How engineers innovate and learn

Dr Jennifer Whyte, Senior Research Fellow at Imperial College London and a member of IStructE's Research Panel considers how engineers are developing the use of glass as a structural material and what this tells us about 21st Century innovation

How do engineers innovate and learn? This question drives ongoing research at Imperial College London. In this work I am considering how engineers develop and refine techniques for using glass as a structural material and am privileged to work with the structural engineering practice Dewhurst Macfarlane and Partners. The aim of the research is to improve wider understandings of industrial innovation in the 21st century.

Pioneers of the British industrial revolution are classic examples of engineers as innovators. Indeed contemporary engineering is often discussed as though it were a pale shadow of this previous 'heroic' age. Then, men like Brunel, Telford and Paxton broke new ground in projects for bridges, railways and exhibition halls. By contrast, much engineering today is seen as routine. The knowledge required for practice is seen as highly codified with standards, building regulations and detailed codes of practice.

However this view of contemporary engineering is partial. The routine nature of much engineering work has many benefits – including safety, quality, compatibility of parts or systems and consistency across international borders. However at the boundaries of what is possible there are no standards and engineers develop new understanding. Structural engineers are active in developing and transferring new techniques and technologies. They use their deep technical knowledge of engineering and also bridge across multiple worlds, collaborating with fabricators, architects and clients. In so doing they can recognise patterns and connections between seemingly unconnected ideas and are able to build previously un-thought-of solutions.

Dewhurst and Macfarlane's work on structural glass spans across more than 15 years, from early experiments with glass and acrylic on staircases, to laminated floor plates, glass beams and columns, bolted glass, laminated double beam system and parallel cable supporting walls. Tim Macfarlane has been central to this work. He has been working extensively with other engineers within the firm as well as glass fabricators, architects, and research laboratories.

Fig 1. The Yurakucho Canopy, Tokyo International Forum, Japan: structural engineer Dewhurst Macfarlane and Partners

It is by combining a deep practical engineering knowledge with an ability to bridge across worlds that he is able to combine and use solutions from a wide variety of sources. One example of this is how, to develop a new way of bolting glass together, he adapted a solution suggested by a carpenter with an interest in motorcycles. The proposed solution was then extensively tested in university laboratories and made possible the practice's award winning glass structure of the Yurakucho Canopy at Tokyo International Forum (Fig 1).

Many of the other projects which use structural glass have also won many awards for the practice and are individually recognised as innovative. I am interested in how each builds on, extends or re-interprets thinking on existing projects: the trajectory of ideas through which these technologies, techniques and applications have been developed and refined. A theme developed in one project may be developed further in later projects. For example the use of glass beams and columns to support a house extension was then reused to develop a glass extension to the Broadfield Glass Museum in Dudley. New ideas may also be brought into the practice from elsewhere, as in the case of the single-span parallel cable supporting wall, used in the Kimmel Center (Fig 2), which was developed from earlier work by Jörg Schlaich. These have set off new trajectories of work within the practice.

Learning about innovation

What can we learn about innovation from this case? Innovation for these designers, fabricators and engineers is not a carefree gallop into a projected future. Rather it is motivated by an interest in contemporary problems and their potential solutions: the broad and often forgotten question of how we make life better. Technological change is effected through the portfolio of projects that different engineers are working on within the practice.

The engineers studied have a central concern with managing risk, seeking out and understanding potential sources of failure and their consequences. When Tim Macfarlane describes his work, the description is of a process of working with the hypothesis that structural glass isn't possible and then disproving it, rather than starting out with a belief that it will work. Whilst the use of a null hypothesis is a standard scientific method, it is quite different from the way that people normally talk about innovation.

This ongoing research is conducted within the EPSRC Built Environment Innovation Centre at Imperial, which focuses on innovation and technological change. Other research projects within the Centre consider the project-based nature of work in engineering, design and construction firms; the impact of simulation and virtual prototyping tools; and the changing nature of innovation and design in 21st century practice. Such projects are not solely of academic interest: recent projects have had a significant impact on policy making and practice. For example, the Design Quality Indicators (DQIs), for which we provided research input, are now written into government policy and used widely across the construction sector. The findings of my detailed empirical and archival research are now being prepared for journal publication.

The work on structural glass and my role on the IStructE Research Panel have set me thinking about issues relating to 21st century structural engineering practice. One thing that is clear is that we are fortunate to have practising engineers with the expertise, motivation and creative thinking skills to think deeply about problems and to develop new solutions. se

Fig 2. The Kimmel Center for the Performing Arts, Philadelphia, USA: structural engineer Dewhurst Macfarlane and Partners