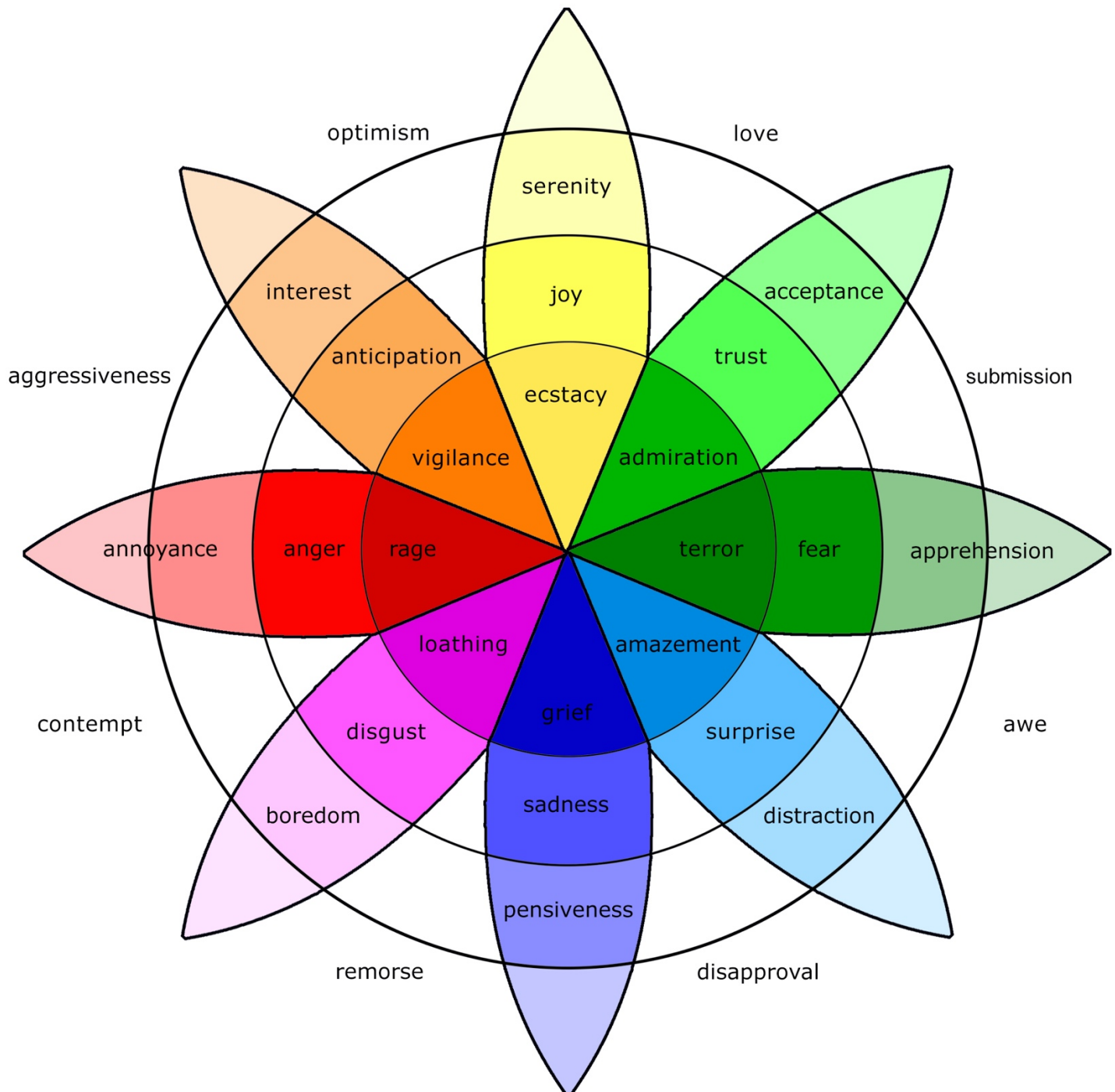


The Henderson Colloquium 2019

How can Structural Engineering be an unending stream of goodness?



