Can this diversity continue?

HOMELAND SECURITY

The events of 911 has stimulated worldwide interest in security. In providing its first report in January 2003 ASHRAE has provided an excellent source of risk assessment methods. The report is available for download from the ASHRAE website. The centrepiece of protection against extraordinary incidence in buildings is a realistic risk assessment. There is a balance between cost and absolute safety.

The report shows that significant reductions in risk can be achieved by sensible housekeeping. Simple precautions in food safety, operation of filters, location of outside air inlets

and security awareness for visitors are all effective. In high risk buildings further steps are required.

ASHRAE is conducting a review of all technical publications, Standards and activities to ensure that the principles of Homeland Security and Risk Assessment are correctly addressed.

INTERNATIONALISM

The telephone, air travel, E-mail and the Web have made the world smaller. Technologies, companies and people communicate across geographical, political and language barriers. As communication, including television develops, as the world's resources are used to provide a better quality of life, the users of our buildings have raised expectations. What was an acceptable condition in buildings 20 years ago is no longer accepted. These qualities are being raised worldwide.

Heating, ventilating, air conditioning and refrigeration were recognised by the American National Academy of Engineering as one of the top 10 technologies of the 20th century. Food cannot be kept, a good quality of environment cannot be provided in many parts of the world, without ASHRAE activities. There is a constant change in leadership of finance and contracting strength. While America and Japan have been dominant with Europe becoming stronger and for a period Korea and other parts of the Pacific group, China has now become a powerful influence.

In design ASHRAE members have reported a trend for design companies to sub-contract technical activity to India and elsewhere. This follows precedent in the computer industry. Those who state that this will lead to lower quality buildings should examine the changing roles of the designer, contractor and manufacturer. Some have argued that much of the work carried out by designers, particularly following the American model can be carried out by different groupings within the construction team or indeed is largely computerised.

There is one manufacturer of air conditioning equipment in Italy who encourages his principal clients to specify their exact requirements on the computer Web page. Not only does the purchaser specify in full detail, but they can purchase production time in the manufacturing facility whether in Italy or subcontracted to China. There is very little intervention by the manufacturer beyond maintenance and quality control. Should this detailed specification and selection of equipment be carried out by the consultant, by the contractor or indeed by the end user?

In this working across international boundaries, can international Standards continue to be dominated by political pressure? ASHRAE meets this challenge by providing Standards which can then be adopted by any American State or country worldwide. In Pakistan the best engineers use the ASHRAE Standards on a voluntary basis. As stated earlier however, most ASHRAE Standards are directed at single technologies. The cross interest or multi-disciplinary Standards are the ones which absorb much time and effort to incorporate the many non-HVC&R interests.

HOW DOES AN ENGINEER SPEND THEIR TIME?

In subjective discussions with firms of consultants, design contractors, architects and multi-disciplinary practices principally in America, but also in other parts of the world, it emerges that design engineers will spend between 10 and 20% of their time on matters of strict technology as set out in the ASHRAE Handbooks, Standards and other publications. This equates to something under one day per week. The remaining four days are spent on the process of construction including negotiation and discussion with architects and other members of the design team, financial planning, special awareness, risk assessment, leadership, management and working within the team, the use and abuse of computers and the whole process of communication throughout the team. The subjective response is also that several years are spent in learning a degree in engineering, followed by several more to achieve Charter or Professional Engineer status and then continuing technical education lifelong.

The remaining four days of activities are generally picked up within the office from others. ASHRAE addresses this in courses, lectures and publications on these "soft" side of their activities.

In the UK there has been, at least during the last 20 years, much cross construction industry discussion and decision making on the process of construction. Emphasis is on team work, on partnering to achieve reductions in cost. Most consultants are employed directly by the client. There has been a trend towards a form of managing contracting with many sub-contractors employed by a management firm.

In the USA the architect generally remains dominant in the design process. They provide leadership, they employ the consultants and sub-contractors and specify the works. The consultants are then paid by the architect out of the architect's fee. At tender stage the responsibility for the drawings which have professional engineers stamp passes to the contractor who then has the legal responsibility for performance of the completed building.

In both the UK and in America there are alternatives with America moving towards partnering and in the UK projects run by the general contractor on a design and build basis. The differences are based on the way in which the building industry has developed on each side of the Atlantic.

In both continents there are excellent buildings and a very large number where the air conditioning and other building services do not operate as intended.

It is generally accepted that structural engineers work with great integrity. Indeed it is driven by the need for buildings never to fail. Although the same will apply to refrigeration, this integrity is not a driver in air conditioning. Most calculations are driven at the optimum performance against cost

solution. Unfortunately this stretches beyond the simple matter of integrity.

In every building in which I have given a lecture during my Presidential Year, I have used an example from either that building or the city in which I am speaking to give examples of failure either in performance or visually. There is a generally accepted relationship that engineering systems which are straightforward in commissioning and familiar to the commissioning engineer can be put to work within the specified short time. If there is complexity and the systems are prototypes, commissioning is not completed for several heating and cooling seasons. Normal practice however, is that the owner of the building will correct the problems themselves after two years and in a very small number of cases proceed to litigation or arbitration. Both these problems may be traced back to the separation of design from craft and the one day in four technology. While each skilled worker within the construction industry is very well educated, and indeed trained in that narrow field, there are great problems in communication, a fuzzy edge disease.

THE FUTURE

Speed of communication, the coming together of client bodies, the changing relationships of designers, contractors and manufacturers cannot allow the separation of design and operation to continue. Although partnering should solve most of the problems, the application in the early days where operation is less important than construction have predicated against a solution.

The rapid changes and developments in technology have pushed designers away from standardisation. Historically manufacturers will prefer to sell specials at a higher profit margin than standard components. The bidding process of all consultants and contractors usually on an incomplete specification and with harsh conditions of contract are normal practice. The combination of designing prototypes for all components and the pressure on costs has put construction in a precarious position where increased turnover is required with small profit to support future work.

Designers are uncomfortable with standardisation. My experience with the very small number of Standard systems on the market is that designers see it as a challenge to modify Standard products. As example, with an underfloor system, with standard fan tiles, central units in each 300 square metre zone and standard controls always gives good feedback to the supplier in every building I have visited. It will work very satisfactorily in a great variety of building shapes and sizes providing standard components within a sophisticated building.

In the aircraft, ship building and car industries these techniques of standard components in unique products is well developed. Why is it resisted in buildings?

It has often been stated by practitioners in buildings that the shortage of money prevents good quality. Is this an acceptable excuse for poor performance? As the slide rule has been replaced by a calculating computer there are already indications that the majority of the work of design, particularly if based on standardised products, will remove much of the design requirements as practised in our present design offices. Similar changes are occurring in the accountancy profession and throughout manufacturing.

We continue to concentrate in university selection, university courses and discussion of engineering practice on the one day per week activities. We avoid the four days per week or at best include those activities as a minor part of the curriculum.

As horses were replaced by the motor car, so will our present design processes and tools be replaced, but the rate of change is much faster. Young people currently at university are being prepared for the processes of the late 20th century. Fortunately they are adaptable and may have the wisdom to adapt and lead us forward.