

# ICE PROFESSIONAL SKILLS

A Report by the Skills Review Group  
July 2018



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# Foreword



## Foreword from the President

Change is all around us. Changes in technology and how we apply it, changes in materials and equipment, changes in processes, changes in the way organisations are arranged to deliver infrastructure. And nowhere is this change more apparent than in the development and application of digital technology.

It is imperative that the Institution does not just keep pace with, but anticipates these changes to ensure that professional civil engineers are properly equipped with the appropriate skills. Consequently the ICE Council asked ICE Vice President Ed McCann to lead a thorough review 'to ensure that ICE members have the necessary skills to practise in an industry in which technology and digital science are changing rapidly'.

I thank the Review Group for all their work in producing this report. They have provided some welcome reassurance that the ICE's professional review process is well-respected and broadly fit for purpose. But they also make important recommendations, in particular regarding the breadth of skills which the modern civil engineer requires, and ensuring skills are maintained and enhanced post-qualification. These recommendations have important and wide-ranging implications both for ICE's membership and qualification role, and for the Institution's learned society and knowledge activities. I hope also that they will be taken into account more widely in construction and engineering.

## Review Group Members

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<b>John O'Connor</b>	Laing O'Rourke - Group Commercial and Human Capital Director, Construction Leadership Council Subcommittee for Skills



## Foreword from the Review Chair

A combination of technological, economic, social, educational and geo-political factors are generating huge changes in the profession of civil engineering.

In the UK but also internationally the construction industry is being challenged to improve its productivity, both through addressing endemic structural problems and by embracing the opportunities presented by emerging technologies and improved diversity.

Also, the Grenfell Tower tragedy and a number of other recent events require ICE to examine whether our current systems adequately ensure the competence of practising engineers through their working lives.

This Review was set up to explore whether in the context of this changing environment and considerable challenges, the Institution of Civil Engineers – in its 200th year – was adequately ensuring that civil engineering professionals have the skills needed to fulfil their role providing society with the infrastructure that it needs.

Our Review Group has spent 9 months researching and reflecting on the subject, and this report is the output of that effort.

There is a huge amount of on-going work by Government, professional and trade bodies across the sector to address the challenges. We have done our best to understand and consider that work, and I hope that our contribution both builds upon and complements that of others.

I would like personally to thank the Review Group who have shown remarkable levels of enthusiasm and insight. I would also like to thank all of the consultees and survey participants who gave up their valuable time to provide us with the information on which we based our thinking. The quality and value of this sort of review is entirely dependent on the people who contribute, and I hope that we have done them justice.

We have been very conscious of the opportunities and challenges that are presented by the introduction of digital technology and the profound effect that it will have on the work of civil engineers in coming years, in both the construction and operation of infrastructure assets.

It is important that in adapting to future needs, we don't lose sight of the skills that we need to do our jobs today. Most of the people we spoke to were more concerned about what might be called "traditional skills". As the American actor Casey Kasem put it "Keep your feet on the ground and keep reaching for the stars!"

**Ed McCann | 25 June 2018**

# Executive Summary

The ICE Skills Review Panel held four workshops and considered the output from three important pieces of research: a desk study to identify key trends affecting the profession; face-to-face interviews with industry leaders; and an online survey of 1,792 members worldwide. Their key findings are:

- Civil engineering is not just about building new infrastructure, but also about operation and maintenance, renewal and adapting, and decommissioning of infrastructure. Skill requirements should reflect this diversity.
- The ICE's qualification process is broadly fit for purpose. But the notion that a qualification, once achieved, is for life - is untenable. A culture of continuous learning needs to be embedded more deeply into the Institution and its members, together with a recognition that civil engineers who fail to keep abreast of changes affecting their areas of activity are simply unfit to practise. A vigorous campaign is needed to raise awareness of the importance of continuous learning, and also to ensure that appropriate learning resources are available.
- The Institution's CPD requirements should be urgently reviewed to establish a more robust system which ensures that a member's qualification remains relevant and up-to-date throughout the member's career.
- The increasing pace of change in the industry requires the Institution to improve its systems and procedures for continuously reviewing and updating the skills requirements of civil engineers.
- 'Soft skills' are becoming increasingly important, particularly with the increase in multi-disciplinary working in construction, the increasing importance of stakeholder engagement and the impact of digital technology. These skills are seen to be lacking among civil engineers in the workplace. The importance of soft skills should be promoted at every level, and appropriate training or upskilling provided.
- Team working is becoming increasingly important, particularly with multi-disciplinary working crossing the boundaries between disciplines and companies. This reinforces the need for greater breadth of skills, including understanding of other disciplines and soft skills such as communication.
- The profession must embrace digital technology, and civil engineers should develop the rapidly-evolving skills needed to exploit its benefits.

- 
- The modern construction industry is increasingly multi-disciplinary and a more flexible approach is needed to allow, and indeed encourage, people to enter the profession without the 'traditional' background.
  - There are likely to be calls for more specialist registers and for additional professional qualifications in specific skills. Such initiatives should be welcomed and encouraged, where there is appropriate demand.
  - There is no strong demand in industry for major changes to the content of 'conventional' civil engineering first-degree courses. However, greater flexibility is needed in the education system to allow (and encourage) a greater variety of courses as the basis for qualification as a civil engineer.
  - Practical knowledge and skills remain vitally important ingredients in a civil engineer's make-up, and the development of practical knowledge skills should be encouraged from the earliest stage.
  - Recruitment into the profession via universities is too narrowly focused on people with strong maths and physics A-levels. Greater encouragement of able people with different talents into undergraduate courses (with appropriate 'catch-up' classes) would increase the pool of potential undergraduates, and help improve the supply of graduates with broader skills.

**The Review Group's 22 recommendations to the Institution are contained within the body of report, and are summarised in Section C.**

# Section A – Introduction

Over the 200 years since the Institution of Civil Engineers was founded, civil engineering practice has undergone continuous change as society and technology have developed. The last 20 years has seen particularly fast change arising from the growth of digital technology and huge international multidisciplinary professional service firms, globalisation of services and economic upheavals.

Recognising this, in September 2017, the ICE Council asked ICE Vice President Ed McCann to lead a review to identify trends in engineering practice and to explore how skills should be developed, maintained and qualified in future.

The review was intended to help civil engineers, their employers, educators, professional bodies and policy makers to understand and address the challenges that the profession faces in relation to skills.

We set out to answer the following questions:


- 1 “What are the skills required of practising civil engineers today and how do we see these changing in future?”
- 2 “What role should the ICE and others play in the development and qualification of skills?”
- 3 “What structures and systems should the ICE have to fulfil its role in relation to skills?”

The terms of reference for the review are included in Appendix 1.

The members of the Review Group were selected because of their expertise and interest in civil engineering practice. Through our research, a much wider range of views was collected, including from clients. Members of the review team also met with representatives of the Joint Board of Moderators, ICE's Professional Development Panel, Professional Review Panel and Qualifications Panel. Appendix 2 presents a full list of those consulted.







# “ Directing the great sources of power in Nature *for the use and convenience of man*....”

Thomas Tredgold

We structured our review around three important pieces of research, undertaken by Ms Arapi, the ICE Research Manager.

- 1 A desk study to identify trends in the economy, society and industry which are affecting civil engineering practice, with insofar as possible, a focus on skills. The results of the desk study helped to frame the discussion and design the other pieces of research.
- 2 Qualitative research based on semi-structured interviews with industry leaders and senior practitioners to understand how they were experiencing change in their organisations and personal professional lives in relation to civil engineering skills.
- 3 An online quantitative survey targeted at ICE members to explore current skills needs and perceptions of changing requirements.

The research methodology is described in Appendix 3 and the full results of the research are available on the ICE website.

The results of this research acted as fuel for the discussions at the Review Group workshops.

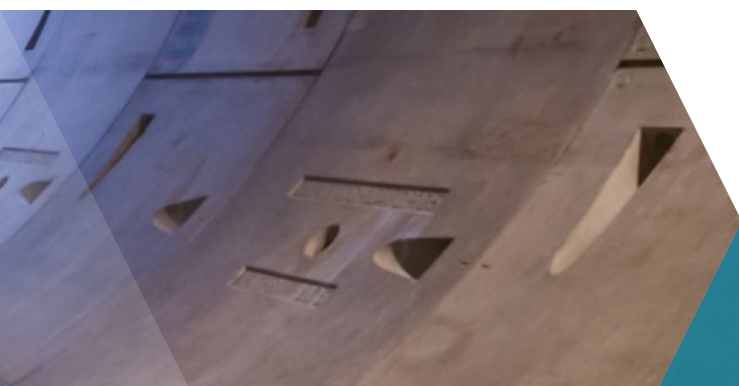
The Review Group met formally for four workshops to discuss the research and other inputs and the drafting team met on numerous occasions.

It should be noted that the Review Group did not set out to establish a definitive list of skills required by civil engineers. A number of such lists are available from different sources; each with its own strengths and weaknesses: The ICE Required Attributes are shown on the ICE website, while the American Society of Civil Engineers provides a more detailed and specific set of required skills, knowledge and abilities ([www.onetcenter.org](http://www.onetcenter.org)).

In accordance with our terms of reference, this report uses the term ‘skills’ to mean ‘the learning or know-how, ability, attributes and experience needed by an individual to practice safely in line with their professional duties and responsibilities’. This broad definition embraces competence, knowledge and professional attitude. Some of these skills may be acquired through formal education, others through subsequent training or upskilling. We discuss this in more detail in section B4.

We have done our best to ensure that the review is relevant beyond the UK by engaging with international members and global organisations as well as drawing on sources of information relating to other countries.

The following sections set out the findings of our Review.



# Section B – Findings

## B1 SKILLS TO DO WHAT?

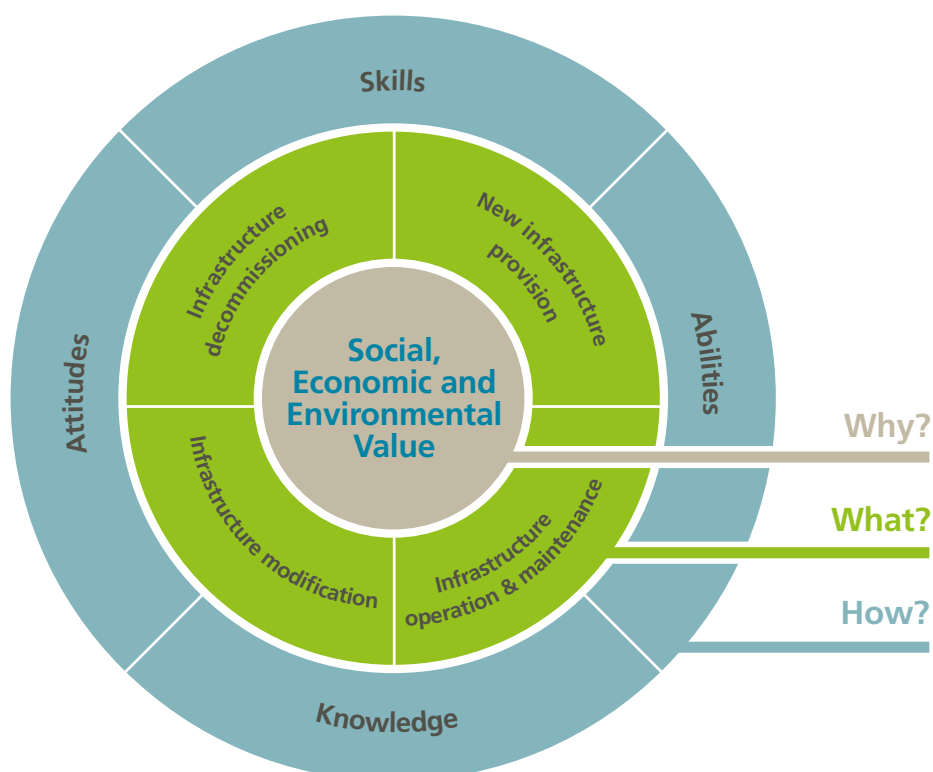
Before we could begin to address the ‘skills’ that are needed by a civil engineer, we first needed to address the question: What do we need these skills *for*?