*"But the engineer himself looks back at
the unending stream of goodness
which flows from his successes with satisfactions
that few professions may know. And the verdict of
his fellow professionals is all the accolade he wants."*

On Engineering, Herbert Hoover, 1951

Since 1975 the British Group of IABSE have held a two-day colloquium in Cambridge every summer for about 25 invited participants. The purpose of the event is to exchange views on a structural engineering theme of topical importance. Each participant is invited to make a short presentation to trigger constructive discussions in the relaxed surroundings of Christ's College.

The 2019 Henderson Colloquium comprised 4 sessions of presentations on Tuesday 2nd July and 2 sessions on 3rd July. The theme discussed was:

"How can Structural Engineering be an unending stream of goodness?"

A graduate structural engineer entering the profession 40 years ago began a process of development that would have been recognised by a Victorian. Working in a stable team under an experienced professional, with periods on site and plenty of time spent on drawing boards, they were colleagues with people almost identical to themselves. The new structures delivered were surely of benefit to the expanding economy and hence assumed to be good for society.

In the subsequent decades many changes have begun to impact this process. The lack of diversity in teams has been recognised as has the environmental impact of construction. The procurement process has become subdivided and the link to site is sometimes lost with increased use of specialists and remote teams. Technology has refined and transformed some tasks but left others untouched or badly linked, disrupting our understanding of the whole. Less construction is done on site, and more structure is manufactured elsewhere.

Meanwhile society and its needs and expectations have rapidly evolved. Structures need to be seen as part of an interconnected infrastructure. In many places new build has increasingly become interventions in existing fabric. Commercial drivers seem to dominate decision making. We expect greater safety, reliability and service, and different societies in different parts of the world have different needs and expectations. What we deliver needs to be ever increasingly sophisticated, but our profession often still doesn't reflect the diversity of our communities. So...

- How can a structural engineer understand what 'good' looks like in the future?
- How do our models of behaviour and development need to change?
- Do we need to grasp revolutionary new approaches or get 'back to basics'?

Presentations were made by **Chris Wise, Phil Davis, Nick Cooper, Richard La Trobe-Bateman, Bill Harvey, Kevin Masters, Martin Knight, Margaret Cooke, Tanya de Hoog, Paulo Silva, Kiera Mudd, Nick Cole, Tim Lucas, Nick Francis, Tara Clinton, Dave Cotton, Cezary Bednarski, John Armitage, John Roberts and Nathalie Richards**. The after-dinner speaker was Anne Kemp of Atkins SNC-Lavalin.

Themes that emerged during the two days included:

- Over-design
- Social Value
- Leadership
- Sustainability
- Technology
- Institutions
- Communication
- An Engineer's Hippocratic Oath

Cover Image: Plutchik's Wheel of Emotion

My Goodness! Why Goodness?

John Roberts of CSDI Engineering explained how Hoover's quote was chosen as a subject. Rather than defining a specific topic to work around at the Colloquium it was decided to bring together a group of people who could widely explore what they saw as goodness within an engineering context.

John highlighted that Extinction Rebellion's recent 'shut-down' of London had brought the climate crisis into sharp focus. An era of science had led to an era of protest. Active measures to change the way humans live were needed and a new era of engineering would need to be at the forefront of this.

Structural engineering, goodness and sustainability

John Armitage of Ramboll described how structural engineers face a difficult challenge in the face of a climate change emergency. How do we bring goodness to both society and the environment? He explored Ramboll's mission to 'create societies where people and nature flourish' and how this needed to be embedded in all their employees' behaviour and decisions.

How can we see this goodness if we are not honouring those in the future, for instance by providing them with durable structures? Shouldn't the verdict of those with whom we share the planet be our true accolade, and not just that of our fellow engineers as Hoover suggested?

Bishop James Jones said, "there is no human activity which is environmentally neutral". A bridge can increase connectivity and wellbeing but will also increase traffic and reduce air quality. John asked how can we deliver both boldness and humility together to challenge the inbuilt conservatism of our current standards in the face of this climate emergency?

Sustainability, skills, attitudes and mentoring

Kiera Mudd of Curtins noted that we live in a world with ever-depleting resources and an ever-increasing climate emergency. The construction industry is a key contributor. How can construction be either an unending stream of goodness if we are not looking after our world's finite resources? Structures contain huge amounts of embodied carbon. Surely it is logical that we only build them once and build them to last.

