CHANGES IN THE WORLD OF THE BRITISH CONSULTING STRUCTURAL ENGINEER SINCE 1945

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ABSTRACT

The status of consulting engineers has undergone considerable change since 1945. In common with other professions their expertise, and the privileged position that went with it, no longer goes unquestioned. Trust has been in decline. A contributory factor in changing attitudes was the outlawing of fee scales in the 1980s.

Traditional forms of contract between clients and engineers and between employers and contractors were superseded by a variety of other possibilities, usually designed to transfer or extend risk. The boundaries between the different professions and the contractors became less firmly defined. The role of the professional as arbiter between employer and contractor all but disappeared.

The pattern of ownership of consulting engineers changed. Partnerships were vulnerable to litigation and had succession problems. Limited companies had advantages and long-established firms with high reputations were taken over by larger international organisations.

The effect of technological change in the design office was dramatic, from the slide-rule to full computerisation and Building Information Management (BIM) in just a few decades. Codes of Practice increased in complexity in parallel with the computing power necessary to satisfy them. The Building Regulations moved away from prescriptive rules to performance criteria, which could be subjectively interpreted. One of the casualties of fee and cost cutting was site supervision by the design engineer.

Bodies such as the Association of Consulting Engineers, the Institution of Civil Engineers and the Institution of Structural Engineers tried to adapt to new conditions. But since no licence to practice is required these organisations have little actual power. They can only rely on their reputations in an era when self-regulation is treated with suspicion.

Government initiatives to promote engineering came and went, the main obstacles to their success being the low standing of engineers and the poor pay.

Despite all the change engineers have actually been less affected by social, cultural and technological forces beyond their control than many other areas of life.

Keywords: Engineers, Status, Ownership, Institutions, Education, Ethics

1. THE STATUS OF ENGINEERS

The upper classes in Britain have not generally been interested in engineering and technology. They have preferred the more established and better paid professions. Their education is skewed towards non-scientific subjects. Leaders in other countries are more likely to have a grounding in science and technology. Honours in a class-conscious country like Britain tend not to go to engineers but to politicians, civil servants, lawyers, academics and, sometimes, architects. The status of engineers has never been high.

During the Second World War engineers such as Mitchell, Wallis, Bailey and Whittle were quite well known, having been vital to the war effort. Civil engineers such as Maunsell, Gibb and Faber made important but less publicised contributions. In the post-war period of comparative industrial decline engineers were less noticeable. There was an influx of engineers from the Continent before and after the war (e.g. Samuely, Goldstein, Bobrowski and Frischman) who were particularly dynamic individuals. Other professions such as the law and publishing felt the same effect. Being class-less was possibly an advantage for the incomers.

Between 1950 and 1980 chartered civil and structural engineers had a certain standing in the UK, although they complained, as they still do, that it was not on a level with the other professions or with engineers on the Continent. Fee scales existed, at least in theory, giving some certainty of income, advertising was frowned upon. The professions were generally given respect as the holders of expert knowledge. The state in various forms was a major employer and state sponsored organisations such as the Building Research Establishment disseminated information. It could be viewed as a high point of professional privilege.

Fee scales were swept aside by market capitalism in the 1980s. The professions were considered to be vested interests, possibly cartels, whose restrictive practices had to go. Competition was now based increasingly on price.

2. A GOLDEN PERIOD?

Between the 50s and the 70s it could be argued that there was a golden period in structural engineering. In the world of theory the science of soil mechanics was developed. Piled foundations enabled London to be transformed by tall buildings, Professor Skempton at Imperial College was a key figure. In Cambridge Jacques Heyman expanded plastic analysis to encompass masonry structures, which was to have a profound influence on engineers' approach to old buildings and bridges. There were major advances in the mathematics of structural analysis and computing.

Freeman Fox were designing the suspension bridges for the new motorways, Arups were overcoming the design problems of the Sydney Opera House. Advances were taking place in many areas such as structural timber and prestressed concrete.

