What steps can we, as structural engineers, take to raise levels of competence across the profession?

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SYNOPSIS

In his winning entry to the Institution's Kenneth Severn Award 2021 – an annual essay competition for young engineers – Max de Podesta sets out ways in which the structural engineering profession can develop a stronger knowledge-sharing culture and improve competency.

Introduction

When engineers are employed to provide design or construction services, it is understood that the product received will be safe, well thought-out and efficient. This is a reputation that has been cultivated carefully by the industry and allows us to practise with the full confidence of clients. However, recent events have raised questions about the overall level of competency across the profession.

A SCOSS report into the 2018 Florida bridge collapse **(Figure 1)** highlighted critical mistakes by the design team, inadequate peer review, and early signs of failure missed by the resident engineer[1]. And while investigations are yet to be concluded into the Grenfell Tower fire in London in 2017, a common theme emerging is the ignorance or disregard of key design team members towards relevant safety legislation[2].

These events take place against the background of an unprecedented climate crisis, which can only be addressed by a departure from traditional construction practices and the adoption of novel and emerging technologies.

In light of these exposed failings and future challenges, it is more important than ever that we have competent engineers, who not only have an awareness and understanding of critical construction issues, but also the confidence and support to take on responsibility and apply this ability to complex design areas.

Defining the problem

Competency can be defined as a capability to apply or use skills or knowledge to complete a given task. Therefore, when discussing how to improve levels of competency in the structural engineering profession, it may be useful to split the question into two key issues:

- Do practising engineers have the necessary *knowledge, skills and understanding* to practise competently? Are engineers performing tasks that are beyond their ability?
- Are practising engineers able to *apply their knowledge effectively?* Are there barriers that are affecting the application of these skills, despite an apparently sufficient knowledge base to solve the problem at hand?

By considering each of these areas individually, we can analyse positive drivers that can lead to improvement, and also identify barriers that may be preventing engineers from achieving their potential competency.

Developing a knowledge base

An engineer's knowledge base builds over a lifetime of experience and learning through many environments, each of which should be interrogated to identify how a breadth of understanding can be best developed.

Learning in universities

One criticism often levelled at universities is that they do not provide engineering students with sufficient practical skills, and that more emphasis should be put

ALAMY

FIGURE 1: The Florida bridge collapse in 2018 was attributed to failings by both the design team and the site engineer[1]

on industrial good practice to better prepare graduates for working life.

However, there is an argument that precisely the opposite may be true. To succeed in a rapidly changing industry, *the most critical tools for universities to teach are fundamental engineering principles:* stresses, strains, dynamics, and material properties or behaviours.

These give students the adaptability and flexibility to not only pick up good practices as they go, but to be able to push and develop the new technologies and construction techniques that are required to achieve our industry's sustainability goals.

Design codes are slow to adapt, in cases such as the development of stone structures[3] or the specification of low-carbon cement replacement, and in a climate emergency we simply do not have time for design codes to catch up. It is therefore crucial that our future engineers should have the sound theoretical understanding required to use novel approaches in a safe and competent manner.

Learning in practice

Whether it be in a design studio or site office, a huge proportion of an engineer's knowledge will come from carrying out tasks in practice.

Senior engineers should constantly be passing on knowledge and educating less experienced colleagues. This is an important aspect of an experienced engineer's job description, but can often take a back seat to more pressing matters.

Education may take the form of a formal mentoring system or simply exposing junior engineers to as wide a variety of design areas as possible. Ideally, this will be developed further into a culture that encourages learning and knowledge sharing across projects and disciplines.

A rigorous quality management system (QMS; Figure 2) is also vital in ensuring that appropriate lessons learned are passed on to those that are best placed to benefit from them. This requires a company to take ownership of its QMS and buy into its capability to drive change, rather than seeing it as a box-ticking exercise.

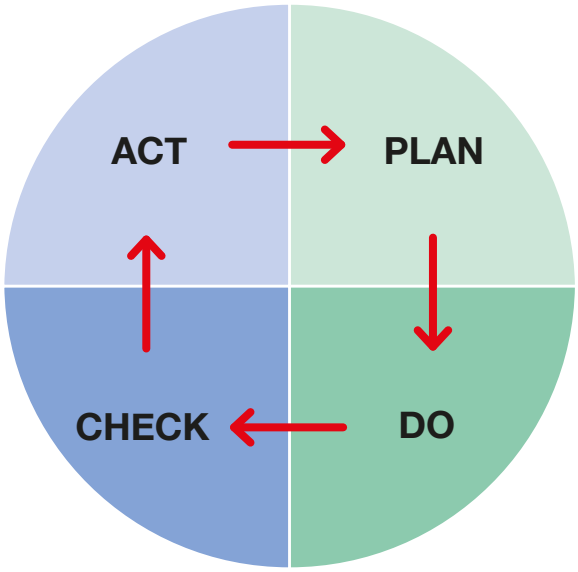

FIGURE 2: 'PDCA' QMS system presents opportunities for improvement of competency at 'Plan' and 'Check' stages

Learning across the profession

The challenges that we face as a society cannot be solved by individual practices working alone. We therefore need companies to be comfortable sharing knowledge across the profession, potentially at the expense of competitive advantage.