The stock answer which civil engineers have trotted out for generations goes something like this: ‘to enable them to design and build large new pieces of infrastructure, of course!’ As we will explain later, this happens to be an inaccurate description of what most civil engineers do. But much more significantly, it fails to address the fundamental issue of the *purpose* of civil engineering: *Why* are civil engineers doing what they are doing? The purpose is fundamental, since it provides the context for the duties and activities which are attributes of competence.

This in turn begs the question: *What* do civil engineers do? Well of course they design and build large pieces of infrastructure, but they do many, many other things as well.

Only when we have established satisfactory answers to the *Why?* and *What?* questions can we start to ask what skills civil engineers need: the *How?* question.

To help understand and explain what we mean, we have introduced a simple model. At the core is the *Why* question, the civil engineer’s purpose. Around this are the various activities which civil engineers perform – the *What* question. And around the outside are the skills which the civil engineer requires in order to perform these tasks: the *How* question.





In order to start populating this model, we found it instructive to revisit Thomas Tredgold's classic definition immortalised in ICE's first Royal Charter in 1828: 'Civil Engineering is the art of directing the great sources of power in Nature for the use and convenience of man, as the means of production and of traffic in states,

both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation, and docks, for internal intercourse and exchange; and in the construction of ports harbours, moles, breakwaters.....'. Within this definition Tredgold provides answers to the three key questions.

### Why: the civil engineer's purpose

'Civil Engineering is the art of directing the great sources of power in nature *for the use and convenience of man.....*', Thomas Tredgold.

Tredgold's definition of the purpose of the civil engineer has a poetic strength which has resonated across the ages. In recent years the ICE has increasingly articulated the core purpose of the civil engineer as delivering social, economic and environmental value through infrastructure. We have refined this further and propose the definition of a civil engineer's purpose as '*delivering social, economic and environmental value through the provision, operation and maintenance, renewal and decommissioning of physical infrastructure*'.





# Section B – Findings

This, we maintain, is the irreducible core of the profession which has held fast over centuries and will continue to do so as long as there are civil engineers. The nature of physical infrastructure changes over time, of course, as do our social, economic and environmental values. But the purpose remains the same.

We believe that it is important to stress the idea of “delivering social, economic and environmental value through infrastructure” as we reflect on the skills that we need. We may be able to do design and build infrastructure, but if we do not understand fully how that results in social, economic and environmental value, or indeed what is meant by social, economic and environmental value, then we are unlikely to make the most of the opportunities. Civil engineering works – and their maintenance and renewal – should of course provide social value through the direct benefits they provide. But the use of construction as a way of helping the unemployed back into work, or a contractual requirement to source materials from the local area, are examples where consideration of social value can also influence the way that civil engineers work.

*All thinking about the skills required by civil engineers, and the associated qualifications, should be built around an agreed purpose for the profession: delivering social, economic and environmental value through infrastructure.*

**Recommendation 1.1 The Institution should put the delivery of social, economic and environmental value through infrastructure at the heart of its thinking about skills and qualifications**

## **What: the activities in which civil engineers engage in order to fulfil their purpose**

‘.....as the means of production and of traffic in states, both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation, and docks, for internal intercourse and exchange; and in the construction of ports harbours, moles, breakwaters.....’ Thomas Tredgold

Around this core, we have placed the four groups of activities which encompass the various ways in which civil engineers fulfil this purpose. We have defined these as:

- A Providing new infrastructure**
- B Operating and maintaining existing infrastructure**
- C Renewing and adapting infrastructure, and**
- D Decommissioning**

All civil engineers are involved with one or more of these groups of activities. Each of the four groups of activities achieves the purpose of delivering social, economic and environmental value, though in different ways or different proportions.

It is instructive to note that the traditional assumption of the main activities of civil engineers – ‘to design and build large new pieces of infrastructure’ – falls entirely within Group A, and indeed only forms a part of this Group: many pieces of new infrastructure are really quite small. This is significant because much of the knowledge and skills which ICE has required its members to acquire and maintain has been skewed towards

“Civil engineering is the art of directing the great sources of power in nature for the use and convenience of man...”

Thomas Tredgold





Implementation of a smart motorway system

Water treatment works in operation

this narrow assumption.

Population growth, urbanisation and industrialisation are both associated with the development of new infrastructure as was evident in Europe and the US in the 19th and early 20th Centuries and is now being seen in China, India and other developing economies. After the initial development of infrastructure systems the skills needs change from those required for new build to operation and maintenance and later still to modification and ultimately decommissioning.

This pattern is evident in the UK on a range of infrastructure types from water supply to nuclear power generation. After significant periods of road construction in the 1930's and between 1960 and 1990, new road construction has also fallen substantially. The number of engineers required

to design and construct new roads is consequently reduced as a result, although many more engineers are needed to operate and maintain the expanded road networks: the Connect Plus consortium including contractors and consultants employs up to 4000 people on construction works as part of its PFI contract to maintain and enhance the M25 motorway.

The skills required of these engineers are different. For example, whilst knowledge about soil mechanics, land surveying and earthworks design and construction are of great importance to an engineer planning and constructing a motorway, they are of relatively limited value to a network manager using traffic modelling software, and vice versa.

Similarly, engineers working on maintenance projects need to know much more about asset classification and inspection and about undertaking work in operational environments than engineers involved in providing infrastructure in "green field" environments.

The balance of focus and expenditure varies from country to country and from time to time. For example, in 2016 the UK construction industry spend on "New Works" was £99.3Bn compared with spend on "repair and maintenance" of £52.2Bn (Source: ONS - Construction statistics: Number

# Section B – Findings

18, 2017 Edition). Given the scale of repair and maintenance activities it is noteworthy how little attention is paid in undergraduate education to these activities. The situation in relation to skills related to operation and decommissioning is, if anything, even worse.

As one recently retired ICE Fellow said to us: “Everyone loves a big project, but asset management isn’t sexy!” On the other hand, we also heard from another industry senior that the UK is seen as an international leader in “sweating operational assets” and is known to be expert in getting maximum value from them.

*Civil engineers need skills related to operation, maintenance, modification and decommissioning of infrastructure – not just the design and construction of new infrastructure.*

## **Recommendation 1.2 The Institution should develop and implement a plan to improve civil engineers’ skills related to operation, maintenance, modification and decommissioning of infrastructure.**

Of course our model here is a great oversimplification. There are many different forms of infrastructure, all with differing balances between the four Groups: decommissioning has more significance with nuclear power stations or skyscrapers than it does, say, with railways. And of course, all engineers need some working knowledge across all Groups: a designer of a new project should take into account how it will be maintained in future.

Also the activities and how they are tackled are influenced by the means at civil engineers’ disposal – the resources and materials, the tools and equipment, the systems and processes, the data and information, and the operational environment

And, of great significance, the activities and the means of addressing them change over time. Different activities and processes change at a different pace at different times, but by and large they are changing faster now than ever before, and change is accelerating. This is in contrast to the core purpose, which remains substantially the same. We explore the major implications of change in Section B2.

## **How: the skills which civil engineers need to do their jobs.**

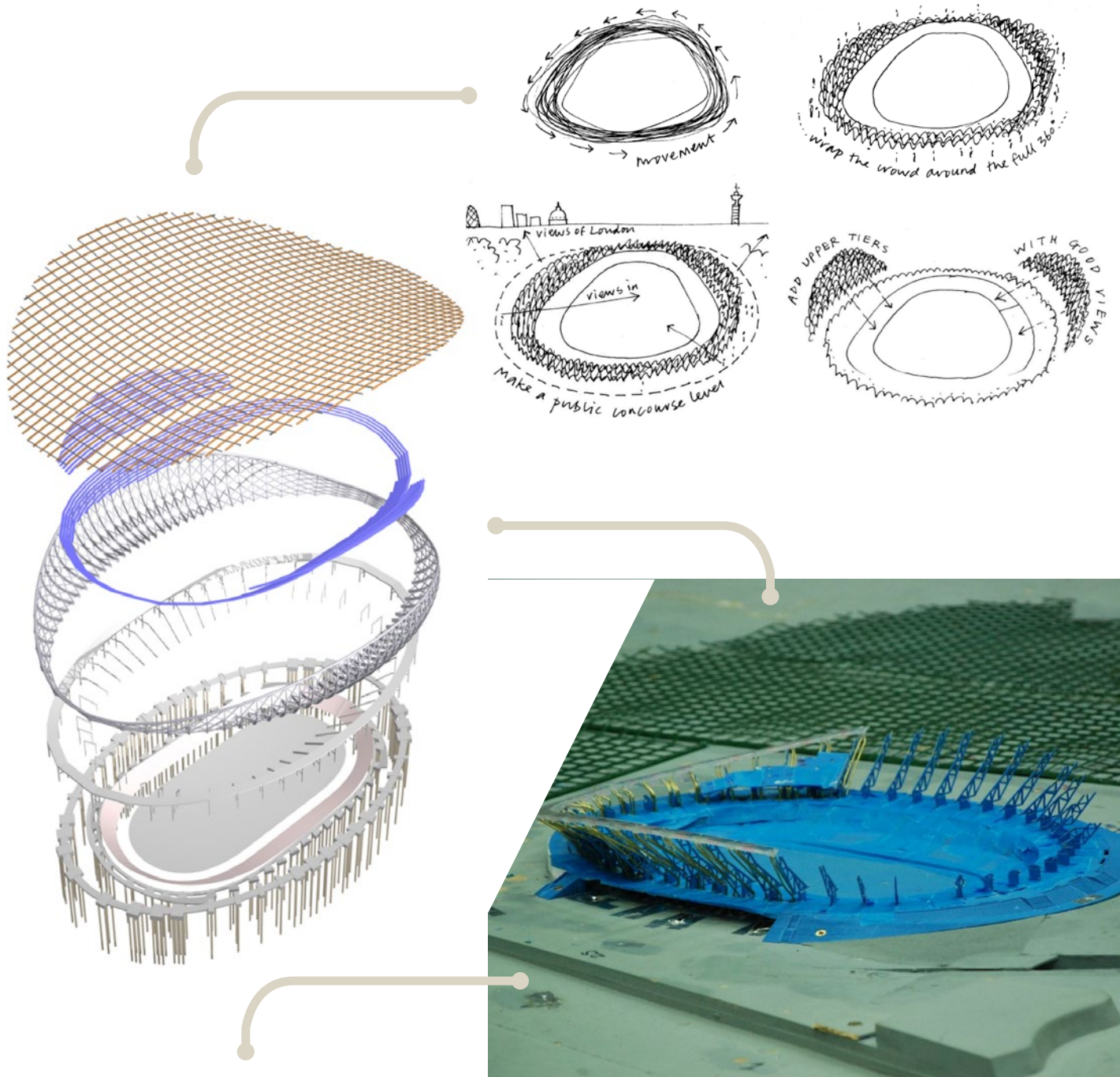
‘Civil Engineering is the *art* of directing the great....’ Thomas Tredgold

Thomas Tredgold’s use of the word ‘art’ – used in its 19th century meaning of ‘skill acquired through patient practice’ - neatly encapsulates the attitudes of his contemporaries to the development of skills, which was predominantly through practical experience, though he makes no attempt to define what skills these are.

The skills required for each of the four Groups of activities differ, though there is considerable overlap. Current practice in education and training is heavily biased towards the first group: in today’s environment, operation and maintenance is just as important as construction.

We will develop our thinking on skills further in Sections B4 to B9. But first we need to consider the major implications of change.





# Section B – Findings

## B2 CHANGE

Change affects everything civil engineers do, in different ways and at varying speeds.

The central purpose of delivering social, economic and environmental value through infrastructure, as we have established, remains constant. But what we mean by 'social, economic and environmental value' does change, at least when measured on a long time-scale. 'Environment' was nowhere mentioned in ICE's first Royal Charter, yet environmental protection has become increasingly important, governing much of what civil engineers now do.