3. CONTRACTUAL RELATIONSHIPS

After the 1970s the state in its various forms withdrew from direct involvement as a client. Utilities were privatised and Local Authorities outsourced their services. Traditional forms of contract, tarnished in the eyes of clients by the perception of a claims culture among contractors, fell into disrepute. One virtue of the traditional competitive contracting system,

that all parties knew their role and what was expected of them and of others, was lost. Bills of quantities were considered dispensable - a useful coordination exercise disappearing in the process. Management contracting arrived. Quantity surveyors turned into cost consultants and project managers with the ear of the client. Architects, and to a lesser extent engineers, lost their roles as lead consultants and as arbiters between client and contractor.

Clients turned to design-and-build, which had always been an option. They used the commercial opportunity offered by a series of recessions to transfer risk onto the contractor, who was desperate for work. Consulting engineers learnt what it was like to be sub-contractors when they were novated to the design-and-build contractors. Forms of contract and collateral warranties were devised to confirm or extend the liabilities of contractors and consultants. Engineers became amateur lawyers to deal with the changing legal arrangements. They tried to tailor their services to the fee that the client was willing to pay. The next fashion in procurement, as it was now called, was partnering, another reaction to the adversarial aspect of traditional contracting. This ran the risk of turning into a cosy relationship between clients and contractors, which again side-lined intermediaries such as the professions. Private Finance Initiative (PFI) contracts were a device of different governments to disguise the level of public spending and use the supposedly greater skills of the private sector to produce buildings more efficiently and quickly. This system was abandoned when it was realised that the short-term bargain was a long term liability.

Under the now multifarious conditions of engagement, but especially with design-and-build, site supervision by the designer was sacrificed on the altar of cost.

The number of separate professions needed even for a small building became a source of amazement and frustration to clients – project manager, architect, quantity surveyor, structural engineer, services engineer, CDM consultant, party wall surveyor and, of course, the builder. No wonder design-and-build looked preferable.

All the attempts to find a contractual system to overcome the poor performance of the building industry were a diversion from the basic problem – a lack of competent staff on all sides. With intelligent, well-trained, experienced people involved any system can be made to work, with a shortage of such individuals tinkering with contractual forms achieves little.

4. PATTERNS OF OWNERSHIP

The pattern of ownership of firms of consulting engineers was changing to suit the times. Traditionally they had operated in partnerships but increasing litigation was a threat, particularly to individual engineers. Changes in the law made it difficult to know the extent or duration of liabilities. A limited liability company, as its name implies, reduces liability relative to the joint-and-several burden on partnerships. There were possibly some tax advantages with the company model. Many firms suffered with a problem of succession. The next generation might not have the drive or money to take over and, if they did, why not set up on their own rather than taking on the baggage of their previous employers. There is no reason why professional firms should continue indefinitely - natural regeneration could be considered a healthy process.

Multi-professional consultancies might have been expected to flourish but that did not generally happen. The professions were divided by their different outlook and training and it was difficult to cater for their varying involvement/workload over the course of projects.

The partners in firms wanting to withdraw capital to finance their retirement (or just to cash in) had the possibility of selling to other larger, more ambitious or better funded organisations. With boom and bust opportunities arose for sellers and buyers to get the timing right. Many famous names with reputations to match disappeared with their goodwill destroyed - a microcosm of what was happening elsewhere in British industry and commerce. As happens with take-overs the synergies did not always live up to expectations.

Firms that had the critical mass expanded, many buyers came from abroad. Gordon Masterton in his review of Hugh Ferguson and Mike Chrimes' book "The Consulting Engineers", which chronicles the foreign takeovers says "… to label global companies that employ global talent with the nationality of their most recent acquirer is flawed". The long-term effect of the loss by British engineers of the ownership of the consulting firms they work for must surely put them at a disadvantage.

EXAMPLES OF FOREIGN TAKEOVERS OF BRITISH ENGINEERING FIRMS

Howard Humphreys were taken over by Brown & Root in 1987.

Travers Morgan eventually became part of Symonds in 1995.

Watson Hawksley were taken over by Montgomery in 1992.

Freeman Fox were taken over by Hyder in 1996 who were taken over by the Dutch company Arcadis in 2014.

Babtie, Shaw and Morton were taken over by Jacobs in 2004.

Binnie & Partners was taken over by Black & Veatch.

Haiste Group went to Carl Bro, then to Grontmij, then to Sweco.

Scott Wilson Kirkpatrick were taken over by URS in 2010 who were taken over by US company AECOM in 2014.

