Identifying the attributes of a profession in the practice and regulation of Fire Safety Engineering

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Highlights:

- A profession is identifiable through the possession of various attributes, including: a systematic body of theory; professional authority and community sanction; a regulative code of ethics; and a professional culture
- This paper explores some of the evidence of these attributes in the practice of Fire Safety Engineering
- There is a need for Fire Safety Engineering to formalise the definition of itself as a profession

Abstract:

The attributes of a profession can be identified as: a systematic body of theory; professional authority; a regulative code of ethics; and a professional culture. Through a discussion of the practice in Fire Safety Engineering we review the current state of these attributes.

It is argued that reliance on prescriptive solutions that often play the role of both a solution to the problem as well as a de facto performance requirement obscures the need for a competent practitioner who possesses mastery of the application of the systematic body of theory that underpins the profession. This opens the domain to practitioners that do not possess a specialist knowledge in fire safety engineering. Secondly, the fire safety engineering process is often triggered through identification of non-compliances to specific prescriptive provisions, and this negatively impacts on the discipline's professional authority. Thirdly, the way in which the discipline allows itself to operate exposes it to challenges of its ethical code; and finally, the lack of a well-defined accreditation framework challenges the professional culture and the respect for fire safety professionals and its ability to reproduce. The result is an environment that favours a customer relationship between those commissioning the work and the Fire Safety Engineer, rather than the client relationship necessary for adequate professional practise.

Many countries implement Fire Safety Engineering within a framework that nominally requires a recognized and recognizable profession. However, the impact of the above is that we fall short of fully implementing such a framework and reaping the benefits that the framework could bring. Thus, at the core of fire safety engineering reform should be the proper implementation of a framework consistent with a profession. Other engineering disciplines learn from failures through a cycle of 'failure – concern – response.' This has historically led to formalisation of engineering professions that refocuses the profession on its duty of care to society by formalising what the profession is. In Fire Safety Engineering, so far, the response has focused on regulation and not, like in other engineering disciplines, on the profession. Recent incidents are a significant impetus and an opportunity for the fire safety profession to formalise itself.

Keywords: performance-based design; professionalism; Fire Safety Engineering; prescriptive provisions; regulatory environments

1. Introduction

In 1928 the St Francis Dam disaster in Los Angeles resulted in the deaths of hundreds of people and massive damage to residences and public infrastructure. It is considered to be the worst failure of civil engineering in California [1]. The disaster was a catalyst for the passing of the 'Civil Engineers Act' in 1929 which required the registration of civil engineers in the state [2]. The 1947 amendment extended these registration requirements to professional engineers in the chemical, electrical, mechanical and petroleum streams [3]. This also resulted in the creation of the State Board of Registration for Civil and Professional Engineers which enabled a co-regulatory approach to professional accreditation and registration in the state.

The Quebec Bridge disaster in Canada in 1907 remains to this day the worst bridge construction disaster in the world. Its collapse during construction resulted in the deaths of 75 workers [4, 5]. The inquiry into the cause of the collapse found that the responsibility lay with two men, the chief design engineer who prepared the original design of the bridge chords and the consulting engineer who reviewed and approved it [6]. Whilst this disaster did not lead directly to the registration of engineers in Canada (for example, in Quebec registration of engineers has been required since 1898 and in neighbouring Ontario registration was only possible since 1922 [7] although the profession remained open until 1937 [8]), the denial by site engineers that the increasing displacement of the chords during construction was an issue, did have an inescapable impact on the registration process throughout Canada. The pressure towards registration placed significant focus on the ethical responsibilities of the profession and this is manifested through the ritual of the calling of an engineer, established in 1925 [9].

These two examples illustrate a cycle of "failure-concern-response" in engineering. Other examples exist. For instance, the process that led to regulation of engineers in Germany, which had as a contributory factor a desire to re-orient the focus of post-war engineering away from being a profession that had contributed to significant devastation. The Association of German Engineers, the VDI, published "Engineers Confessions" in 1950 [10], which acted as a moral pledge for engineers in making an explicit commitment to humanity as a whole.

A final and more current process, which could also be seen as consistent with the cycle of "failure-concern-response," is the increasing belief that the progressive concern for engineering ethics emerging in different countries in the last three decades ("concern") and the resulting explicit inclusion of ethics in engineering education ("response") relates to "globalization" [11]. The "failure" is the strain imposed on engineers for competition on the basis of low-cost production for mass use [12]. Thus, the focus has shifted from the physical failure to the individual and its professional education. Even in countries like France, global competitive pressures, as well as new pan-European efforts, have resulted in challenges to the manner in which engineers are being educated. Traditionally, in France, reassessment of engineering ethics and practises is often seen as a prerogative of the individual and the introduction of external intervention in the form of engineering ethics is perceived as insulting to engineers who are educated as elite professionals “committed to civil service in pursuit of rationalist national progress” [11]. Global commercial interests, a desire for international recognition and a strong shift from the employment of engineers from the public to the private sector has recently resulted in a slow but consistent revisiting of French engineering education and practise.