In today's throwaway society, buildings are designed with a limited design life; whereas buildings from several hundred years ago stand proud. Compare this with some structures built in the 60's/70's that are already ready for demolition or a facelift. Surely when designing new structures, we should be learning from the past, continuously improving, rather than lowering, standards.

A sustainable built environment must both conserve the past and build a better present. Existing structures need cherishing and adapting to ensure they continue to be a part of our everyday lives whilst new structures should be architecturally significant. People admire and cherish existing buildings, experiencing an emotional connection. This experience shouldn't be limited to existing or selected new projects, but for all of new structures. If we stop designing to minimums, people will look after the built environment, believing it's something to neglect, soon to be replaced with something better. We must conserve and learn from the past whilst improving present standards. If this can be achieved our industry might stand a chance of being an unending stream of goodness.

Reassuring Design? Perspectives on new technology and its effect on skills.

Phil Davis of SNC-Lavalin noted that engineering design is changing rapidly as a result of technological advances and our volatile, uncertain, complex and ambiguous (VUCA) world. Phil explored this topic from the perspective of a Control Systems Engineer turned Learning & Development professional.

During Phil's career, Railway Signalling evolved from relay interlockings that gave intuitive feedback to solid state 'black boxes' most engineers just had to trust. As these changes occur, systems engineering and quality management become increasingly important. Phil suggested that as bridge and structural engineering design is further digitised there will need to be a similar shift in emphasis from quality control to quality assurance in order to avoid the hazards that have beset control systems. Organisational design will need to recognise the importance of underpinning sociotechnical systems to assure quality. Collaboration across teams will be increasingly important to achieve the outcomes desired, therefore leaders will need to set the right tone to enable collaboration and change from 'order givers' to 'information sharers'.

In conclusion, Phil opined that the generational and behavioural shift from Digital Immigrant to Digital Native to Digital Dependent must be thoroughly understood and that new skills requirements must be articulated and recognised in order to provide a compelling employee value proposition for this industry.

The training and selection of engineers

There is something about the way we select, train and encourage engineers which means they are bad at being heard. Although we ought to be leaders in the construction world too often, we are not. We lead our own small teams, but we do not "stick our heads above the parapet" to become a force for good more generally.

Margaret Cooke of Integral Engineering believes we should be encouraging those who question "why" we are doing as well as "how" we are doing - although that will make our lives hugely more uncomfortable, especially in a low fee, competitive environment. We have set our profession up to reward young people who "get on" without question. We do not (typically) create the time, the energy, the requirement to push back at clients and contractors and stand back and ask 'why?'

It is difficult to persuade a client that extra time spent thinking is beneficial when they see the fee rather than the construction saving - and it is hard to demonstrate "good" design because we do not start with a "bad" design and then improve it. However, there must be huge long-term savings, environmental benefits and societal effects from activities which may be initiated if an engineer is afforded that bit of thinking space

"Great skills, Good values..... but do they know it?!"

Tara Clinton of Arup spoke about the perception of structural engineers both within our industry and wider society. She believes that structural engineers have a great combination of technical and creative design skills, but perceptions of the profession don't often match. She highlighted the importance of challenging those perceptions internally and externally to ensure we have a seat at the table for the changes our industry is facing.

Her presentation moved through three phases, starting with stereotypes of engineers. The results from Google image searches of "structural engineer" reveals images of technical drawings and people in hardhats. This only tells part of the story. None of the creative thinking, collaboration, sketching and modelling that we use to come up with technical solutions are portrayed.

Secondly, she gave examples of a few perception disruptors from within and outside our industry – Jo Da Silva, Ove Arup, the Bloodhound Project and Elon Musk. Tara finished by identifying what we can do as individuals to shift perceptions, drawing from her experiences from joining cross industry networks like Urbanistas London, participating in University tutoring programmes and creating engaging STEM activities at the Victoria and Albert Museum.

BIM and the Art of Motorcycle Maintenance

In bridge design, a clear story reaches the widest audience - yet the tradition of story-telling is reducing in our everyday lives. It is a skill which can be taught – not so often in schools of engineering – and requires practice to keep sharp. **Martin Knight** of Knight Architects believes that the relationship between design concept and the story is very important. A strong concept is the plot around which the design narrative extends, which remains present throughout the life of the project and long afterwards.