The type of infrastructure required varies over time, and with place. Britain has seen booms in demand for canals in the 18th century, railways in the 19th century, power stations in the early 20th century, motorways (as we have seen in Section B1 above) in the 1970s and (to some degree) a resurgence in railways in the 21st century. Also, the predominance of each of the four Groups of activities changes over time, with the dominance of 'new infrastructure provision', in each of the booms followed by a far greater emphasis on 'operating and maintaining existing infrastructure' and 'renewing and adapting infrastructure'. And rapidly developing countries will currently have far more emphasis on new build than countries (such as the UK) with a mature infrastructure.

Overlain on these changes in the type of work civil engineers undertake have been changes in the ways they do it – the materials, the techniques and the tools.

On materials, the profession was revolutionised in the 18th century with the arrival of structural ironwork, and in the late 19th and early 20th centuries by steel and reinforced concrete: the pace of change of materials was slower subsequently, but more recently many new developments have emerged – for example paving materials (bituminous surface treatments), the use of plastics in ground engineering (geotextiles and geocells) and structurally engineered wood products (GLULAM and Cross Laminated Timber). Other innovations include carbon fibre for structural strengthening, toughened and laminated glass, paint-based corrosion protection systems and a wide variety of adhesives.

In relation to design, up to the mid-19th century civil engineers relied almost entirely on "rules of thumb"

based on empirical research and experience. Since then developments in the understanding of materials, energy, mathematics and information technology etc, have enabled the development of the extensive numerical and digital modelling techniques that form the basis of the modern designer's toolkit. The development of standard methods and codes of practice have the effect of ensuring (in principle) that designs are more reliable, efficient and consistent. We are currently seeing a significant shift in design practice as designers are becoming involved in design for manufacture, assembly and operation including, for example, the use of BIM systems. We are also seeing progressive automation of some of the designers work and expect to see this trend continue.

Over time we have seen numerous developments in construction techniques including: prestressed concrete, pre-cast concrete, CFA piling, reaction piling, directional drilling, twin wall, cross laminated timber, Glulam, structural glass,



insulation products, foamed concrete blocks, geotextiles and any number of structural adhesives and fixings. All of these changes require engineers to adapt and develop new skills.

Indeed, the characteristics required of many civil engineers is changing too, from technocrats to professionals with 'multiple-intelligences', as we explore in sections B7-B10.

*Change is all around us, it comes in different forms and affects us in different ways, but it influences everything that civil engineers do. The pace of change may vary, but by and large change is happening faster now than ever before – and nowhere more so than in digital technology.*

In subsequent sections, we will pick up the impact of change on the skills required by civil engineers. But before we get into detail we wish to stress two important general conclusions related to change. Indeed, these are two of the most important conclusions of our review

# Section B – Findings


## B3 RESPONSE TO CHANGE

The first conclusion is that the implicit assumption built in to the ICE's qualification system – that a professional qualification once attained assures a civil engineers competence for life – is untenable in a fast-changing world. The Engineering Council is now requiring Institutions to introduce compulsory CPD. However, we believe this must be much more than the 'tick in the box' CPD which has frequently been seen in the past. CPD should be compulsory, but also related closely to the individual's required job skills, and audited. Recent reports – notably ICE's *In Plain Sight* and the *Independent Review of Building Regulations and Fire Safety* following the Grenfell disaster – reinforce this point.

*The Institution should instil - in itself and its members - a stronger culture of continuous learning, and a recognition that civil engineers must keep abreast of changes affecting their areas of activity.*

**Recommendation 2.1** The Institution should redouble its efforts to adopt and promote a culture of continuous learning, and a recognition that civil engineers who fail to keep abreast of changes affecting their areas of activity are simply unfit to practise.





We will say more later on how this new culture may be introduced and assured, which includes publicity and debate, provision of training and revision of CPD requirements.

Our second major conclusion regarding the pace of change relates to the frequency and manner of review. Rapid change requires frequent response. We have endeavoured to make sure that our conclusions and recommendations are appropriate for the skills required of today's civil engineers, and so far as we are able we have tried to anticipate future needs. But we have no crystal ball – or rather, our crystal ball merely tells us that change is the new normal, and that the pace of change

is increasing. We suspect that in as little as five years, much of this report will appear outdated. A procedure for continuous review and updating should be introduced, in conjunction with the Engineering Council and the Joint Board of Moderators.

The procedure should involve an element of foresight – predicting how change will affect skills requirements in the future. And although the introduction of such a procedure must closely involve the EngC and JBM, we believe the Institution should take the initiative.

*A procedure is needed for managing continuous review and updating of civil engineers' skills requirements.*

**Recommendation 2.2 The Institution should take the initiative in establishing (in conjunction with the EngC and JBM) a procedure for managing continuous review and updating of civil engineers' skills requirements.**

“ The Only Thing That Is Constant Is Change. ”

Heraclitus

# Section B – Findings

## B4 SKILLS

We now come to the main purpose of this review which is to consider whether the ICE is properly identifying and dealing with the current and emerging skills needs of the profession. So having addressed the core purpose of civil engineering and the variety of civil engineering activities - the *Why* and the *What* questions – and the speed of change, we now turn to the *How* question.

### What do we mean by ‘skills’?

There is a notable lack of consistency in the use or interpretation of terminology in the skills arena. Over recent years civil engineering employers have increasingly adopted staff management and development practice based on job tasks and competence, where ‘competence’ is the ability of an individual to do a job properly and is held to be a combination of knowledge, skills and ability. ‘Knowledge’ is what you know, while ‘skills’ and ‘ability’ are what you are able to do: the difference is that ‘skills’ can be learned while ‘abilities’ are innate and unchangeable (at least, in an adult).

These are helpful definitions, but what constitutes knowledge, or skills, or ability can vary from one competence model to another. And few of these competency models include the critical

issues of ‘values’, ‘attitudes’ and ‘motivations’ – such as caring about health and safety or commitment to sustainability – all of which influence behaviour and performance at work.

The Engineering Council’s *UK Standard for Professional Engineering Competence* (UK Spec) – the standard for EngTech, IEng and CEng qualifications – defines competence thus: ‘Competence is the ability to carry out a task to an effective standard. To achieve competence requires the right level of knowledge, understanding and skill, and a professional attitude.’

The skills required by ICE for IEng/CEng MICE comprise nine ‘attribute groups’ (each with a number of attributes), which include a combination of knowledge, skills, attitudes, motivations and behaviours. The nine attribute groups, and an example of the attributes required under group 3 for the CEng qualification, are shown in box 1. The full lists for the different qualifications are available on the ICE website [https://www.ice.org.uk/my-ice/membership-documents/member-attributes#attributes\\_of\\_ceng](https://www.ice.org.uk/my-ice/membership-documents/member-attributes#attributes_of_ceng).

The ICE qualification framework has the virtue that it captures all the things we seek in a professional civil engineer. However, it does not align with the models used by employers or by the Engineering Council, nor is it structured in a way that enables effective learning and development techniques to be identified and deployed – though we recognise that industry itself is by no means consistent, with many different approaches. For example, box 2 shows the structure and terms used within the Laing O’Rourke Group which are substantially different to the ICE and interestingly include a focus on qualifications. The *Streamlining 2.0 Review* is currently trying to adapt ICE terminology to align with the EngC, and we support these efforts.

*Misalignment of the ICE qualification system with models used by industry results in confusion, and makes it difficult to integrate the staff development systems used by industry with the ICE qualification process.*

**Recommendation 3.1** The ICE should progressively adapt the models and terminology that it uses in relation to skills to align with industry best practice.



## Box 1

### ICE attributes structure

1. Knowledge and Understanding of Engineering
2. Technical and Practical Application of Engineering
3. Management and Leadership
4. Independent Judgement and Responsibility
5. Commercial Ability
6. Health, Safety and Welfare
7. Sustainable Development
8. Interpersonal Skills and Communication
9. Professional Commitment

#### 3. Management and Leadership

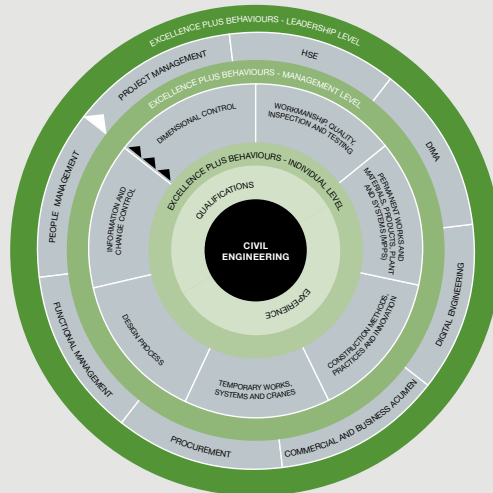
- A. Plan for effective project implementation
- B. Manage the planning and organisation of tasks, people and resources
- C. Manage teams and develop staff to meet changing technical and managerial needs
- D. Manage quality processes
- E. Plan, direct and control tasks, people and resources
- F. Lead teams and develop staff to meet changing technical and managerial needs
- G. Demonstrate continuous improvement through quality management

## Box 2

### Laing O'Rourke Group attributes structure

Experience  
Qualifications  
Technical Capabilities  
Laing O'Rourke Capabilities  
Leadership Behaviours

LAING O'ROURKE



Each toolkit covers expectations in relation to each role/stage of the journey:

Experience	Qualifications	Core technical capabilities	Laing O'Rourke capabilities	Leadership behaviours
The experience likely to have been gained at each step of the career path.	The professional qualifications expected for each role.	The unique functional technical knowledge and skills required for each role.	The knowledge and skills from other related areas that provide breadth to your capabilities and experience.	Excellence Plus Defining the personal, managerial and leadership behaviours expected at each job level.

# Section B – Findings

For the purposes of this Review and Report we have defined ‘skills’ as ‘the learning or know-how, ability, attributes and experience needed by an individual to practice safely in line with their professional duties and activities’. However, we recognise that our research findings may be coloured by different interpretations of terminology by different respondents.

The ‘skills’ that civil engineers need include the ability to: design and plan; manage resources; use tools and equipment; develop, use and/or follow systems and processes; collect, manage and use data; create a suitable operating environment; develop and maintain relationships with stakeholders; and learn new knowledge and skills. Some of these

skills will be acquired during formal education, many others through subsequent upskilling and experience.

The skills they will need for the future, we believe, include understanding of core engineering concepts, breadth of knowledge, ethics, awareness of socio-economic/political issues, communication management and leadership, innovation, ability to integrate sustainability, critical thinking and problem solving, competency in a global environment, lifelong learning, collaboration across networks, leading by influence, agility and adaptability, curiosity and imagination, and initiative and entrepreneurship. A challenging list which includes but extends beyond existing requirements.

The ICE has a huge repository of information, largely in written form. A similarly huge body of knowledge exists in the minds of the ICE global membership. The ICE faces two fundamental and substantial challenges in regard to information and knowledge: firstly, making sure that the information and knowledge are appropriate to the needs of the day; and secondly, making sure that those who need the information and knowledge are able to access it when they need to. ICE’s engineering knowledge team understand these challenges and are currently developing and implementing initiatives to address them. We fully support these efforts.

ICE’s infrastructure learning hub



**Recommendation 3.2** The Institution should ensure that its “information and knowledge” are appropriate to the needs of the day and accessible to those who need it.

### Our research

As we quickly found, everyone connected with the civil engineering profession has an answer to the *How* question, and the answers vary widely. So to introduce some objectivity into the review, we conducted a series of three research studies. Our desk research informed us of how others in the UK and elsewhere have addressed similar issues. This informed a series of semi-structured interviews with industry leaders and employers. And the outcomes of both were used to develop an extensive online survey of ICE members.

### The interview survey and the member survey

The interview (qualitative) and membership (quantitative) surveys provided some clear – and occasionally surprising – results. Responses were separated by grade, and sometimes they differed accordingly: for example, business leaders were more conscious of future skills needs associated with changing markets, organisational structures and technology, while operational people were more concerned with the basic skills needed to do today's jobs properly.