Sir Alexander Gibb went to Law group then to Jacobs Gibb in 2001 and then to the US company Jacobs in 2002.

Oscar Faber and Maunsell were taken over by US company AECOM.

Posford Pavry were taken over by Royal Haskoning of the Netherlands.

Peter Brett Associates were taken over by Stantec of Canada in 2018.

Giffords were taken over by Ramboll of Denmark in 2011.

Halcrow went to CH2MHill and then to US company Jacobs in 2017.
Flint & Neil were taken over by COWI in 2014

White Young Green were taken over by Tetra Tech in 2019

Atkins were taken over by SNC-Lavalin of Canada in 2017.

Waterman were taken over by CTI of Japan in 2017.

MRM, Kennedy and Donkin, Merz McLellan and Mouchel went to WSP who were taken over by Genivar of Canada in 2012.

Engineers were not alone, changes taking place in society were affecting the patterns of ownership in other professions. Vets, doctors and solicitors in general practice had difficulty in finding new partners and were bought up by consolidating "providers of services". The idea of working in a small practice with the pleasures and responsibilities that entails seems to have lost some of its attraction. The responsibilities and long hours are at odds with the modern idea of a work/life balance.

The disappearance of long-established partnerships could have other effects. Collective long-term memory of problems could be lost. Archives do not often survive without the organisations that created them. A tight-knit firm may have an ethos and esprit-de-corps missing in larger businesses. If you anticipate moving jobs or selling up you are unlikely to take a long-term view. Organisational change can affect ethical behaviour.

One indication of the changes was the titles of the new organisations. The impersonal global companies went for abbreviations, the smaller firms used abstract titles unrelated to the names of the people involved. Sometimes these were in French or German, perhaps to give a flavour of continental flair or precision perceived as lacking in British engineering.

There was a divide between engineers working for the large international organisations with specialist sections and those working in small practices or as sole practitioners - there had been a hollowing out of the middle ground. Mobility between the two extremes was limited, since if you had worked for a small practice you would have the strong points and limitations of a generalist and if you had worked for a large firm you would be less likely to have experience of the cut-and-thrust when dealing with clients and contractors.

Does an engineer need broad experience or narrow expertise? The ideal is a well-rounded engineer aware of their limitations and therefore able to call in help in specific areas when needed.

5. SOURCES OF WORK

In the two decades following 1945 rebuilding was the goal, with work coming from both public and private sectors in a time of material shortages. In the 1960s and 70s new infrastructure was built – motorways, universities, hospitals, New Towns, etc. Much of this was done by professionals working within the public sector. The oil crisis in the 70s led to a migration of engineers to the Middle East where the enriched states needed their own docks, infrastructure and buildings. Work for British engineers gradually declined in newly independent nations elsewhere. North Sea Oil required massive rigs, engineering on a vast scale.

An office boom in London in the 1960s was followed by another in the 1980s. Busts followed booms. The construction industry either explicitly or implicitly was used as an

instrument for regulating the economy. The fierce cycle made planning for the future difficult for all those involved in construction.

6. MARKETING

When advertising was allowed engineers turned to marketing - brochures and websites proliferated. They became more and more elaborate and small new firms could compete online with their larger and older consultancies.

The Awards industry grew exponentially with every organisation involved with building and engineering giving awards, at the top end was the RIBA Stirling Award shown on national television. Every Award needed a ceremony with tables to be paid for and a celebrity to conduct the event. The Structural Awards, the Concrete Awards, the Structural Steel Design Awards, the Structural Timber Awards, the Brick Awards all had various categories. Every firm could become “Award Winning”.

The selection of consultants by interview became more commonplace so engineers had to polish up their presentational skills.

7. BOUNDARIES WITH OTHER PROFESSIONS AND CONTRACTORS

Boundaries between professions as always were in a state of flux. Some individuals manage to ignore and cross them but engineers, once committed to the profession, tend to stay within the confines of their field for various reasons - it is interesting and intellectually rewarding so why go elsewhere - it attracts or encourages an introverted type, perhaps short of the necessary imagination to consider other possibilities - the main professional goal is to reduce risk and this attitude extends beyond work to general behaviour. A good engineer thinks about all the ways the project can go wrong in order to eliminate them. In other spheres of life this can amount to “overthinking”. It is a problem common to all professions that practitioners become so involved that they end up with tunnel vision focussed on that one area, which inhibits them being able to see the wider picture. One advantage of this lack of ambition has been that engineers have not been subject to delusions of grandeur.