In his book "Zen And The Art Of Motorcycle Maintenance", Robert Pirsig introduces themes of Quality and a Sense of Place, each at the heart of an architectural story-telling of bridge design. He describes 'Classical' and 'Romantic' understandings of Quality where the former "sees the world primarily as underlying form" whereas the latter sees it "primarily in terms of immediate appearance". Does this reflect the differing understanding of engineers and architects in the world of bridge design?

With the Romantic "feelings rather than facts predominate", yet this is how the public understands these projects. Conversely, the public cannot understand the Classical mode of design, which is controlled and whose "value is measured in terms of the skill with which this control is maintained". That leads to public fear and opposition. In reality these understandings are indivisible, yet it is the narrative which can guide and communicate the project's benefits and define the role that design will play in bringing success.

Pirsig's narrative beautifully describes 'sense of place' - views, weather, noise, speed and their emotional effects. This combination of appearance and experience directly informs the best stories, with characteristics which are memorable, enjoyable and enlightening - all equally true of bridge design. Good design and story-telling go together and must be valued equally and highly.

On getting it wrong

After forty years of considering arch bridges **Bill Harvey** of Bill Harvey Associates feels he knows less than when he started. Much of what was "known" then has proved to be wrong and much of what stands to replace it is, as yet, untested. Similarly, Bill proposed that whilst codes used today are 'the best ideas we could negotiate' at the time, nothing stands still. This may be taken as a microcosm of the broader field of structural engineering.

In the late 80s he developed his software for single span bridges to cover multiple spans. That model remains the most commonly used today, and yet it is wrong. In 2000 Bill left the university, becoming a consultant and saw viaducts which weren't collapsing, but were definitely suffering progressive damage. He now understands that, because of the way they were built, masonry viaducts do not work as arches.

Having got something wrong in a way that has now been copied by many others, the question of providing an unending stream of goodness is a real challenge. Is Emile Coue's phrase, "Every day, in every way, I am getting better and better" a more satisfactory thought? We have to acknowledge that all science is provisional, standing only until a new test is found which proves it false. Alternatively, as Oliver Cromwell said, "In the bowels of Christ, think it possible that you may be mistaken."

Does the fundamental story of our projects need to change?

Structural engineering will always struggle to be an unending stream of goodness. If the public were a person, where would they sit on Plutchik's Wheel of Emotion when face-to-face with the construction industry? With cost over-runs, procurement problems and unforeseen ground conditions occurring on major projects across the UK, the public often view Infrastructure projects with Fear and Anger, rather than Trust and Joy.

Mark Farmer's 2016 'Modernise or Die' report made the point that the industry has a poor image that can only be addressed by changing the fundamental story, not just by attempts to better use social media. **Dave Cotton** of Atkins proposed that if structural engineering is to be an unending stream of goodness, this surely has to start at inception, not simply during use. Does this mean changing the fundamental story during inception, procurement and implementation from cost and programme, to project value, legacies, transformational impact? And if so, how do we do that? Can we move the public emotion to maybe even Amazement?

The requirement of utility and the desire for 'beauty'

Structural Engineering enables two different human needs. **Richard La Trobe-Bateman** described his journey as an artist turned bridge builder, exploring and intensifying the actual experience of crossing a bridge – an individual body enacting a physical metaphor, not just experiencing a conceptual one.

Starting in the 1980s, his key event, his 'road to Jericho' moment, was when his self-identity moved from that of the 'individual original' artist/designer to realising he was part, however small, of a global, on-going endeavour stretching back into prehistory – making bridges. This was both humbling but even more liberating.

Is it possible not to be an unending stream of goodness? Unfortunately, the answer is yes. "When the structures, you as a profession, are going to be asked to make stand up, become increasingly absurd (and non-structural) it is the engineers who are going to be the ones criticised, through ignorance both wilful and normal, to the detriment of the profession as a whole, not the clients and their designers in asking for such vacuous, attention grabbing nonsense. Wherever this breaks out the profession should cry foul!"