# Section B – Findings

## B5 SKILLS GAPS, SHORTAGES AND MISMATCHES

‘Skills gaps’ occur when businesses do not have sufficient staff with the required skills in their existing workforces. Our membership survey showed clearly that skills gaps are a serious problem on many projects. More than a quarter of senior managers report critical or severe challenges due to lack of skills, on a large majority of their projects. This is having a major impact on project outcomes, such as significant increases in time, money, risk and potential litigation.

A majority of members – whether they were designers, clients, contractors or project managers, or whether they were senior or junior – perceived this lack of skills to be most problematic in design teams. The six most frequently cited

areas of weakness were cited as: specific technical skills associated with particular professional roles; broader skills required to work within a multi-disciplinary and cross-professional environment; understanding/awareness in the broader

context of a project; understanding/ appreciation of the challenges faced by other people in the project; poor communication across teams; and the ability to tell when something is wrong or is likely to go wrong.





We consider it to be significant that only one of these weaknesses (albeit the one most frequently cited) relates to the technical skills seen as the core of a civil engineer's competence: the remainder all relate to 'soft' skills. We will return to this issue later.

'Skill shortages' are where businesses have difficulty finding suitably skilled individuals from the pool of potential recruits. Our survey also revealed a shortage of civil engineers, across the sector (though notably not at graduate level). Many of these shortages were largely of people with particular skills in high demand, such as coding or experience of offsite construction. Nearly half of the members who have been involved in recruitment in the last twelve months claim they could not fill all their vacancies or had to settle for less than ideal candidates.

The principal reasons given for not being able to fill vacancies were lack of technical skills or experience, low numbers of applicants and inadequate remuneration. Training existing employees and outsourcing are the main means of mitigating the effects of skills shortages. Relatively few respondents were proposing higher salaries to attract more people into the sector.

'Skills mismatches' are where individuals are mismatched to their jobs in terms of competences, qualifications and field of study. Our survey revealed that over 40% of respondents did not feel their job was 'very or completely appropriate' to their level of education. This may be evidence of the growth of graduates doing administrative tasks that we have heard of anecdotally.

*These issues of skills gaps, skills shortages and skills mismatches suggest that there is much to be done to ensure that the profession has people with the right skills to do the jobs of today, let alone in the future.*



# Section B – Findings

## B6 WHICH SKILLS AND ABILITIES ARE THE MOST IMPORTANT?

Both in the qualitative and quantitative studies we explored which skills are most important to performance and success at work. The results of the online survey – which included clients, consultants and contractors - are shown and discussed below.

### Which skills are most important?

The survey responses to the question ‘Which skills are most important?’ are shown in the box, with definitions of terms shown below.

We were struck by the relatively low importance given to Science – (using scientific methods to analyse and understand problems) which seems in stark contrast to the importance given to these activities in formal education both at school and in universities.

It was also notable that many of the most important skills are rarely if ever the direct subject of formal study or training.

We believe that it would be of great benefit to focus more effort and attention on to the efficient development of key skills such as judgment and decision making, critical thinking, thinking creatively, complex problem solving etc.



#### Definitions:

**Judgment and Decision Making** - Taking in consideration both subjective and objective criteria in assessing the relative costs and benefits of potential actions to choose the most appropriate one

**Critical Thinking** - Using logic to identify the strengths and weaknesses of alternative solutions.

**Time Management** - Managing one's own time and the time of others

**Complex Problem Solving** - Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions

**Thinking Creatively** - Developing, designing, or creating new applications, ideas, relationships or systems

**Coordination** - Adjusting actions in relation to others' actions

**Management of Personnel Resources** - Motivating, developing, and directing people as they work, identifying the best people for the job

**Resolving Conflicts and Negotiating with Others** - Settling disputes, and resolving grievances and conflicts, or otherwise negotiating with others.

**Active Learning** - Understanding the implications of new information for problem-solving and decision-making.

**Monitoring** - Assessing performance to make improvements or take corrective action.

**Social Perceptiveness** - Being aware of others' reactions and understanding why they react as they do

**Science** - Using scientific methods to analyse and understand problems

**Management of Material Resources** - Obtaining and seeing to the appropriate use of equipment, facilities, and materials needed to do certain work

**Learning strategies** - Selecting and using training/instructional methods and procedures appropriate for the situation when learning new things.



## Which abilities are most important?

The responses to the question ‘Which abilities are most important?’ are shown in the box. When the results were divided by type of member, it was found that senior members were even more convinced of the importance of “Idea Generation and Reasoning” abilities with over 75% ranking this as the most important. We were interested to see the relatively low importance given to quantitative abilities particularly when compared to the focus on these abilities in the formal education of civil engineers. It would seem sensible to increase the focus on these other non-quantitative abilities in attracting and selecting people to work as civil engineers.

Idea Generation and Reasoning Abilities	66%
Attentiveness	59%
Perceptual Abilities	49%
Quantitative Abilities	37%
Spatial Abilities	34%

### Definitions:

**Idea Generation and Reasoning Abilities** - Abilities that influence the application and manipulation of information in problem solving e.g. ability to combine pieces of information to form general rules or conclusion, ability to tell when something is wrong or is likely to go wrong

**Attentiveness** - Abilities related to application of attention e.g. ability to shift back and forth between two or more activities or sources of information

**Perceptual Abilities** - Abilities related to the acquisition and organization of visual information e.g. Ability to quickly make sense of, combine, and organize information into meaningful patterns, to identify or detect a known pattern, to quickly and accurately compare similarities and differences among sets of numbers, objects, pictures, or patterns

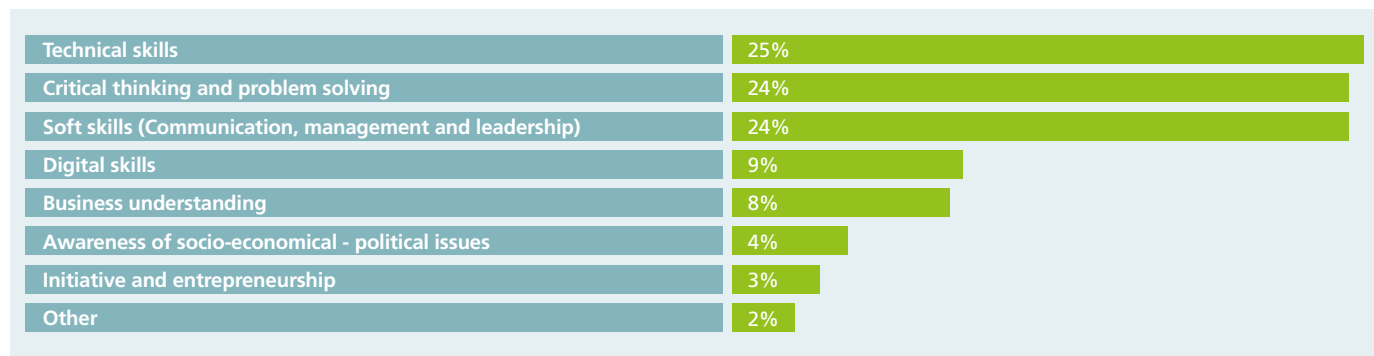
**Quantitative Abilities** - Abilities that influence the solution of problems involving mathematical relationships e.g. ability to choose the right mathematical methods or formulas to solve a problem

**Spatial Abilities** - Abilities related to the manipulation and organization of spatial information e.g. Ability to imagine how something will look after it is moved around or when its parts are moved or rearranged

# Section B – Findings

## B7 WHICH SKILLS NEED TO BE DEVELOPED THE MOST?

When asked which skills today's engineers need to develop most, the answer was remarkably consistent across all sectors, career levels and geographical locations: technical skills, critical thinking and soft skills.



Perhaps surprisingly, lack of digital skills was seen as a much smaller area of concern: this may have been partly because members were responding on improvements in skills needed for *today's* challenges, rather than in the future. We will return to digital skills in Section B8.

From the results of all our research, we have identified several skills areas requiring particular attention, and these are discussed below.

### Soft skills

The three most important skills for today's civil engineers, according to the membership survey, are judgement and decision making; critical thinking; and time management. These (and many more) are typically called 'soft skills' – a loose short-hand term for a complex set of (non-technical) skills and attitudes. In this and other areas of our research, these and other soft skills – including being able to form and maintain good working relationships, to inspire and motivate others, to engage productively with stakeholders, to resolve disputes, to negotiate effectively, and particularly to communicate effectively – emerged as significantly more important in the workplace than many of the technical skills which dominate the

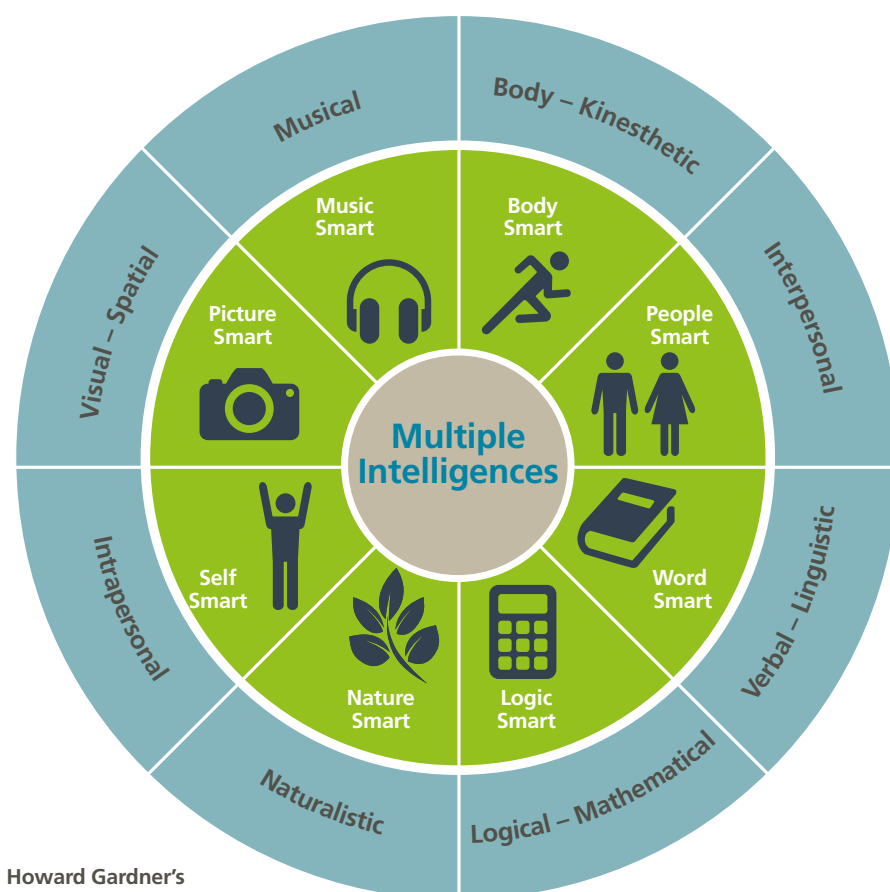


curricula of undergraduate courses. Also, increasingly recognised as an important skill is wellbeing – the ability of individuals to look after themselves and be physically and emotionally fit, and purposeful.

Employers are pointing to the lack of soft skills among civil engineers as a key area of concern. Technology has changed the nature of work, and clients are placing more emphasis on the soft aspects of the relationship with their suppliers.

In general, the education system treats soft skills as complementary and less important than technical skills. As a consequence, civil engineers do not grasp the importance of soft skills and are not prepared for the transition from the classroom to the labour market where soft skills have become the real differentiator. We do not suggest that the teaching of soft skills should be introduced into curricula at the expense of technical subjects, but by the time they graduate young civil engineers should at least have a clear *awareness* of the importance of such skills, and the opportunity to acquire them through training soon afterwards.

In particular, employers point to ‘communication breakdown’ as a key factor in creating friction on projects. They also point out that young engineers still do not grasp that being able to communicate effectively is not



Howard Gardner's multiple intelligences

a ‘nice to have’ skill any more: it has become a ‘must have’.