Structural engineering has always been a subservient profession to architecture. Many engineers get their work from longstanding relationships with particular architects. This relationship may not be healthy, in that it can be used to hide inefficiencies. The engineer is under pressure to make the architect’s scheme work, not to complain about its problems. It is difficult to say no or to walk away if work is scarce.

One boundary that has changed is that between consultants and the design done by contractors or their subcontractors. Architects have tended to retreat from detail design to be replaced by contractor’s design portion, which adds complexity for the engineer since so many different parties are involved, often late in the project. Responsibility for overall behaviour risks becoming blurred as the number of inputs from different designers increases.

8. TECHNOLOGICAL CHANGE

The effect of technological change in the design office was dramatic, from the slide-rule to BIM (Building Information Management) in just a few decades. The Codes of Practice that engineers work to were re-written and expanded, mainly by academics with their own

priorities, such as publishing papers and defending their departments. Elastic design gave way to ultimate load design, then limit state design; British Standards were superseded by Eurocodes. Practising engineers were dragged along somewhat reluctantly.

Imperial units gave way to metric theoretically in about 1970. On the continent engineers have generally done their calculations using kilograms and centimetres, which are handy units, related to human scale. The British chose to adopt the Newton, millimetre, kilonewton and metre, which are less easily related to human scale.

Computing power increased according to Moore's Law (that computers get faster as their cost decreases exponentially). Engineers were able to analyse large structures with great precision if questionable accuracy. They became reliant on the machines, on the IT expert and on the companies that supplied the hardware and software, which seemed to require expensive upgrading quite often. Did all this power free their imaginations from the tyranny of the right-angle or were their thought processes constrained by the software? Did the increased computing power available lead to the increased complexity of design codes or vice-versa? Neither appeared to lead to more efficient or economic structures - rather the opposite, since all sorts of tortured geometries could now be imagined, analysed and (with difficulty) built. Did productivity increase in the design office? To quote Robert Solow's famous observation "you can see the computer age everywhere but in the productivity statistics". The increasing deluge of emails was a distraction, but not just for engineers.

9. THE ENGINEERING INSTITUTIONS

Professional Institutions such as the ICE (The Institution of Civil Engineers) and IStructE (The Institution of Structural Engineers) are a British construct. Non-governmental bodies, run to a some extent by volunteers, are a valuable and praiseworthy feature of British civil society. The Institutions were a product of their time, the Civils being formed in the heyday of Victorian engineering, the Structures with the birth of reinforced concrete. The Institutions have three pillars, they have examinations for chartered membership to demonstrate a degree of competence, they have a Code of Conduct backed up by an ethical policy, with reprimands and penalties for offenders, and as a learned society they disseminate knowledge and offer a certain camaraderie between members. Like many organisations their continued existence depends on members volunteering to participate in their running and public confidence in their expertise and ethos. The future of the professions was questioned in the Edge Report of 2015. Many other traditional organisations, which similarly rely on active voluntary participation, have been in decline.

The members of the Institutions have no monopoly of the work of engineers, which can be performed without being a member. There is no licensing system for engineers, unlike some other professions and in some other countries. The Institutions perform a function which might otherwise be done by the state without much support or recognition by government. They are available to share the blame or to sort things out when they go wrong.

In addition to the members there is a secretariat for the running of the Institution. There is an inevitable risk of tension between the members and this executive, which may have its own agenda. There is a tendency for bureaucracies to expand rather than stick to the core activity. The day-to-day running of an engineering institution may lack excitement. In parallel with the change to a more "business-like" model there was inflation in the titles of the officers -

Secretaries became General Directors and CEOs. Presidents of Institutions are in office for just one year so have only a short opportunity to exercise control.

Institution initiatives did not always go to plan. The Institution of Structural Engineers started the Structural Engineers Trading Organisation Ltd. with a view to providing Professional Indemnity Insurance to its members but that did not end happily, an example of the peril of an organisation straying from its core function.