There are good examples of this happening already, whether it be Structural-Safety sharing lessons learned, or companies collaborating with the IStructE to produce guides on reducing embodied carbon and designing sustainably.

However, this is an area with huge potential, and should be seen as a key strategy to raise the general level of understanding in the profession in the future.

Application of knowledge

As engineers, we always aim to produce consistently high-quality, efficient and effective designs. However, any engineer will be able to point to work they have done that they are not particularly proud of, whether it be rushed, poorly presented or otherwise flawed.

This is not a sign of an incompetent engineer, but a product of the variety of factors that can affect the quality of a finished piece of work. To ensure a high level of competency, we must understand the nature of these effects on design quality and safety, including how they can be mitigated.

In *Conceptual design of buildings*, Oliver Broadbent emphasises the effect of our emotional state on our ability to create[4]. If we are to be able to apply our knowledge effectively and creatively, we need to be in an environment that is conducive to a positive mental state.

This positive space is constantly threatened by project pressures such as dwindling fees, insufficient resourcing or tight programmes, as well as office politics or personal issues. It is therefore vital to foster a working environment that counterbalances these external factors and supports engineers as they seek to design effectively.

Engineers must be able to admit mistakes without fear of reprimand, or ask for additional support when they feel that they are being asked to perform the impossible. This 'no blame' approach is a cornerstone of modern health and safety practice, but is often lost in a creative design environment, especially when wider project stresses are at the fore of the design team's thinking (Figure 3).

These issues are often most severely felt by minorities, where any day-to-day issues are compounded by existing biases and discrimination. We can work to reduce this discrepancy with good equality, diversity and inclusion (EDI) initiatives which can go some way in reducing historical imbalances in the workplace and lessen the load on those effected.

A poor and stressful environment inevitably leads to engineers designing conservatively, oversizing elements and relying on traditional materials and methods at the expense of more efficient and appropriate solutions.

If we are to progress as a profession and achieve net-zero targets, this is a disaster. We need competent and confident engineers pushing the boundaries of traditional practice.

This highlights the second benefit of an effective QMS in supporting the application of engineering knowledge. Strong checking systems enable engineers to be confident in pursuing ambitious solutions and novel schemes, which will lead to better building designs.

Implementing change

Now that drivers behind competence have been identified, we can begin to evaluate what actions can be taken, and by whom.

> "WE NEED COMPANIES TO BE COMFORTABLE SHARING KNOWLEDGE ACROSS THE PROFESSION

Kenneth Severn Award 2021
Winner: Maxwell de Podesta
Commendation: Caomhan Cronin
Commendation: Matthew West

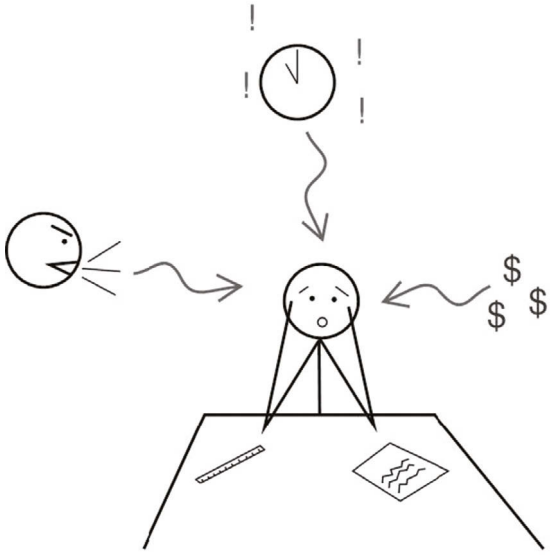

FIGURE 3: Many factors can affect an engineer's emotional state

Individual level

- Take ownership of personal professional development and learning.
- Identify and develop areas of limited knowledge.
- Take steps where possible to control and improve our personal working environment.

Practice level

- Adequately resource projects.
- Create strong systems, including QMS, mentoring and EDI initiatives to support staff.
- Encourage a positive culture which promotes learning as well as supporting problem identification.

Professional level

- Share knowledge across the profession as freely as possible.
- Review chartership criteria to reflect the changing skill profile required of engineers.
- Encourage universities to prioritise the teaching of fundamental principles.

Looking to the future

While the ideas discussed in this essay may help drive positive change and improve competency, it is important to recognise this as an ongoing process. It is not an issue that we can simply 'solve'. Rather, we must be vigilant and dedicated, always reviewing, looking forward and doing all we can to improve competence across the profession into the future.

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