There is also a lack of understanding of the *nature* of communication. Transmitting information is not the same as communicating effectively. While new technologies simply make it easier to send words, civil engineers need to be equipped with methods to enable them to secure accurate interpretation and appropriate actions by the recipients – and vice versa.

We believe all this marks a shift in the skills and role of the civil engineer. Notwithstanding ICE's current

requirement for soft skills at IPD level, our research shows that soft skills are becoming increasingly important and are seen to be lacking. Work over the last few decades by cognitive psychologists, including Howard Gardiner's influential work on ‘multiple intelligences’, provides a theoretical basis for us to understand the importance of non-technical abilities.

# Section B – Findings

As our researcher Ms Arapi put it succinctly after interviewing many industry leaders: “the industry’s requirements are moving from engineers with soft skills to emotionally intelligent people with engineering skills”. This leads to one of our most important conclusions:

*Soft skills are becoming increasingly important for civil engineers, and are perceived to be lacking. Awareness of the importance of soft skills needs to be inculcated early in their education, and appropriate upskilling provided early in their careers.*

**Recommendation 4.1 The Institution should take appropriate steps to promote the increasing importance of soft skills, and in particular, to raise awareness among undergraduates of the importance of soft skills and to ensure that appropriate upskilling is available post-graduation and pre-qualification.**

This is not to say that civil engineering courses should be packed with more soft-skill training at the expense of technical content, as we make clear in Sections B9 and B10 below.

## Leadership skills

Leadership skills are one of the soft skills that have always been important to civil engineers in senior positions. But today’s workplace environment is more complex and fast-changing, and empowers people at a more junior level to take the initiative and make decisions. Leadership skills are now required at every level of employment, and there is a growing need for civil engineers, in whatever capacity, to



“We are rapidly developing and recruiting an outstanding team with the necessary breadth of skills and attributes to meet the requirements of the smart infrastructure revolution.”

Andrew Wyllie, CBE FREng, MBA, BSc CEng FICE CCMI,  
Chief Executive, Costain Group plc and ICE Senior Vice President

be open, to understand business goals, to be confident in their decision taking, to be able to influence others, to take ownership of issues, and to help ensure that others around them perform to the required level.

Most of the organisations we interviewed were looking for leadership skills when recruiting, even among graduate recruits. Generally, employers are recruiting for attitude, for people with a special ‘spark’ and a strong work ethos, and are then prepared to upskill them.

*Leadership skills are increasingly important, even for recent graduates, and are particularly sought after by employers.*

### Team skills

Teams, not individuals, are increasingly understood to be the basic building blocks of organisations and projects. Indeed, the creation of successful and collaborative teams is a key and recurring theme of the *Project 13 initiative*, which has been launched by the ICE to create “a new approach to delivering high performing infrastructure”.

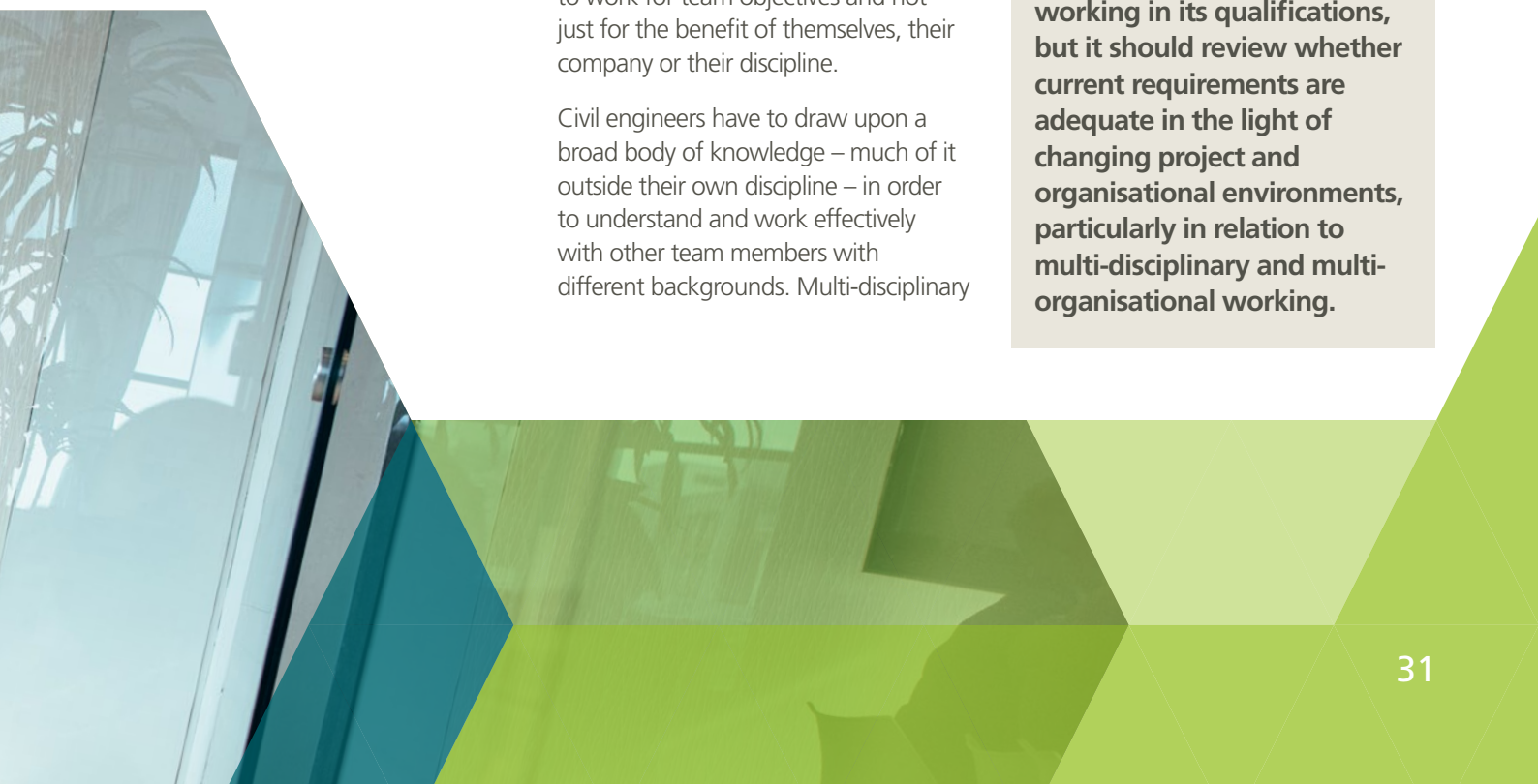
The multi-disciplinary, multi-organisational team has become the norm on bigger, more complex projects, and indeed the growth of interdisciplinary working was identified as a key factor in our research. This requires many soft skills, but it also increases the need to translate information across occupational boundaries, and it requires civil engineers to work for team objectives and not just for the benefit of themselves, their company or their discipline.

Civil engineers have to draw upon a broad body of knowledge – much of it outside their own discipline – in order to understand and work effectively with other team members with different backgrounds. Multi-disciplinary

knowledge was cited in our research as the area of knowledge which is most important today. Indeed, organisations are likely to be required to provide evidence that they have a competent team before being appointed.

*Team working is the norm for civil engineers, and these teams increasingly include people from many different backgrounds and disciplines, and may work together for longer. It is increasingly important for civil engineers to develop team-working skills, and to acquire a broad understanding of the disciplines of others on their teams in order to work with them productively.*

**Recommendation 4.2 The Institution already recognises the importance of team working in its qualifications, but it should review whether current requirements are adequate in the light of changing project and organisational environments, particularly in relation to multi-disciplinary and multi-organisational working.**





# Section B – Findings

## Technical skills

Technical skills, in the sense of the applied science and mathematics foundational knowledge and process skills which civil engineers learn as undergraduates and early in their careers are regarded as highly important. Among the leaders interviewed, there was broad agreement that scientific understanding and numeracy skills are vital, and likely to remain so for years to come. Additionally, there was also a general recognition that one of the benefits of a rigorous academic education is that it teaches people how to learn.

There is also a recognition that technical skills (particularly those related to process skills) may become outdated quickly, and increasingly so, as new techniques emerge. There is therefore a continuing need for civil engineers to keep abreast of technological developments in their areas – a point made strongly in the *Independent Review of Building Regulations and Fire Safety* following the Grenfell disaster. Examples of recent developments in technical practice which would have been

essentially unknown a generation ago include: the use of whole life carbon calculations; product life cycle assessments; BIM; optimisation techniques (such as genetic algorithms); SUDS design techniques; air quality modelling; or structural design with glass.

Currently, digital technologies are creating new techniques and processes which are rapidly changing the way that civil engineers work. We consider this further in Section B8 below. Some people believe this will cause numbers in the profession to decline. However, none of our interviewees showed particular concerns about technology taking over the civil engineering profession or jobs: particular tasks may go, but these will result in redeployment and not a reduction in the workforce. Rather, they all reinforced the need to embrace digital and other technologies to take advantage of the opportunities that they offer.

*Technical knowledge and skills remain vitally important. Civil engineers must keep abreast of technical advances and developments in their fields.*

**Recommendation 4.3**  
**Through its engineering knowledge activities, the Institution should encourage and enable civil engineers to keep abreast of technical advances and developments in their fields, and to make the most of the opportunities that they offer.**

There is a wider issue that emerged from our qualitative research. The feedback suggested that ICE is currently too focused on its world of infrastructure, and could do much more to infuse openness of mind and extend the boundaries of thinking. The Institution has the potential to be a melting pot of ideas, concepts and thought-provoking discussion, but to do so it needs to expand its vision of what civil engineers should know, learn and discuss. Today it is seen by many to be not sufficiently challenging, not encouraging and not provoking out-of-the-box thinking.

“ We will provide better jobs. Jobs in digital design, high-tech manufacturing, expert assembly, bespoke technicians valued for their artisanal skills, not reduced to commodity players forced to ply their manual trade. We will build careers in construction that parents are proud to see their kids follow, in what I still believe is the most exciting industry in the world. ”

Ray O'Rourke, KBE, HonFREng, CEng, FIEI, FICE,  
CEO, Laing O'Rourke

*ICE is seen to be too narrow in its learned society activities, and a wider agenda would help and encourage civil engineers to become more curious and broaden their skills.*

**Recommendation 4.4** The Institution, through all its activities, should expand its vision and embrace a wider range of subjects, in order to encourage and enable civil engineers to expand their horizons and develop a broader range of skills.



# Section B – Findings

## B8 TRENDS

### Digital technology

To no-one's surprise, the development and adoption of digital technology was perceived by members as the main trend which will have an impact on skills. Digital technology comes in many forms, notably building information modelling (BIM), artificial intelligence, 'big data' and robotics. Under this heading in our research, the most important trends were seen to be: automation of parts of the design process; massive increases in the amount of data collected; and the use of digital techniques to enable manufacture and assembly.

Current examples of the former, particularly automation of the production stages of the design process, include production of fabrication or construction information directly from structural models without the production of traditional shop drawings. Some say that once the basic structural solution has been identified, engineers should already be integrating structural analysis models with design specification models to produce economically optimal, code-compliant fabrication information. Many say that this sort of work, following standard and codified processes, will be automated within a few years.

Digital technology has had a profound impact on the way in which both data and information are produced, collected, transferred, stored and accessed. There are a great many potential benefits arising from easy access to data and information. At the same time there are significant challenges in managing large amounts of data and information, including the need for engineers to work alongside a new breed of 'data scientists'. Many are complaining of "information overload". The uncontrolled and unverified nature of much of the data and information available means that making sure that data and information are reliable assumes increasing importance. And without the right controls in place, the data can start to control the engineers (and others in the team) and result in them being 'chained' to their desks in a very isolated way. So the issue is not just the technology itself, but also the new ways of working – including greater collaboration – required to apply it productively.

