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Fire safety engineering at a crossroad

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ABSTRACT

Fire safety engineering (FSE) has become widely accepted throughout the world. This is quite an accomplishment for a young engineering discipline. Fire safety engineers are employed by public and private sector organizations of all types. We are involved in almost all major building and infrastructure projects, enabling amazing buildings to be designed, constructed and occupied. We play critical roles in high hazard industries, helping to mitigate risks and achieve acceptable levels of safety. We undertake groundbreaking research and develop new technologies aimed at reducing the impacts of unwanted fire. However, as an engineering discipline, we lack several attributes that one might expect to see in a mature discipline, including a robust analytical engineering framework. We have not experienced any transformational changes in technology or practice in some time. FSE degree programs and recognition of FSE as a unique discipline remain lacking in several countries, leading to wide variation in the level and consistency of fire safety performance delivered. This has unfortunately led some to question the competency and the efficacy of the profession, in some cases resulting in more regulatory control over the fire safety engineering analysis and design of buildings. The net result is that we are at a crossroad. We face some significant challenges, but we have the opportunity to shape an amazing future. If we are up to the challenges and take advantage of the opportunities, we have a chance to evolve the discipline towards maturity and greater respect. In this article I outline my view of the current situations, some of the challenges we face, steps we might take to overcome them, and areas for research, development and implementation into practice concepts that can lead to a promising future.

Current situation: an adolecent discipline

At the *6th International Symposium on Fire Safety Science*, I presented an invited lecture on international experience in the development of performance-based fire safety design methods [1]. At the time, I observed that fire safety engineering (FSE) had developed to the point where it had become an accepted, if not fully mature, engineering discipline. I based my assessment of the maturity of FSE on characteristics identified by the internationally respected earthquake engineering Professor C. Allin Cornell [2]. Today, as in 1999, I would argue that FSE is a healthy adolescent. Over the past three decades, research has become more focused on addressing the needs of FSE practice, the essential elements of a framework and vocabulary have been developed, and many practitioners appreciate where and how the current methodologies can address their problems [3]. For the most part this been facilitated by the publication of numerous FSE standards, guidelines and

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handbooks e.g., [4–12], which are widely used and/or being developed for use in practice. It has also been facilitated by the promulgation of performance-based building regulations in numerous countries [13,14]. Data, research reports, tools and methods are also widely available via the internet (e.g., see websites for such organizations as BRANZ, NIST, NRCC, SP, etc.). Nonetheless, while the current situation is encouraging, the ongoing development of FSE remains largely uncoordinated, with rapid advancement in some areas and incremental or no advancement in others, with significant gaps remaining. I touch on some of the gains and gaps below.

Computational tools

The past two decades has seen considerable advancement in computational tools for FSE. Advancements in cost-effective computing and graphical user interfaces has resulted in widespread use of computational fluid dynamics (CFD) for fire effects modeling, finite element (FE) tools for fire response of structures analysis, and human behavior and evacuation models. However, how well they work, and more importantly, how well we use them, remains a concern e.g., [15–19].

The FSE and PB code frameworks

Although a general framework and vocabulary for FSE exists, in nearly all of the standards and guidelines cited above, the basic approach is to provide general guidance regarding what should be considered in a FSE analysis, but detailed guidance on how to actually conduct FSE analyses is missing. In addition, guidance regarding how to integrate fire safety performance with all other required and desired performances for a building – in normal and emergency situations – is also missing. Details which are lacking include means to quantify performance expectations and measures, characterize targets and their vulnerabilities, quantify fire threats, and evaluate the building and fire safety systems' ability to deliver desired performance in normal and emergency conditions. In addition, guidance for how to address uncertainty and variability across all aspects of FSE analysis is largely missing. The net result is that fire safety engineers are free to select data, tools and methods of their choice, in consideration of scenarios which they think are important (with varying degrees of stakeholder involvement), evaluated against criteria they select, with the potential for no explicit consideration of uncertainty and variability throughout the life of the building. These gaps and lack of detailed guidance are significant contributors to the wide variation in safety performance being delivered in practice and the growing lack of confidence by regulators e.g., see [3,18,20]. Until we find better and more consistent ways to address some of these issues, we will not achieve the level of respect and confidence needed for our engineering peers and enforcement officials to universally accept FSE as a mature engineering discipline. Some insights have been provided in this area, looking at parallels to other engineering disciplines as well as taking fresh approaches e.g., [21–24], but more effort is needed. Advances in the performance building regulatory structure is needed as well, so as to get the right mix of stakeholders, working in the right arenas, to agree how safety performance is to be defined, quantified and implemented into regulatory, design and safety management practice.

Education, qualifications and ethics of fire safety engineers

We have a lack of adequately qualified fire safety engineers, particularly those with appropriate education, the confidence and wisdom of experience across a diversity of applications, and the ethics and accountability needed to help foster confidence in the profession. At the same time, we have a continued reliance on longstanding prescriptions and rules of thumb to guide decisions, even when the science and data exist to better support decisions, and proper application of the science is not mandated. The net result is that critical fire and life safety decisions are sometime being made – and allowed to be made – by people without proper credentials. In some cases there is a lack of FSE university degree programs. In others there is a lack of regulatory controls (defining and requiring minimum qualifications) and enforcement. However, in some cases it is ignorance and hubris, where a professional thinks he knows it all actively rejects helpful data and information. Sadly, we have even seen intentional falsification of analysis or misrepresentation of analytical or computational outcomes. Unfortunately, these issues are not new, but have been raised by a diversity of individuals and groups going back almost 20 years e.g., [1,2,13,15–20,25–31]. More FSE education is needed. More certification of qualifications is needed. Stronger ethics are needed. We should look to the medical profession here: first, do no harm.

Lack of data and reluctance to qualify data for FSE

While we have seen significant growth in the availability of computational analysis tools, the availability of data for use in these tools and in engineering analysis in general remains a problem across all FSE areas – from fire properties of materials to human factors. This is of particular concern with respect to the widespread use of models, since the appropriateness of the analysis is related to the appropriateness of the data. In part this is driven by the perception amongst some that advancements in computational tools have diminished the need for experimental data, when in fact it is just the opposite: experimental data are needed to support model development, verification and validation e.g., [32,33], as well for use in analysis and design applications e.g., [16]. Without experimental data, we lack a fundamental basis for application of our computational tools. The lack of usable data for engineering analysis is also impacted by reluctance within the industry to develop or