In the examples above, there are two things in common: firstly, the development of the engineering profession follows this cycle (whether this is an engineering failure, in the case of, the St Francis Dam, or a failure of the profession itself). And secondly, the response is always followed by a formalisation or re-formalisation of the professional identity leading to regulation of the professional. The above examples relate to civil engineering or engineering generally. They illustrate the positive impact of the introspection following engineering failures or related disasters. Overall, professionalism of engineering has been significant in enforcing the social responsibility of engineers.

In fire safety, the response to failures historically follows a similar cycle, leading to changes in the emergency services, such as the formation of the early organised municipal fire services in the mid to late 19th century [13]; or to changes in the regulations that cover fire safety in the built environment. Many of the aspects of prescriptive design, rather than being based on engineering analysis, are founded on experience of disasters and have appeared in building regulations in a manner that was described by Law and Beever as ‘magic numbers’ [14]. For example: limitations of compartment areas in Approved Document B in England are based on a survey of post-war buildings in the UK [15]; or escape distances inscribed in codes around the world have at their origin the evacuation of the Empire theatre in Edinburgh, in the UK, in 1911 [16]; and compartment sizes for firefighting provisions can be traced back to the Tooley street fire in 1861 [17]. The use of these so-called ‘magic numbers’ in Fire Safety Engineering is a well-known practice that has had an influence on the design of buildings for more than a century [14].

However, in contrast to the examples from other engineering disciplines, these changes in fire safety engineering tend to focus on the regulation of the built environment, not on those who practise fire safety engineering. The ‘failure-concern-response’ cycle in other engineering disciplines recognizes that professionals’ practice the profession, and that the profession protects and supports the monopoly of qualified practitioners whilst enabling reproduction of the profession itself. In Fire Safety Engineering this cycle has not been recognised.

It is important to note that this is not the case with the fire and rescue services where ‘failure-concern-response’ cycle focuses on staff. For example, recent reforms of the fire service in the UK was undertaken by introducing an Integrated Personal Development System to ensure career progression was linked to ability rather than rank and hierarchical position [18].

Another example of regulatory changes in Fire Safety Engineering that have contributed to the development of the practice without developing the profession is the first Warren Centre project on Fire Safety Engineering in Australia which reported in the late 1980’s [19]. This project paved the way for the Fire Code Reform Centre work in 1994, and informed the first performance-based building code for fire safety in Australia that was introduced in the late 1990’s [20]. It enabled the transition from a prescriptive regulatory environment to a performance based regulatory environment. This also led to the publication of the first version of the International Fire Engineering Guidelines [21].

As will be discussed in this article, while this process should have reinforced the role of the professional Fire Safety Engineer in the design process, the way that performance-based design has been implemented in Australia and around the world actually obscures this need. This is because, upon its introduction, performance-based regulation was made to co-exist with prescriptive solutions in such a way that both were seen as viable codified alternatives to demonstrating safety in the built environment. This was a necessity, for two reasons:

- Unlike other engineering disciplines, such as structural engineering, fire cannot be treated using semi-probabilistic code formats [22] that enable the introduction within a single code structure regulated prescriptive elements (ex. loads) and performance-based analysis (ex. methods for member stress calculation).
- There was not a sufficient number of well-educated and qualified fire safety practitioners to work in an environment which only permitted performance-based design.

The result, however, is that this enabled a growth in the numbers of practitioners to be filled by poorly qualified individuals. These individuals perpetuated the reliance largely on the prescriptive solutions as a means of demonstrating safety but also, in many cases, developed very poorly conceived and justified performance-based designs. New products, new materials, new trends in the built environment were almost without exception held up against the benchmark of prescriptive design. While it is clear that designs of exceptional quality have been developed throughout the years, the lack of definition of what is a ‘quality practitioner’ has confused the assessment of quality and thus disabled the profession from being able to identify and highlight such exemplars [23]. It is much more common to find criticism to the practise than quality highlights [24].

Fire killed 3,655 individuals and injured 15,200 in the US in 2018 [25]; in Europe fire kills a similar number, 3500 annually but results in significantly more (70 000) injuries [26]. According to Allianz, fires and explosions in the built environment account for 59 % of annual business interruptions globally [27]. And yet, there has never been up until now a significant introspection into the profession of fire safety engineering in response to a fire. On the basis of the frequency of fires, the economic impact of fires, the numbers of fatalities, and the number of injuries annually the need for such a review should be clear. However the Grenfell tower disaster in the UK in 2017, the Lacrosse fire in Melbourne in 2014 [28], and the results of Government enquiries in Australia such as the Lambert enquiry [29] and the Victorian Attorney General’s report [30], amongst others internationally, have given further high profile impetus to this need. The scrutiny that fire safety is under, following these incidents, has been an opportunity for fire safety engineering to follow that same cycle of ‘failure, concern, response’ but this time to focus on properly defining its professional identity.