The landscape of digital technology is changing rapidly, and the pace of change is increasing, so it is very difficult to anticipate exactly how it will develop and thereby how we should prepare people for the future. In the long term this could have a profound effect on the civil engineering profession and industry, with numerous tasks currently done by civil engineers being taken over by machines, or by less-highly qualified technicians assisted by machines.

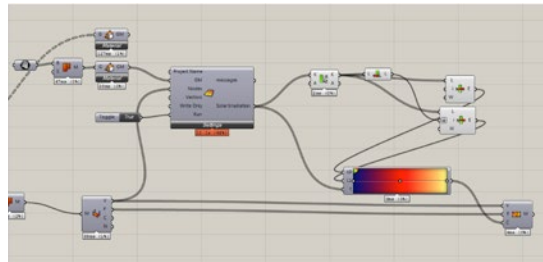
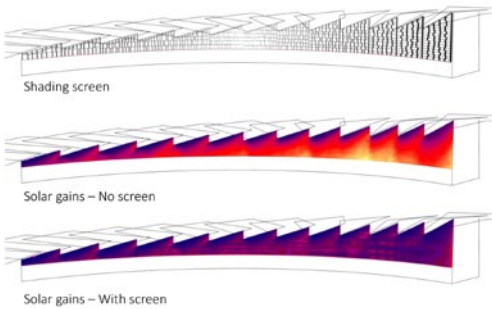
However our research identified that just because a technology can replace human activity it doesn't mean that it will. There are certain types of work that are particularly vulnerable to automation, and others that are not. The former group typically involves work which is high value, and which involves codable processes (even very complex ones). As examples from other industries, we can already see the replacement of commodity traders with algorithmic trading software, but not (yet) the replacement of hotel cleaners with robot equivalents.

In construction, digital technology has not replaced the 'high value' processes involving creativity, complexity or human interactions. But we believe that, in the future, it may.

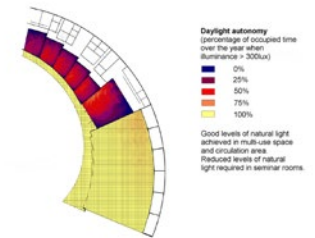
Our approach to the changes driven by a growth in digital technology is twofold. In the short term, we believe that civil engineers should embrace digital technology and explore to the utmost the efficiencies and other advantages it can bring, which means acquiring the skills to apply the technology.

Interestingly, our research did not find that digital skills were a priority for development among respondents. This may be because they already have good digital skills. Alternatively, they may not yet have seen digital technology impact on their job roles. Perhaps, they are just very aware of the other skills challenges. Nonetheless, we believe that digital skills will





Natural light levels



### Parametric modelling used to optimise the design of a building façade

be increasingly significant for civil engineers in the future.

For the longer term, the changes are impossible to predict, and we propose simply that, as discussed in more detail in Section B3, a procedure for continuous review and updating of civil engineers' skills requirements should be introduced so that the profession can respond quickly to changing circumstances.

*Civil engineers should embrace the revolution in digital technology, acquiring the will and the skills to use it to improve the quality and efficiency of their work. The longer term changes wrought by digital technology – as yet unpredictable – should be monitored (under the procedure proposed in Section B3), and appropriate changes to skills requirements introduced promptly.*

Digital technology may be the most

profound change affecting the skills needed by civil engineers, but it is by no means the only one. We have already discussed in previous sections how changes in the way the industry works such as the increase in multidisciplinary working have made soft skills – particularly in communication, leadership skills and team skills - more important for all civil engineers than they once were. Among the other changes currently affecting the way civil engineers work, and the skills they need, are changes in markets and in organisational structure, and increasing use of offsite construction.

### Emerging markets

The new technology which is so dramatically affecting how civil engineers work is also creating new and expanding markets to provide supporting infrastructure. Digital communication, renewable energy,

electric and hydrogen powered cars, autonomous vehicles – all will require infrastructure to support their development, and some of the skills required will differ from those needed for traditional infrastructure.

### Changes to organisational structure

There have been major changes in recent years in the way that organisations are arranged to deliver infrastructure. Examples include the emergence of the global multidisciplinary professional services firms, the growth of frameworks and alliancing models, and outsourcing of technical services. All of these changes influence the skills, knowledge, abilities and attitudes required by civil engineers. New organisational structures also influence the ways that information is processed and managed and the way that engineers acquire skills and knowledge.

# Section B – Findings

“We are entering an era of man machine partnership. This will make us much more capable, and get us involved with data and the operations of the actual built environment, but won't significantly change the numbers of engineers/designers required!”

Tristram Carfrae, RDI MA FEng FTSE FStructE FIEAust FRSA  
Deputy Chairman, Arup

## Changes in infrastructure provision

Much has been said over recent years about the low productivity growth in UK construction. Many have advocated fundamental reform both in the way that infrastructure is delivered and in the way that it is operated. It seems highly likely and indeed desirable that the UK construction industry undergoes a fairly substantial transformation. Current trends include the promotion of different procurement models based on alliancing and the increased use of offsite manufacturing techniques. Some are exploring the opportunities to bring factory assembly techniques and practices on to construction sites and 'industrialising' the approach to project and program delivery. Some of these trends are evident internationally and are likely to develop further.

These changes in markets, working practices and in organisational structure create changes in the skills needed by civil engineers.

**Recommendation 5.1** The Institution should identify and respond to emerging markets (such as infrastructure for new technology) and to changes in organisational structures and methods, by continuously monitoring skills requirements and making changes where necessary.

**Recommendation 5.2** The Institution should encourage civil engineers to embrace the revolution in digital technology, and to acquire the skills to use it to improve the quality and efficiency of their work. The longer term changes wrought by digital technology – as yet unpredictable – should be monitored, and appropriate changes to skills requirements introduced promptly.



## B9 QUALIFICATION

The ICE is (under license to the Engineering Council) the qualifying body for civil engineers with various grades of MICE membership from EngTech through IEng to CEng and the Institution needs to address whether the requirements for qualification are in line with the skills needs. But as we have done with skills, we need to ask first: what is the *purpose* of qualification?

We believe that the purpose of qualification is twofold: it provides *assurance* to the client (or employer) and to the public that the person is competent to do the job; and it provides *motivation* to the engineer to pursue learning to achieve (and maintain) qualification.

### Qualification as a civil engineer

The IEng/CEng and EngTech qualifications are generally well regarded by industry both because they cover much of what is relevant to practice and because they drive learning behaviours in new professionals. But their great weakness is that they do not in any meaningful way assure competence or drive learning behaviours years after they are awarded.

In modern practice the responsibility

to clients and the public for the performance of professional services generally sits with the companies rather than individual engineers. As such it is important to understand whether and to what extent employers value the ICE qualifications as a proof of competence and as a driver of learning behaviours. Discussions with employers were not conclusive on this matter. Moreover, the issue of assuring competence is currently receiving a lot of scrutiny in the UK because of high profile problems at Grenfell Tower and the Edinburgh Schools.

There is a broad agreement in the industry that ICE has well defined the civil engineer in the traditional sense and the skills that the civil engineer needs to acquire in order to succeed in that space. Similarly, satisfaction of employers with the technical competency of young engineers is high

when they cover traditional roles. This does not mean that every engineer in the industry is an accomplished professional but that the system in place, the combination of initial education, professional qualification and working experience, enables individuals, with willingness and ambition, to become accomplished professionals. We support these views, and consider that the ICE's qualifications are broadly fit for purpose – in the early stages of a civil engineer's career, up to the point of qualification.

We have a couple of qualms. The first, as we mentioned in Section B7, is the need for a greater emphasis on post-graduate, pre-qualification upskilling in non-technical skills.

The second concerns people who do not neatly fit the mould of the



# Section B – Findings

‘traditional’ civil engineer. Our qualitative research points at ICE’s lack of flexibility and closed mind-set in recognising, supporting and welcoming these ‘new’ civil engineers as well as all the other professional figures which surround, support and collaborate with them. It is in those organisations where the role definitions are stretched that employers are looking for more support and a change in both the education system and young engineers’ understanding of the skills they require in order to become successful professionals.

We recognise that the ICE has made significant efforts in recent years to attract members from the wider infrastructure and construction community, including notably the introduction of the revised AMICE membership grade. It may be that the feedback that we received is based on opinions formed before the recent efforts and changes.

*The modern construction industry is multidisciplinary, and a more flexible approach to the backgrounds of those allowed, or encouraged, to enter the civil engineering profession would be beneficial.*

**Recommendation 6.1 The Institution should recognise the multidisciplinary nature of the modern construction industry, and be more flexible in allowing people to enter the civil engineering profession without the ‘traditional’ background. Indeed ICE should be proactive in seeking such people out and welcoming them into the profession.**

## Maintaining qualification

But when we get to the ICE qualification process post-qualification, we have some serious concerns. The first is one that we addressed in Section B3. The assumption that a professional qualification once attained qualifies a civil engineer to practice for life is simply untenable in a fast-changing world, with greater expectations by clients and the public of up-to-date professional competence. In our view ICE’s current voluntary CPD model is not an adequate means of assurance.

The Engineering Council and ICE have recognised this and that voluntary CPD is on the way out: Engineering Council has introduced a requirement for compulsory recording and auditing of CPD and at the time of publication of this report, ICE is balloting members on the introduction of compulsory CPD. We welcome this move,

but our concerns are not merely about whether CPD is voluntary or compulsory. If the purpose is to ensure that civil engineers remain competent in their jobs, then the content of the CPD must also be *relevant* to the engineer’s job. A more robust check of relevance should therefore be the next step for the engineering profession.

Our second, related concern is that the skills assessed at qualification are a combination of *general* skills required by all civil engineers, and *specific* skills which the candidate was applying at the time of assessment. Some years later the civil engineer may be (and almost certainly will be) doing work for which their ‘old’ skills are outdated or inappropriate, or doing work which requires greater, specialised skills in a particular area. The ICE’s Rules of Professional Conduct require that ‘All members shall develop their professional knowledge, skills and competence on a continuing basis...’ and ‘All members shall only undertake work that they are competent to do’. That puts the onus on the individual civil engineer, but provides scant comfort for the client – or member of the public – seeking assurance that the work is in the hands of someone with appropriate, up-to-date qualifications.

Several conclusions emerge from these two concerns. The first, and most important, is the one we introduced in Section B3, and repeated here:

*The Institution must instil - in itself and its members - a stronger culture of continuous learning, and a recognition*

*that civil engineers must keep abreast of changes affecting their areas of activity.*

The means of instilling this change of culture requires thought and planning, and will take time to achieve. It requires coordinated initiatives from both the Institution's engineering knowledge team (on provision and dissemination of knowledge and lifelong learning) and its qualifications team (to provide assurance that it is done). We recognise that valuable work is already being done in this area, but we are asking for more. We will not attempt to be prescriptive about how this should be achieved, but we believe it should include the following three elements:

*A process of publicity and debate - engaging members, employers and clients - both to establish best means to bring about this change of culture and to secure the change;*

*Ensuring that appropriate upskilling is provided to enable qualified engineers to keep up-to-date with their skills, and where appropriate to re-skill;*

and

*An urgent review of CPD requirements, to establish a more robust system which ensures that a member's qualification is relevant and up-to-date throughout the member's career. This is not just a question of whether CPD is voluntary or compulsory, but also whether the content of the CPD is relevant to the member's job.*

**Recommendation 2.1** *The Institution should redouble its efforts to adopt and promote a culture of continuous learning, and a recognition that civil engineers who fail to keep abreast of changes affecting their areas of activity are simply unfit to practise.*

**Recommendation 6.2** *As part of this culture change to promote continuous learning, the Institution should instigate a process of publicity and debate involving members, employers and clients*

**Recommendation 6.3** *Through both its engineering knowledge activities and its qualifications activities, the Institution should actively seek to provide, or encourage others to provide, appropriate upskilling to enable qualified engineers to keep up-to-date with their skills, and where appropriate to re-skill.*

**Recommendation 6.4** *The Institution should urgently review its CPD requirements, preferably in conjunction with the EngC, in order to establish a more robust system which ensures that a member's qualification is relevant and up-to-date throughout the member's career. This goes beyond the question of whether CPD is voluntary or compulsory.*

## Section B – Findings

The ICE's basic qualifications assess a range of *general* skills, and, to a lesser degree, the candidate's specific skills, but they convey nothing to the employer or to the public about the engineer's skills in *specific* areas. We are now seeing some demand for forms of assurance of competence in specific skills. We understand why clients, owners and the public seek assurance in this way that the works which they own, use or are affected by are properly – and, above all, safely – designed, built and maintained by people who have all the necessary up-to-date skills, knowledge and experience to do so. We think that the demand will grow, along with a worldwide trend to require greater accountability from professionals.