Another tension is that between the central organisation in London and engineers elsewhere in Britain who can feel short-changed when most meetings take place in the capital. This divide may well narrow as digital meetings, webinars etc. take over from face-to-face encounters.

The Institutions risk being prisoners of their London Headquarters buildings. The Civils building in Great George Street speaks from another age. The portraits of dark-suited Victorian and Edwardian patriarchs fill the staircases. It is a wonderful building but difficult in the 21st Century. The Structures made the bold move from Upper Belgrave Street in smart Belgravia where their lease was getting short to a freehold building in Bastwick Street, Clerkenwell. The advance of the digital age with remote working and Zoom meetings is a threat to all city centre offices including those of the Institutions.

One very useful and important function of the Institutions has been to take a leading role in the post-graduate training of engineers. Until 1980 graduate engineers were to a great extent trained by the firms that they worked for. Older, experienced engineers would transfer knowledge that was not part of a degree course. The Civils and the Municipal engineers had Agreements for the formal training of young engineers in a type of apprenticeship. As financial pressure grew on the consulting engineering firms and the Local Authority engineering departments were run down, the Institutions took on this role of training, a wholly laudable endeavour.

There was a belief among older engineers that, as the computer dominated structural analysis and design, young engineers were not developing a good understanding of basic structural behaviour being too dependent on the software. The important work of Dr David Brohn in identifying this trend and taking steps to correct it was taken up by the Institution of Structural Engineers, eventually leading to the examination for GStructE. The Institutions also did sterling work in “decoding” the new Codes of Practice, producing user-friendly manuals.

Symptomatic of the changes in the Institutions was the development of their journals. The old dry but rigorous Proceedings of the Institution of Civil Engineers gave way to a variety of specialist journals and the weekly New Civil Engineer in 1972. This attempted to find news every week. A relentless effort to be upbeat favoured praising the new and controversial. Engineering became journalism. There was a tendency to publication bias against criticism of the parent organisation. The views of the members did not get much space with the exception of the Verulam column in the Structural Engineer. The magazines were a vehicle for employment advertising, which was to shrink with the coming of the internet. By 2015 the New Civil Engineer came out once a month and is now in the process of going online.

Both ICE and IStructE have opened up membership to non-engineers, called Affiliates. A similar change took place several years ago when the Association of Consulting Engineers

became the Association for Consultancy and Engineering. How will the layman distinguish between AMICE (non-engineer) and MICE (chartered engineer)? Will the concept of the "gold standard" of chartered membership be devalued? There are other organisations that already cover the whole industry such as the Construction Industry Council. Do the Law Society and the Royal College of Surgeons have a grade for unqualified members of the public with an interest in their subject?

The engineering profession continues to fragment - in January 2014 the Association of Building Engineers obtained its Charter. There are about 35 types of Chartered Engineer. The Institution of Municipal Engineers was subsumed into The Institution of Civil Engineers in 1984, a casualty of the changes taking place in Local Government.

The Institutions saw themselves as international bodies with worldwide influence. It was useful for engineers in the developing world to obtain a First-world qualification by becoming chartered members of a British Institution. When dramatic development took place such as in Hongkong, the Institution of Structural Engineers expanded its branch there enormously. However as other countries develop it is inevitable that they will have their own professional organisations or choose some other system.

The Association of Consulting Engineers underwent even more change than the Institutions. All of its three basic premises of unlimited liability, no competition on fees and no advertising were gradually overturned in the late twentieth century.

10. REVERSALS - RONAN POINT, BOX GIRDER BRIDGES, THE EDINBURGH SCHOOLS AND GRENFELL TOWER

Periodically tragedies take place that force organisations and professions to question the basic assumptions that they have been working under. A black swan event comes out of the blue to force a fundamental rethink. In medicine Harold Shipman came as a shock, in veterinary medicine Bovine Spongiform Encephalopathy was unanticipated, the collapse of Equitable Life was a surprise to the Pensions Industry and the Subprime Mortgage Crisis in banking led to the collapse of Lehman Brothers in 2008 with the subsequent recession. Civil and Structural Engineering has had its share of disasters. The challenge for a profession is how to deal with the aftermath and adapt its outlook and practices.

