3. Lean design

Structural fire safety when responding to the climate emergency

Luke Bisby urges structural engineers to improve their understanding of ‘fire resistance’ as the profession looks to innovate rapidly in response to climate change.

As a member of the Standing Committee on Structural Safety (SCOSS) and Confidential Reporting on Structural Safety (CROSS), I was asked to offer some thoughts on how the fire safety pitfalls that might be relevant in the light of the IStructE’s important work to address the climate emergency.

Given the enormous impact of structural engineering decisions on carbon emissions, it is clear that structural engineers have a moral obligation to urgently take action to address the climate emergency.

New design approaches and new technologies bring with them new hazards; they at least partially invalidate experience of them disastrous – that have led to failure modes. Safety-critical disciplines are littered with failures – some potentially unexpected, failure modes. Safety-critical disciplines are therefore wary of change. The history of engineering is littered with failures – some of them disastrous – that have led to learning and to changes to our practice.

Of course, new technologies and approaches themselves inevitably catalyse new learning and understanding; however, we must recognise that our powers of foresight are not complete. The collective experience of our profession has taught us there are some failure modes that we may not anticipate – where we will be forced to learn from our errors and mistakes, rather than our successes. Learning from failures is rarely a ‘sustainable’ approach.

We must therefore constantly scan the horizon for failure modes that may lurk just out of sight. And we must be ever more vigilant in this during times of rapid innovation. An alternative could be to walk blindly into the future, perhaps because the consequences of not acting are greater than the consequences of continuing on our current path. But surely such an approach must be taken only as a last resort.

At times of rapid innovation, it is crucial that members of the structural engineering community constantly reflect on safety, and thus on the structural fire safety assumptions and simplifications that are inherent in their designs. The increasing use of mass timber for high-rise buildings has recently received considerable attention in this regard, but more conventional building materials such as reinforced concrete and structural steel, particularly when applied in novel ways, including lean, modular and offsite construction, each present their own, admittedly very different, challenges in this context.

‘Fire resistance’ design – the conventional framework

For the vast majority of structures, adequate structural fire safety – adequate for the protection of life, that is – is presumed to be provided by ensuring that the individual structural elements (or partitions) from which a structure is constructed have appropriate ‘fire resistance’ ratings.

My own experience suggests that many structural engineers, both in the UK and elsewhere, have only a cursory understanding of the fundamental basis of ‘fire resistance’ design, or of the fire safety design framework that they themselves are routinely applying in projects.

For instance, it is my experience that few structural engineers understand what ‘fire resistance’ is, how (or why) ‘fire resistance’ tests are performed, or the extent to which such testing and assessment captures (or indeed fails to capture) either the thermal environments or the mechanical boundary conditions, loading or deformations of a structural element or a system of elements during a real building fire.

Many structural engineers (and other building designers) fail to understand that the prescribed periods of ‘fire resistance’ given, for instance, within Table B.4 of Approved Document B in England and Wales do not represent actual periods of time in a real fire.

These issues are worth careful consideration by structural engineers seeking to optimise building designs or introduce material or other innovations. For example, how can a multi-parameter optimisation of a structural design be confidently undertaken without deeply considering the consequences for structural fire safety?

‘Fire resistance’ design – uncertainty and conservatism

The evidence that the existing ‘fire resistance’ design framework is providing an adequate level of safety in buildings is largely historical. Notwithstanding the reality that fires that are sufficiently severe to seriously challenge loadbearing structures are comparatively unlikely, we only rarely observe significant structural failures in real fires. Applying the argument from ignorance could lead to a conclusion that this absence of evidence confirms that our coarse, conservative and unrealistic ‘fire resistance’ design framework – despite its many documented shortcomings – is indeed delivering societally tolerable fire safety outcomes.

My own view is that, by and large, structural engineers don’t actually know what level of safety is being provided by the existing ‘fire resistance’ design framework. We struggle to rigorously quantify the error bars that are inherent in most of our structural fire design decisions; or even to

“It is crucial that structural engineers constantly reflect on the structural fire safety assumptions and simplifications that are inherent in their designs”
And so to the future

Given the enormous impact that structural engineering decisions have on carbon emissions, structural engineers have a moral obligation to act quickly – through optimisation, innovation and evolution – to address the climate emergency. However, structural engineers also have legal and professional obligations, e.g. under the Building Regulations 201011 (England and Wales), to ensure that all buildings:

- ‘shall be constructed so that in the event of an accident [including fire] the building will not suffer collapse to an extent disproportionate to the cause’
- ‘shall be designed and constructed so that, in the event of fire, [their] stability will be maintained for a reasonable period’.

These functional requirements are mandatory and apply to all buildings. In the UK, upcoming legislation via the Draft Building Safety Bill12 is also likely to increase the obligations on designers to develop credible ‘safety cases’ to demonstrate that measures exist to mitigate all relevant hazards (including fire) and their consequences.

The optimisation, innovation and evolution that is necessary in structural engineering can only be achieved if we raise our collective competency and the working relationships between chartered structural engineers and chartered fire engineers become closer, more collaborative, and more explicitly linked. I’m encouraged in this regard that the IStructE’s CROSS scheme is, in partnership with the Institution of Fire Engineers, being expanded in 2021 to include confidential reporting on fire safety. Increased fire safety competency and collaborative working will hopefully become the norms in the future.

Until then, my hope is that all structural engineers will reflect on some of the ideas presented in this article as they continue to work towards addressing the climate emergency: all the while feeling accordingly uneasy.

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REFERENCES

11) The Building Regulations 2010, SI 2020/2214