“An exciting opportunity exists for the ICE to support assurance in the sector, in a way that would add value to all of us. By actively validating civil engineering competence throughout a member's career life-cycle - the ICE will effectively provide the industry's 'kitemark' for civil engineering quality, and technical expertise. This will benefit the individuals themselves, their employer and the wider industry, but requires the ICE to work in a dynamic manner with educational institutions, training providers, skills assessors and business.” ”

John O'Connor, FRICS  
Group Commercial and Human Capital Director, Laing O'Rourke



The ICE has an honourable history in providing such assurance. The Reservoirs Act 1930 established an inspection regime for dams and reservoirs by approved 'panel engineers', on a register maintained by ICE. The Institution continues to maintain registers of panel engineers qualified to design and maintain all large and high-risk dams on behalf of the UK Government, including certifying and regularly reviewing each member. In the 21st century other registers and/or specialist qualifications have followed (For example: <https://www.ice.org.uk/careers-and-training/careers-advice-for-civil-engineers/specialist-professional-registers#reservoirs>). Such registers are

usually accompanied by a qualification process in the specific area.

We believe the Reservoirs Panels have provided such assurance (and the absence of any major dam failure in Britain since the 1930 Act is some testament to their success). We anticipate a growth in the demand for such registers and qualifications. These are most necessary where the consequences of failure are high or where specialist knowledge is required. One example of this sort of qualification is the 'Certificated Surveyor in Structural Waterproofing' qualification, which is now a requirement for those specifying some waterproofing systems, otherwise

warranties are invalid.

*The need for specialist registers and for additional professional qualifications in specific skills should be investigated. The Institution should respond positively and actively to fulfil these needs, where appropriately acting in conjunction with others.*

**Recommendation 6.5** The Institution should work closely with members and employers to explore where specialist qualifications are most needed and how they can best be provided.



ICE training workshop



# Section B – Findings

## B10 PRE-QUALIFICATION

The 'traditional' path to a civil engineering qualification starts with an undergraduate degree course in civil engineering. Such courses are inspected and approved on behalf of ICE by the Joint Board of Moderators, and the JBM requires a strong core content of technical subjects in the curricula: structural materials and geotechnics, plus a minimum of two from fluid mechanics, surveying, transport infrastructure engineering, public health, construction management, environmental engineering and architectural technology.

We have heard many criticisms of the lack of soft skills among graduates entering the workplace. However, these have not been accompanied by loud calls for the teaching of soft skills to be included to a greater degree in curricula, at the expense of technical subjects. A variety of views was

heard, but the majority from both our qualitative and quantitative research expressed general satisfaction with the technical education in first degree courses.

However, we did hear calls for greater flexibility in education. An increased variety of career paths and mix of skills

in an increasingly multidisciplinary industry call for greater variety of learning paths than the conventional single-discipline course. New engineers are required to have knowledge well beyond civil engineering. There is a need for more flexibility in the education system to allow some



“As academics it is really important that we stay tuned in to the emerging needs of the profession and progressively adapt and enhance the content and character of our courses, as well our teaching techniques, to ensure that we deliver the highest quality learning experience.”

Fiona Bradley BEng (Hons) CEng MICE FHEA  
Head of Civil Engineering Discipline, University of Glasgow

students to create a bundle of modules from different providers based on their interest and learning paths. We recognise that the Institution already accommodates some flexibility: the door is unlocked for people with non-standard backgrounds, but we would like to see the door opened wider – with a welcome mat.

*Greater flexibility is required in the education system, to allow undergraduate students to bundle together a greater variety of courses which will be accepted as a basis for qualification as a civil engineer.*

**Recommendation 7.1 The Institution should encourage, support and accept greater flexibility in the education system, to allow undergraduate students to bundle together a greater variety of courses which will be accepted as a basis for qualification as a civil engineer.**

A number of academics and universities are actively trying to improve the efficiency and effectiveness of education, for example through the application of emerging pedagogies utilising digital technology and project-centred learning. At the same time many observed that a continued focus on research activities within universities meant that less focus was generally given to education. It will be interesting to see how the Teaching Excellence Framework and developments in the Higher Education market influence the attitudes of university departments towards education.

Several academics observed that the primary interaction with the ICE was through the accreditation role played by the Joint Board of Moderators, which is essentially about ensuring compliance. Despite the efforts of the JBM visit teams, the nature of this role was not generally felt to be conducive to the development and encouragement of best practice. ICE can – and does – exert a positive influence, particularly by acting as a convenor for discussions between

academia and employers, and we would encourage an increase in such efforts.

*ICE should continue to use its position and convening power to support the development and adoption of educational best practice.*

**Recommendation 7.2 The Institution should develop a Community of Practice focused on education and skills.**

The Institution has always considered practical experience as important as, if not more important than, academic study as the basis for professional qualification. We found continuing support for this approach, and we strongly endorse these views. While education provides the framework, it is important for young engineers to understand how things actually work. It is important that engineers learn to understand how their jobs relate to reality and the consequences that their decisions have in real life.



# Section B – Findings

However, we found some evidence that these practical skills are in decline: students who no longer spend their spare time maintaining cars or doing DIY, turning into academically-competent undergraduates who cannot draw the basic components of a suspension bridge or a water supply system.

*Practical experience remains a very important ingredient of professional qualification. We support the continuing importance attached to good practical experience, and we would encourage initiatives which instil practical skills at undergraduate level.*

**Recommendation 7.3 The Institution should continue to place a high priority on the importance of practical experience, and should use its influence to encourage the development of practical skills from the earliest stage.**

As we established in Section B5, employers currently perceive a shortage of professional civil engineers, albeit not necessarily at graduate level, and we do not foresee this changing – at least in the short or medium term. It is therefore vital that the profession encourages bright and able people to join, and in particular in the context of this Review, that it removes perceived barriers which may deter suitable people.

Great strides have been made over the past half century to make the profession more accessible to women and to people of different ethnic, class and economic groups. Several current initiatives are reinforcing the message. We strongly support these efforts.

Also the UK has an education system which undervalues engineering, and a construction sector with a poor image which is therefore not attractive to a diverse range of potential recruits. Improved engineering curricula in schools and colleges, better informed careers advice, and a campaign to inspire people already in work to transfer to engineering, could all help to bring more, suitable people into civil engineering.

*Initiatives must be maintained and strengthened to encourage a wider variety of bright and able people to choose a profession in civil engineering.*

We also considered whether degree entry qualifications were an unnecessary barrier to entry. It is

somewhat sobering to reflect that the single biggest determinant of entry into the civil engineering profession is possession of an 'A' level in maths (achieved by only about 95,000 children a year in the UK out of a total of around 650,000).

In effect we restrict our pool of recruits to about 1/7th of the population because of their desire and ability to achieve a maths 'A' level at the age of 18.

When you factor in the common assumption in the UK that three 'A' levels including both maths and physics are necessary to study for a degree in civil engineering, the situation gets much worse with numbers reduced to circa 30,000.

However, it is not clear that removal of the requirement for maths 'A' levels would necessarily lead to a significant increase in the number of recruits into civil engineering degrees, or change their character. The perceived linkage between STEM subjects and engineering careers appears to be very strong among teachers, parents and students.

As a notable example, UCL removed the requirement for a maths 'A' level for their BEng and MEng civil engineering degrees in 2006, yet less than 5% of their subsequent recruits do not have a maths 'A' Level. It is also interesting that these students usually end up towards the top of the class on graduation, and are reported to be easily employed and successful in practice.

Of course, ICE qualifications depend



“Most of the problems that I come across are depressingly ordinary....and we really need to make sure that as we take advantage of exciting new technology to modernise the industry, we don't forget to do the knitting.... !”

Damian Leydon FICE MCIOB.  
Operations Director, Berkeley West Thames



Undergraduates and apprentices learning practical skills from 'old pros' on the Big Rig

on the civil engineer's attributes as assessed when presenting for the review, and not on the student's possession of a particular qualification when aged 18. We are interested in where you end up, not where you start your learning journey.

Some industry seniors have observed that those with an interest and ability in maths and physics at 18 do not necessarily possess the creative abilities, the communication skills or

the practical intelligence that turn out to be very important in practice. Some have argued that skills and abilities in the arts are as important for engineers as science and maths.

Overall, we believe that ICE needs to give further attention to the abilities and attitudes of those who the Institution tries to recruit into the profession if the future skills needs of the profession are to be met. At present, as our qualitative research

shows, ICE is perceived as a less welcoming place unless you tick all the boxes. This is likely to require a rethink of both the way that civil engineering is described and promoted, and the requirements placed on entry to university education. STEM alone is no longer enough. There is an increasing requirement, for example, for civil engineers to work collaboratively in cross-discipline teams and to care for the environment.

# Section B – Findings

*Taking a broader approach to the backgrounds and entry qualifications of potential civil engineers at undergraduate level will not only increase the size of the pool from which they are selected, but also broaden the skills and aptitudes of future professionals to meet the breadth of needs.*

**Recommendation 7.4.**  
**The Institution should, in conjunction with the JBM and through its influence as a convenor, work with educational establishments to explore the potential for a broader approach to the backgrounds and entry qualifications of potential civil engineers at undergraduate level.**

In this Review we considered 'technical skills' without much subdivision as to area or depth. Not surprisingly, many talked about the importance of technical skills and many identified technical skills gaps but we did not get very far into precisely what people meant by this. In particular we didn't differentiate between foundational knowledge (eg the theoretical understanding of structures, materials, hydraulics, soils etc) and experience doing engineering processes (eg structural analysis, hydraulic design, product specification, project procurement) in practice. We believe that more work is required to understand properly where the focus needs to be applied.

However, we did hear from several industry seniors who observed that the MEng qualification was not as effective at generating high-level technical mastery as the BEng supplemented by a post-graduate MSc in a specialist subject. This is not perhaps surprising given that the introduction of the MEng qualification followed a recommendation in the 1980 Finniston Report into the engineering professions, and that Finniston's intention had been for the MEng to create more rounded engineers with soft skills, rather than to hone technical skills.

Academics added that specialist technical MSc's are relatively unattractive to UK students, who find the prospect of an additional year of study unappealing, due to challenges in terms of both funding and domestic

arrangements. Some consultants observed that they were relying on overseas educated engineers for some of their more technically specialist roles.

*Universities should work with employers to explore the need for high-level technical qualifications delivered in a more attractive form to mid-career professionals. ICE has the ability increasingly to work with academia, employers and Government to help secure the necessary improvements.*

**Recommendation 7.5.**  
**The Institution, through its influence as a convenor, should encourage universities to work with employers to explore the need for high-level technical qualifications delivered in a more attractive format to mid-career professionals.**

ICE Project 13







# Section C – Summary

## 1. Skills to do What?

**Recommendation 1.1** The Institution should put the delivery of social, economic and environmental value through infrastructure at the heart of its thinking about skills and qualifications.

**Recommendation 1.2** The Institution should develop and implement a plan to improve civil engineers' skills related to operation, maintenance, modification and decommissioning of infrastructure.

## 2. Response to Change

**Recommendation 2.1** The Institution should redouble its efforts to adopt and promote a culture of continuous learning, and a recognition that civil engineers who fail to keep abreast of changes affecting their areas of activity are simply unfit to practise.

**Recommendation 2.2** The Institution should take the initiative in establishing (in conjunction with the EngC and JBM) a procedure for managing continuous review and updating of civil engineers' skills requirements.