The Wheel of Emotion

Chris Wise of Expedition explored design theory, construction and project management. Whilst science makes our ideas conform to the world, engineering is the opposite – it makes our world conform to our ideas. It is the art of changing the physical world for the benefit and use of mankind. It is also a political activity.

Expedition have initiated a number industry and academic collaborations that aim to improve the use of physical, energy and people resources we use. Marginal Gains In Construction (MAGIC) is a UK strategy with the aim to make engineering more efficient. Minimising Energy in Construction (MEICON) with the Universities of Cambridge and Bath has reviewed structural engineering practice. The Getting It Right Initiative (GIRI) aims to eliminate the 21% of costs due to human errors.

Collaboration is key to speed up the feedback loop from the lessons learnt stage at the end of a project to the need/brief/conceive stage at the start. Chris explored the dynamics of the team and how the engineer's slough of despond, John Bunyan's allegory, can get replaced by the good bits of Plutchik's Wheel of Emotion.

Do we have space for morality in engineering decisions?

Nick Francis of Imagine Engineering classified engineering decisions using Kohlberg's three stages of moral development. At the "pre-conventional" level we need not to fail and we seek reward. At the "conventional" level we consider wider consequences and aim to promote good practice. These are well established in modern industry but have so

far failed to adapt to the challenge of climate change.

To once again create an “unending stream of goodness” Option 1 is to keep on doing what we are doing now but only chose our projects to suit the aim. We may end up as “ethical” engineers seeking ever more impoverished areas in which to work, whilst “unethical” engineers happily accrue profit as catastrophic climate failure proceeds.

Option 2 is to embrace our moral obligations, recalibrating what “good” looks like by adopting a “post-conventional” moral reasoning. Start by Knowing it is wrong, then Feeling it is wrong, and then finally be empowered to Do something. We change the zeitgeist behaviours, become conventional, then pre-conventional, then automatic. Slavery and witch-burning are examples where previous acceptance was changed.

Nick proposed the following ‘To Do’ list for our profession. 1: Move education from knowing to feeling. 2: Change our language and questions. 3: Find new heroes. 4: Support rebels. 5: Decouple our institutions from commerce. 6: Give ourselves a new vision with an engineer’s version of the Hippocratic oath.

Moving experiences supporting Tottenham Hotspur

Nick Cooper of JN Cooper and Partners, a Huddersfield fan, described his recent work engineering the system to transform the Spurs’ new stadium from a grass soccer facility into a synthetic NFL stadium. At one level goodness was supplied through the excellence of engineering but also in the commercial and positive team working of the people involved. The basic diagram of a few moving panels required huge complexity to be overcome. How do you store grass under a stadium? How do you water it? How do two levels of pitch connect to the changing rooms?

Nick explained how the project was delivered by a network of excellent UK technical suppliers. He is passionate about the preservation of UK engineering skills at all levels, from the system designer to the importance of the intuitive engineers welding and fabricating the parts. ‘Goodness’ comes from appreciating all the talents involved in realising engineering from empathy with the operator through to appreciation of ideas and input from the shop floor.

Having a detailed and broad understanding of the mechanical, electrical and hydraulic procurement, decisions were based on value to the long-term operation of the facility, rather than being driven by short term costs. ‘To the wheel supplier saving £10 on bearings is significant, however increasing the overall project’s reliability for an extra £10 not only is good value but enables flexibility into the future’. Goodness in engineering is not just resolving the questions that were asked but pre-empting the questions that should and will be asked into the future.

Finally, an enlightened, active client is key to getting a stream of goodness flowing. Spurs’ Chairman, Daniel Levy, was ‘hands on’ throughout from project inception right down to the details. His support throughout ensured success.

The Dichotomy of Digital Design and Traditional Methods

The construction industry is long overdue a significant change. While there have been significant improvements in computer modelling, modular construction and offsite manufacturing, the construction industry as a whole has not delivered the advances seen in other modern technology-based industries.

Nick Cole of the Robert Bird Group noted that a digital revolution within the construction industry is inevitable and already fast enveloping tasks that have been carried out in the same way for many years. We should expect to see significant changes in the way we approach engineering in the next decade with the adoption of design automation, AI and machine learning - things which are already commonplace in other industries.