The collapse of three concrete cooling towers in November 1965 at Ferrybridge was a surprise and led to a reconsideration of wind loads, the effects of wind on adjacent structures, the reality of uplift and overall safety factors.

A gas explosion took place in Ronan Point, a 22 storey tower block in East London, on 16 May 1968. Some load-bearing walls were blown out causing the collapse of one corner of the building with four people killed and 17 injured. The realisation that large structures of a new type being built all over the country were potentially unsafe caused alarm if not panic. One reaction was to consider the pressure produced by the explosion and the possibility of designing members capable of resisting it, another was to model the ability of the structure to survive the removal of individual members. Both of these difficult if not impossible approaches were eventually discarded in favour of having frames for tall structures and tying together less tall structures in different directions. There were useful consequences in the

profession's reaction in that lateral load, even notional lateral load, was taken more seriously and the concepts of robustness and disproportionate collapse were developed.

There is a theory that generations repeat the mistakes of their predecessors once the communal memory has been lost. Disproportionate collapse of Victorian mills did take place in the nineteenth century and conceivably if those failures had been better known engineers might have questioned the robustness of large precast panel towers like Ronan Point.

The collapse of the steel box girder Milford Haven Bridge in June 1970 and the West Gate Bridge in October of the same year was a double blow to the prestige of British bridge building. The hubris of the sixties became nemesis in 1970. The Merrison Report apportioned blame with an emphasis on independent scrutiny of the design and construction method, better communication and the need to ensure the competence of all involved. "No amount of writing of design codes and writing of contracts can in the end be guaranteed to prevent the results of stupidity, carelessness or incompetence. But one can do a great deal to discourage these vices and that must be done." Competence is a slippery concept, usually only defined by its absence. The engineers on these bridges and on the Severn Bridge had a philosophy of designing tightly. Subsequent events revealed that they had been over-confident in their ability.

In the Ramsgate Ferry Passenger Walkway Collapse of 1994 six people were killed. It was a case of totally inadequate design, by European rather than British engineers.

The problems of the Edinburgh Schools fortunately involved no loss of life. The external skin of cavity walls was sucked off the buildings because the ties that should have been holding them back were missing. The contracts for the buildings had been let on a PFI basis so that the contractors designed and built the buildings and then maintained them for a time afterwards. Therefore they had to put right the many defects that were revealed when the schools were examined in detail. The problems were put down to lack of site supervision but poor detailing was also a factor.

The fire at Grenfell Tower in Kensington in 2017 was an appalling tragedy with 72 dead. Fire precautions are one of those indefinite border areas between the responsibilities of different professions and contractors. The Hackitt Report is an effort to put right the many shortcomings of the building industry, no easy task. It found that the roles and responsibilities of the various parties are unclear and that the regulations can themselves be ambiguous and inconsistent. It states that competence levels must be raised but how they are defined let alone measured is an interesting question. It stressed the importance of keeping records of a building but experience shows how often they go astray even in a comparatively short period as personnel change, as information storage systems are superseded and as companies go to the wall (as so many do).

To what extent were the reasons for these disasters previously known or unknown? Hindsight is a wonderful thing. The tower blocks were new to this country, the box girder bridges were also novel and being designed by a small group of people, which is inherently dangerous. Innovation carries risk. The problems of cavity walls were well known and there is no excuse. There is no discernible pattern to the various failures. Lack of competence is not necessarily a common factor, competent people make mistakes. The engineers involved on the box girder bridges would have been considered the most competent in their field at the time, more competent than anyone else.

SCOSS (The Standing Committee on Structural Safety) was founded in 1976 by the Institutions and CROSS (Confidential Reporting on Structural Safety) started in 2005. These were a sensible effort to anticipate potential problems. They highlighted many concerns but did not prevent Edinburgh or Grenfell.

Every fatality is a tragedy but it may be that structural failures attract particular criticism. The public quite rightly do not expect buildings to fall down. Looked at objectively the number of fatalities from these collapses is not great. And Britain was by no means alone, collapses and near misses took place on a regular basis elsewhere.

11. HEALTH AND SAFETY/ THE LEGAL ENVIRONMENT

Engineers are responsible to their clients in contract and have other responsibilities, for example to the public, for the safety of their designs. These duties have increased as time has gone on. The Health and Safety at Work Act was introduced in 1974. In 1994 CDM, the Construction (Design and Management) Act, arrived, to be superseded by further Acts of 2007 and 2015.