## 3. Skills

**Recommendation 3.1** The ICE should progressively adapt the models and terminology that it uses in relation to skills to align with industry best practice.

**Recommendation 3.2** The Institution should ensure that its "information and knowledge" are appropriate to the needs of the day and accessible to those who need it.

## 4. Which Skills Need to be Developed the Most?

**Recommendation 4.1** The Institution should take appropriate steps to promote the increasing importance of soft skills, and in particular, to raise awareness among undergraduates of the importance of soft skills and to ensure that appropriate upskilling is available post-graduation and pre-qualification.

**Recommendation 4.2** The Institution already recognises the importance of team working in its qualifications, but it should review whether current requirements are adequate in the light of changing project and organisational environments, particularly in relation to multi-disciplinary and multi-organisational working.

**Recommendation 4.3** Through its engineering knowledge activities, the Institution should encourage and enable civil engineers to keep abreast of technical advances and developments in their fields, and also to develop sufficient understanding of 'new technology' and the advantages it can bring.

**Recommendation 4.4** The Institution, through all its activities, should expand its vision and embrace a wider range of subjects, in order to encourage and enable civil engineers to expand their horizons and develop a broader range of skills.

## 5. Trends

**Recommendation 5.1** The Institution should identify and respond to emerging markets (such as infrastructure for new technology) and to changes in organisational structures and methods, by continuously monitoring skills requirements and making changes where necessary.

**Recommendation 5.2** The Institution should encourage civil engineers to embrace the revolution in digital technology, and to acquire the skills to use it to improve the quality and efficiency of their work. The longer term changes wrought by digital technology – as yet unpredictable – should be monitored, and appropriate changes to skills requirements introduced promptly

## 6. Qualification

**Recommendation 6.1** The Institution should recognise the multidisciplinary nature of the modern construction industry, and be more flexible in allowing people to enter the civil engineering profession without the 'traditional' background. Indeed ICE should be pro-active in seeking such people out and welcoming them into the profession.

**Recommendation 6.2** As part of this culture change to promote continuous learning, the Institution should instigate a process of publicity and debate involving members, employers and clients

**Recommendation 6.3** Through both its engineering knowledge activities and its qualifications activities, the Institution should actively seek to provide, or encourage others to provide, appropriate upskilling to enable qualified engineers to keep up-to-date with their skills, and where appropriate to re-skill.

**Recommendation 6.4** The Institution should urgently review its CPD requirements, preferably in conjunction with the EngC, in order to establish a more robust system which ensures that a member's qualification is relevant and up-to-date throughout the member's career. This goes beyond the question of whether CPD is voluntary or compulsory.

**Recommendation 6.5** The Institution should work closely with members and employers to explore where specialist qualifications are most needed and how they can best be provided.

## 7. Pre-Qualification

**Recommendation 7.1** The Institution should encourage, support and accept greater flexibility in the education system, to allow undergraduate students to bundle together a greater variety of courses which will be accepted as a basis for qualification as a civil engineer .

**Recommendation 7.2** The Institution should develop a Community of Practice focused on education and skills.

**Recommendation 7.3** The Institution should continue to place a high priority on the importance of practical skills, and should use its influence to encourage the development of practical skills from the earliest stage.

**Recommendation 7.4** The Institution should, in conjunction with the JBM and through its influence as a convenor, work with educational establishments to explore the potential for a broader approach to the backgrounds and entry qualifications of potential civil engineers at undergraduate level.

**Recommendation 7.5** The Institution, through its influence as a convenor, should encourage universities to work with employers to explore the need for high-level technical qualifications delivered in a more attractive format to mid-career professionals.

# Appendix 1

## ICE Council Terms of Reference

### for a Review into the changing skills required of practising civil engineers

1. The ICE Council has directed that a review be conducted to determine the skills required of practising civil engineers. In directing this review the ICE Council is not suggesting that the ICE requirements as currently configured are anything other than the best available to practising civil engineers anywhere around the world. But the Council believes that periodic review to ensure that the ICE remains relevant to modern professionals is both healthy and necessary. This review has been specifically prompted by the rapidly changing nature, and use, of technology by practising civil engineers and their employers. But the Review will consider other changes in civil engineering practice.
2. At the end of the review the ICE Council wishes to be reassured that the ICE has identified those skills needed by members of the ICE (both professionally qualified and not) and that the attributes the ICE requires of a professionally qualified civil engineer are the right ones; and that the process and procedures that result in the award of an ICE professional qualification are the best that can possibly be designed to suit the needs of practising civil engineers. The review should make recommendations as it sees fit to enable this outcome to be achieved.
3. The Review Team, which is to be chaired by Vice President Learned Society, is to report to the ICE Council. It should give regular progress reports to the ICE Executive Board. The review is to provide an interim report to Council no later than December 2017, with a final report, complete with implementation plan presented to Council for agreement no later than April 2018.
4. The review team will develop a plan of activities for the review including such studies and consultations as are necessary. These are likely to include: a desk study; workshops; interviews and online surveys.
5. Vice President Learned Society should ensure that the Review Team reflects the diverse nature of society, and that it should, as far as is possible, reflect the broad nature of the industry (drawing on clients, contractors, academics and consultants). The composition of the Review Team, which should be no greater than 12, and will be quorate if half of the team is in attendance, is to include:
  - a. Vice President Learned Society (Chair);
  - b. Two members of ICE Council;
  - c. Two Graduate members;
  - d. A major civil engineer employer;
  - e. A professionally qualified engineer academic;
  - f. A member of the Professional Review Panel;
  - g. A member of the Professional Development Panel;
  - h. An SCE or DE.
  - i. Others as directed by the Chair.Secretariat support will be provided by the Knowledge Division. Other support will be procured as required from within the ICE or externally.



6. The Review is to consult widely to:
- a. Determine the skills that are required of practising civil engineers. For the purpose of the review “skills” means the learning, competence, attributes and experience needed by an individual to practise as safe engineer.
  - b. Determine whether the existing qualification process ensures that engineers who attain an ICE professional qualification are equipped with the skills identified by the Review in answer to Question 5a.
  - c. Determine whether all of the competences and attributes currently required by candidates for professional qualification remain necessary and or relevant.
  - d. In conjunction with Vice President Membership, determine whether the ICE should offer additional professional qualifications to members already qualified as CEng, IEng or EngTech.
  - e. While the Review is not to focus exclusively on the implications of greater digitisation, and the changing nature of technology in the industry, it should note that Council instituted this Review in part because of a discussion about how technology is changing in civil engineering. Therefore the review is to make specific examination of this particular issue.
  - f. Consider the implications of the Uff Report recommendations for both the ICE’s professional qualifications, and the ICE professional qualification process.
7. The Review is to make its recommendations to Council no later than April 2018. Any recommendations should be supported by an implementation plan, the creation of which the Director General and Secretary is to oversee.

# Appendix 2

**The review team would like to thank the following people for their contribution to the review.**

**Paul Astle**, Principal Engineer, Ramboll

**Mike Burnett**, Group Acquisitions Director, Eurovia Group Ltd, ICE Professional Review Panel

**Chris Burton**, Business Development Director, Tony Gee & Partners, ICE Qualifications Panel

**Susan Clements**, Head of Qualifications, ICE

**Kyle Clough**, Framework Director, Costain, ICE Vice President, Membership

**Ian Cutler**, Associate, GB Card & Partners

**Stephen Dellow**, Director, The Stilwell Partnership

**Tony Ellender**, Emerging Talent Manager, Balfour Beatty

**Veronica Flint Williams**, Contract and Risk Manager, Environment Agency, ICE Professional Development Panel

**Jane Grant**, UK Head of Learning & Development, WSP

**William Grose**, Director, Bill Grose Consulting

**Kate Hall**, Design Director, HS2

**Sean Harris**, Director, Membership, ICE

**Matthew Harrison**, Specialist Consulting Regional Director, BuroHappold Engineering

**Bill Hewlett**, Technical Director, Costain

**Tim Ibell**, Sir Kirby Laing Professor of Civil Engineering, University of Cambridge, Joint Board of Moderators

**Ian Kirkaldy**, Independent Consultant



**Emma Kent**, Director – Construction, Metropolitan Police

**Barbara Lane**, Director, UK Leader Applied Innovation and Technology Group, Arup

**Tim Lohmann**, Director, Wentworth House Partnership

**Steve P McAndrew**, Consultant, AECOM

**Tom Mossop**, Associate, Arup

**Michael Nathan**, Associate Director – Emerging Talent Leader, MACE

**Group Services**, UK, MACE, CLC Skills Working Group

**Charles Oldham**, Director Strategic Consulting & Technology, AMEY Consulting

**Richard Price**, Strategic Projects & Network Operations Director, Bristol Water plc

**Mark Reynolds**, Chief Executive, MACE, CLC Skills Working Group

**Nick Russell, Director**, Thomasons, Joint Board of Moderators

**Susan Scurlock**, CEO, Primary Engineer

**Paul Skerry**, Early Careers & Professional Development Manager, BAM Nuttall

**Rachel Skinner**, Executive Director & UK Head of Development, WSP, ICE Vice President, Public Voice

**Hannah Vickers**, Head of Policy, ICE

**Timothy Worsfold**, Associate Director, Arup

**Andrew Wyllie**, Chief Executive, Costain, ICE Senior Vice President

# Appendix 3

## Research Methodology

In preparation for the steering group meetings, a series of market research activities were conducted with the objective of providing insight on the subject; desk research on the state of the industry today, qualitative research with business leaders and industry experts in key engineering and construction companies and a quantitative survey which engaged with 50,000 ICE members worldwide.

The objective of the qualitative research was to understand how the profession is evolving as well as the increased variety of knowledge, skills and abilities that will enable engineers to be successful in the future. During November and December 2017, a series of one-to-one interviews were conducted with business leaders and industry experts in key engineering and construction companies. An exploratory methodology was used to gain an understanding of opinions and visions regarding the future of the sector and the skills engineers must possess and develop in order to realise those visions. Given the exploratory nature of the research objectives, a

semi-structured interviewing technique was chosen. The respondents were provided with the research objectives and background and were free to tell their own story in their own terms. Questions were prompted where necessary, particularly with the objective of placing the interview in a timeline starting from the present and slowly moving the respondents' timeframe towards the future. While extensive desk research had been conducted in preparation for the interviews, the flexibility of this approach allowed for the discovery and elaboration of information that is important to participants but had not been captured in previous published reports. It also enabled the mapping of the journey which different organisations are undertaking, their strategy and their vision for the future of the sector.


The objective of the quantitative report was to investigate in numbers the skills shortages and assess where and how those skills shortages become apparent in the industry. Approximately 50,000 ICE members, of all grades and geographic locations, were invited to answer the online questionnaire. Because we were keen to get as many responses as we could, we did not sample the respondents.

1,792 ICE members of all grades replied to the questionnaire.

In the quantitative report we adopted the Cedefop definition of skill shortage as a situation where skills supply (type of abilities and number of people available to work) is not sufficient to meet labour market demand.

1. Insufficient supply of professionals can be a consequence of the inability of the education system to supply enough professionals, lack of attractiveness of specific occupations (difficult working conditions, low remuneration, insufficient social recognition etc.), inability of the industry to retain talents etc.
2. Skills shortage can also be a consequence of skills mismatch, a situation of imbalance in which the level or type of skills available does not correspond to labour market needs.<sup>1</sup> It may be a consequence of many factors; insufficient education and training supply, inadequate lifelong learning, fast changing occupational requirements which make skills obsolete just to name a few.





For the purposes of analysis of the competences required for a civil engineer, the O\*Net Content Model was used. We wanted to focus on the **trainable competences** of engineers so we only used the worker characteristics and worker requirements domains of the model. In our survey we looked at identifying the importance of knowledge, skills, abilities and personal characteristics (attitudes). We applied the definitions of the model where possible with some fine-tuning where necessary.

Further details on the desk research, qualitative research and quantitative research may be found on the ICE website.



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