There is resistance to the adoption of digital design from parts of the industry, often due to its impact on the 'goodness' of future engineers and the potential for a skills shortage. How do we balance new approaches with getting back to basics?

How can Engineering be an unending stream of goodness?

Engineers solve complex problems, transform landscapes, build economies, bring communities together and improve the lives of millions. **Kevin Masters** of Bryden Wood believes we are uniquely positioned to deal with the world's challenges. Strong leadership is needed to ensure delivery of an unending stream of goodness.

The engineering industry is extremely complex, and we all engage different locations along the 'service tree'. Projects are 'carved up' and risks allocated. We have created tribal barriers and in turn formed groups, which are no longer anchored to a shared vision of good engineering. Kevin proposed that fees and services are based on incorrect service models where quality is judged on the amount of output. Maybe we should not be judged by this but instead by how effectively we fulfil our purpose, or put in another way, how much value is generated by one's input.

For engineering to be an unending stream of goodness we must dissolve these barriers and elevate our purpose to a common set of principles that we all agree on (climate change, macro social-environmental impact, etc). Kevin proposed that key steps for our industry would be the removal of tribal barriers, effective procurement by informed clients and alignment through high level principles and objectives. Engineering must modernise or die.

An Opportunity: Could a BIM company become a Tier 1 Contractor?

Paulo Silva of Robert Bird Group asked what characterises structural 'goodness' in the future. Will future changes in technology and society help or hinder the profession's ability to create it? After exploring our current world of late projects, small (if any) profits and disappointed clients he postulated that we needed a new model for infrastructure delivery, fit for the new world of 7D and Digital Twins.

Short term savings of time, materials and costs are just materialistic sugar rushes in our divided industry, which leaves design-led professions feeling undervalued. How do we avoid the Amazonification of construction with zero-hours contracts all round?

Paulo believes that the advent and embrace of new technology will allow an inflexion point, with engineers using technology to place themselves at the heart of project delivery in a role akin to the project integrator role envisaged in Project 13. With this change, allowing engineers to drive and lead projects, he foresees an opportunity for us to lead, re-define and embrace the concept of goodness.

Good Value

Tanya de Hoog of Thornton Tomasetti described her personal journey, developing a concept of proactively giving back through her work rather than working solely for her own technical development and success. She started to realise that there is a lot more we can do using our skills and knowledge, especially for the safety and well-being of others.

How can we use evolving and future technology to improve the lives of everyone? Her realisation developed in parallel with her more direct involvement in the Institution of Structural Engineers, culminating in a new focus on projects that contribute to social and environmental equity and justice for all.

Structural Engineers can have an even greater positive impact in society by evolving our value proposition and brand. Clients are embracing new requirements to incorporate social good into their strategies. Our industry needs to be prepared, responding to these changing needs and our profession adjusted to suit.

Michael Gove: "People in this country have had enough of experts" (God help us)

The Financial Times (June 3, 2016) reported Michael Gove refusing to name any economists who backed Britain's exit from the EU, saying that "people in this country have had enough of experts". While this related to economists, we all experience situations when all and sundry claim to know how to build buildings better and cheaper than experienced professionals.

Cezary Bednarski of Studio Bednarski dealt with politically motivated degrading of public trust in professions, and the growth of dilettantism and ineptitude. His example was the process and outcome of a design competition winning footbridge in Gdansk. This highly compromised bridge has now been built, with its design author kept away from the process and regularly lied to by the client's team throughout the project. Materials, details and procedures have been changed and compromised by a client whose only aim was the lowest cost.

A discussion is needed on the procurement process, from initial design, through detailed design, construction to completion. What value for money, life-time cost outcomes, and cultural, social, environmental and ephemeral values are achieved?

Who carries the can and who gets off the hook? Cezary is preparing public action aimed at protecting his reputation and making sure that issues which will arise in operation and its maintenance will not become his liability.

Can Structural Engineering be an unending stream of goodness? Let's break that down

Nathalie Richards of Project Centre explored the Colloquium's question. What constitutes unending, what is a stream and what is goodness in the realm of engineering?

Structural engineering projects are full of end points. Our project stage completes. A project ends when its funding is cut. A structure reaches the end of its design life. However, there are multiple overlapping projects and often one structure is demolished to be replaced by the new. The next generation of engineers and clients comes to replace those before. This give continuity to the creative stream.