CDM was introduced to reduce construction and in-use risks. The professions were now expected to have responsibilities on site where they had not previously been formally involved. The danger arose, which has not been sufficiently discouraged, for others to believe that design engineers' powers on site are greater than they actually are. Safety on site improved considerably but that may have been for other reasons. Small firms of engineers were vulnerable to prosecution when things went wrong since the individual's responsibility is more easily traceable.

Engineers became much more involved in temporary works, which had previously been the responsibility of the contractor. This was in part a consequence of CDM but was also necessary as more complicated structures posed problems of stability during construction.

Engineers' relationships with the legal profession could be difficult. Acting as expert witness in civil cases an engineer can find judgement based on the balance of probabilities problematic. The engineer with a different mindset to a lawyer would prefer a greater degree of certainty such as beyond reasonable doubt. In common with other professions engineers find it difficult to accept that a lawyer or judge is the right person to decide upon a technical matter.

The long legal arguments about liability when things have gone wrong and the involvement of insurers tended to prevent or delay the dissemination of information which could avoid repetition of the problem.

Professional skill and judgement were no longer sufficient. They had to be backed up by "Quality Management". A bureaucratic procedure was needed to show that all was in order. There was another attempt to find a perfect system that would overcome the shortcomings of the individuals or organisations involved.

The professions were under pressure from government to show that they were taking their responsibility for technical expertise seriously - Continuous Professional Development arrived as a formal requirement, after having initially been rejected by the members of the

Institution of Structural Engineers. As yet it is CPD-lite in comparison with some other professions. It could be criticised as a box-ticking exercise. With the pace of technological change it is not easy to remain up to date as a design engineer. Few engineers manage to achieve it beyond their 40s or 50s. It is unusual to find engineers still active as detail designers late in their careers. Good detailing is often the essence of good engineering.

12. BUILDING CONTROL

Building Control was another area where the market was now involved. Approved inspectors were allowed to compete with Local Authorities to offer Building Regulations approval. Local Authority Building Control departments were a convenient target for cash-strapped local government looking for savings. The number of engineers employed by local government decreased as it had done in central government. In London the draconian powers of the District Surveyor were effectively abolished. The agency for Building Control could be chosen by the client or sometimes even by the builder.

The regulations became less prescriptive and more a matter of performance specification. The interpretation of these more complex criteria could be subjective. The general level of knowledge in the building industry did not keep up with the changes.

As a consequence of cost cutting site inspections by Building Control and by consultants was cut back. The resident engineer and the clerk-of-works virtually disappeared. In design-and-build the designers were usually not encouraged to visit site. The problems of the Edinburgh Schools were in part a result of lack of experienced supervision. In both Kensington and Edinburgh the client authorities discovered that they had outsourced their work but had not managed to outsource the public reaction when things went wrong.

13. EDUCATION OF ENGINEERS

The qualifications and training of engineers have changed considerably since 1945. At that time engineers could gain an HNC (Higher National Certificate) in engineering and then spend time in a drawing office and on site before taking exams and interviews to become chartered engineers. It was possible to study at night school while working. Keen late starters, who had not prospered at school, could develop, become chartered engineers and rise to the top of the profession. This encouraged social mobility.

A degree became the minimum starting point and then a Masters. This was an unstoppable development as the technical colleges and polytechnics became universities, but it removed a path that had previously produced some excellent engineers. The increased educational requirement did not seem to improve the social standing of engineers.

There was another problem with the degree system - the best engineering graduates could be identified and headhunted by other professions and lost to engineering. Organisations like banks, looking for people with excellent numeracy and problem solving ability, could cherry pick the best engineering graduates and offer much higher pay.

14. ETHICS

It would be reasonable to think that stark ethical problems do not occur often in the working life of an engineer and that is so. However underlying issues are there and after 2000 pressure

was brought to bear on the professions to have an ethical policy to support their Code of Conduct.