The most difficult part is how structural engineering can create 'goodness?' Is it to do with time and money, environmental impact, highest quality etc? What are the motives of all involved? We are often faced by mutually exclusive drivers. Therefore, not everyone will be happy, and goodness is will always be debated.

Engineering in action. Knowing, and not knowing yet

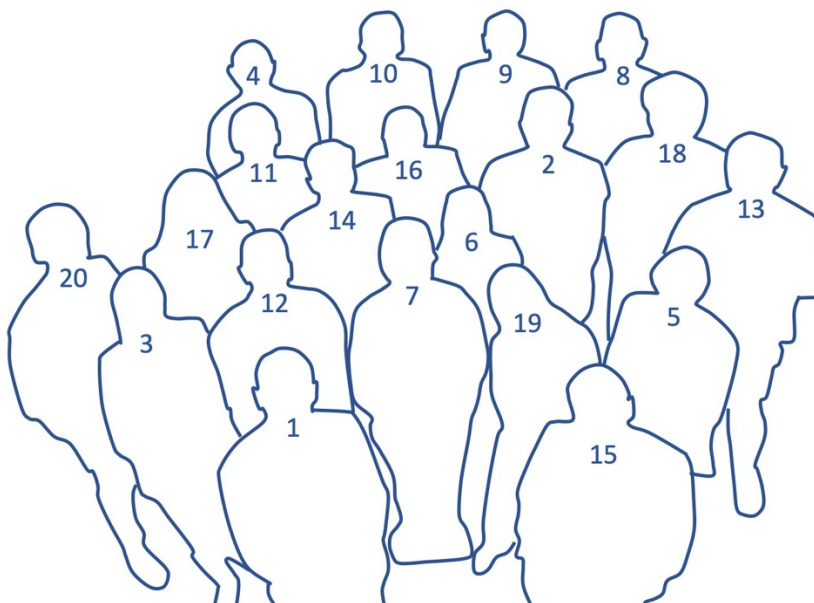
Tim Lucas of Price and Myers suggested that whilst we want engineers to know the answer, to really develop projects well 'not knowing yet' is fundamental to a good outcome. This, he said, is because it allows flexibility in the best approach to deal with emerging constraints.

Tim also noted that the French philosopher Bruno Latour thought social context and technical content are both critical in understanding scientific activity. He explored whether this is also true for engineering in his projects including Richard Wilson's Slipstream sculpture at T2 and the house he has built with his wife Jo.

How do engineers generate goodness? Is it by being less deterministic about what we do and more experimental; bringing others along on that journey and seeing the engineer as part of a team? We must persuade and give confidence in doing things differently even when the path is not completely clear. We can generate value in the process that leads the outcome rather than just the outcome itself and 'embrace the not knowing.'

'To the engineer falls the job of clothing the bare bones of science with life, comfort, and hope. No doubt as years go by the people forget which engineer did it, even if they ever knew. Or some politician puts his name on it. Or they credit it to some promoter who used other people's money.

*But the engineer himself looks back at the **unending stream of goodness** which flows from his successes with satisfactions that few professions may know. And the verdict of his fellow professionals is all the accolade he wants.'*



- 1 John Roberts
CSDI Engineering Ltd
- 2 John Armitage
Ramboll
- 3 Kiera Mudd
Curtains
- 4 Phil Davis
Atkins
- 5 Margaret Cooke
Integral Engineering
- 6 Tara Clinton
Arup
- 7 Martin Knight
Knight Architects
- 8 Bill Harvey
Bill Harvey Associates
- 9 Richard La Trobe-Bateman
Artist
- 10 Chris Wise
Expedition
- 11 Dave Cotton
Atkins
- 12 Nick Francis
Imagine Engineering
- 13 Nick Cooper
JN Cooper and Partners
- 14 Nick Cole
Robert Bird Group
- 15 Kevin Masters
Bryden Wood
- 16 Paulo Silva
Robert Bird Group
- 17 Tanya de Hoog
Thornton Tomasetti
- 18 Cezary Bednarski
Studio Bednarski
- 19 Nathalie Richards
Project Centre
- 20 Tim Lucas
Price and Myers