Ethics is not a subject easily addressed or put into words, least of all by engineers with no training in the subject. Fortunately the Engineering Council and the Royal Academy of Engineering produced a Statement of Ethical Principles. It was a good document without too much detail, uncontroversial and therefore acceptable. The Institution of Structural Engineers backed this up with examples of scenarios where ethical dilemmas arise, teaching by example, case or parable in the British tradition. The most acute problems arise from the engineer serving two masters, in particular their immediate client and the world at large.

15. HISTORY AND CONSERVATION

There was an awakening of interest in the history of structural engineering. The Newcomen Society had existed since 1920 but had tended to concentrate on mechanical engineering. PHEW (The Panel on Historical Engineering Works) was founded by the ICE in 1971 to identify and record Britain's engineering heritage as its importance became more widely appreciated.

Professor Skempton was instrumental, writing papers on Victorian mill design and organising the archives of the Institution of Civil Engineers with Mike Chrimes. Professor Heyman produced papers on Westminster Hall, the timber Octagon at Ely and other medieval buildings. The History Study Group of the Institution of Structural Engineers was started by James Sutherland and provided a vibrant forum for discussion of the history of structures.

Engineers became much more involved with the repair and modification of old buildings and structures. They previously had a bad reputation with conservation bodies such as English Heritage since they were considered unsympathetic to the retention of existing buildings that they were unfamiliar with and could not justify by structural analysis. The Institutions established the Conservation Accreditation Register for Engineers (CARE), an elite group of engineers qualified to work on historic structures to overcome this.

There is a potential problem in working in the conservation area that engineering judgement can be ignored or overruled by other professions that have authority when the responsibility is carried by the engineers.

16. CLIMATE CHANGE AND SUSTAINABILITY

When a general consensus on the need to minimise the effects of climate change was reached sustainability became another factor in the work of the engineer. Good structural design has always been economical design and therefore should guide the engineer toward sustainable design. The structural engineer, as always, has to be constantly vigilant - there is a potential conflict between thermal and structural objectives.

However any engineer looking around can see the vast number of energy inefficient buildings being constructed. The profession has an ambivalent attitude when one article in a journal praises an "Award-Winning", clearly wasteful, vain project and the next article reminds us how important it is that we design sustainably. For an engineer trained by post-war engineers

who designed tightly it can be painful to look at a some of the structures that have been built in the last twenty years.

If you are looking for an example of good engineering design with the lightest of carbon footprints go no further than the Skylon, that 90 metre icon of the 1951 Festival of Britain. It far outdoes more recent “sculptures”.

17. DEMOGRAPHICS AND GOVERNMENT INITIATIVES

A demographic time bomb began to appear in the late 20th century as older engineers retired without sufficient young replacements. Engineers came from abroad to plug the gap and women came into the profession but these developments did not solve the problem. The welcome arrival of women in the construction industry in the last 50 years is one of the greatest changes although the numbers are still far short of other areas of life. Working practices have had to change to accommodate maternity and childcare.

Science and technology were heavily advertised to schoolchildren. Subjects needed for engineering such as maths and physics are hard. Schools are judged on exam results and the table positions are improved by high marks more easily obtained in softer subjects. There is also the problem of a shortage of teachers in the STEM subjects.

Campaigns to sell engineering were hindered by a lack of modern role models. For promoters of civil engineering to refer to Telford, Brunel and the Stephensons gives an impression of a profession stuck in the Victorian era. Architecture has its star architects who are public figures even if they actually depend upon an unsung team of assistants. Engineering suffers from a lack of modern celebrities.

Government initiatives addressed the perceived deficiencies of the building industry and the professions. Engineers were urged to innovate by people with little knowledge of engineering design, the main aim of which is to minimise risk to the public, the client and the engineer. The patient seeing a medical practitioner does not expect to be experimented on, they expect the use of safe, tried methods. An engineer’s client expects the same.

18. CONCLUSION

It is a mistake to present a romanticized version of the past. The life of an engineer was never easy. All interesting jobs present problems or they would not be interesting. Engineers are subject to social, cultural, and technological forces beyond their control. Other occupations have undergone or are undergoing much more drastic changes - bank managers, miners, and secretaries have disappeared in Britain since 1975. Engineers’ circumstances have changed comparatively little. There is not much outside interference, government inspectors do not arrive unannounced to make inspections. The comparatively low profile of engineers, which bothers some, has its advantages. Their job of making things carries great satisfaction, not to be found in other careers.

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