This opportunity has been taken by the second fire safety project launched through the Warren Centre in 2017. Concluding in 2020, this project has had as its objective the professionalization of Fire Safety Engineering in Australia. This objective echoes similar calls from elsewhere around the world, for example by the SFPE in Europe seeking professional recognition of Fire Safety Engineers, and requiring a consistency in education, competencies, and standards in Fire Safety Engineering [31]. The objective of the current Warren Centre project is further motivated by the Australian Government Productivity Commission reports [32] as well as historic goals of the Australian Building Codes Board to improve market penetration of performance based designed buildings within Australia [33], removing many of the potential barriers to innovation that prescriptive regulation could impose.

This article draws on some of the content of two of the reports from this second Warren Centre project on Fire Safety Engineering, to further promote the case for global reform of the fire safety engineering professional community. Specifically, the article draws from the Education [34] and the Method reports [35] and discusses some of the issues highlighted in these in reference to the attributes that define a profession and the identification of these in fire safety engineering practice.

The issues presented herein, although largely written from an Australian perspective, are recognisable in other jurisdictions around the world. For example in Europe, and as already noted [31], these issues have been recognized in countries with an accreditation process for practicing engineers that reflects the accreditation process as described by the International Engineering Alliance. Some of the issues discussed are however are also recognisable, to some degree, in some countries that are not signatories to the Washington Accord, such as Sweden where it has elsewhere been highlighted that there are no requirements for licensing of fire safety designers, and that the title of “Fire Safety Engineer” is not protected [36]. The issues of inconsistent levels of both education and the accompanying checks on first and second tier accreditation are therefore likely familiar to many; as is the discussion around the over reliance on the prescriptive solution to the problem not just in its own application but also as a de facto performance objective for design.

2. Attributes of a profession

In defining a profession, one inevitably looks to identify the specific attributes that differentiate a profession from a vocation. However, these are difficult to quantify and in many respects the differences between a vocation and a profession may be considered to be more relative than absolute. That is to say, there is a scale between those traditionally vocational occupations at one end and the traditional professions such as medicine or the legal professions at the other end. Most engineering disciplines sit somewhere within this scale. In defining qualitatively what a profession is, various writers have done this from the perspective of a variety of different occupations [37, 38, 39]:

The sociological approach to professionalism is one that views a profession as an organised group which is constantly interacting with the society that forms its matrix, which performs its social functions through a network of formal and informal relationships, and which creates its own subculture requiring adjustments to it as a prerequisite for career success.'

'Professional status is ... an implied contract to serve society over and beyond all specific duty to client and employer in consideration of the privileges and protection society extends to the profession.'

'For a profession may be defined as an occupation based upon specialised intellectual training, the purpose of which is to supply skilled advice and service to others in return for a definite fee or salary.'

The attributes that define a profession according to these same writers are summarised below under four headings: A systematic body of theory and skill in its application; professional authority; a regulative code of ethics, and finally a professional culture. These are based on various attributes identified in the professions of Social Work (Greenwood [38]), Dentistry (Fleming [37]), and Electrical Engineering (Dahrendorf [39]).

2.1 A systematic body of theory and the skill in its application

Mastery of a systematic body of theory and skill in its application are the skills that characterize a profession and which flow from and are supported by a fund of knowledge that has been organized into an internally consistent system.

This was identified explicitly by Greenwood, writing about social work; as well as by Fleming writing about Dentistry who refers to a "combination of Skills and a Foundation of Theory"; and by Wickenden, a former president of the Institution of Electrical Engineers as a "Body of Knowledge or Art".

2.2 Professional authority

Professional authority can be either assumed or granted. Assumed authority is based on the mastery of the systematic body of theory and its application which serves to differentiate between the level of knowledge of the professional and the comparative ignorance of the layman. Granted authority is the license granted by the state to members of a profession to practice in a monopoly and which allows their control over the educational programs which enable the profession to reproduce.

Identified by Greenwood as separate attributes of "Professional Authority" and "Community Sanction", this attribute is also similar to the attributes of "Authority" identified by Fleming and of "Recognition of Stature" identified by Wickenden.

2.3 A regulative code of ethics

A regulative code of ethics applies to both the client-professional relationship and the intra-professional relationships. It dictates the neutrality with which professionals must engage with their clients and the supportive nature with which they must engage with their colleagues.

This was identified by Greenwood; as well as by Fleming who referred to "Professional conduct and ethics"; and by Wickenden who referred to a "standard of conduct".

2.4 The professional culture

The professional culture, being the network of formal and informal groups that comprise the profession, includes centres of practice, educational establishments, and the professional associations that comprise that culture. Amongst other things, the function of the professional culture includes the reproduction of the profession through accreditation of university degrees and the "screening" of potential candidates prior to admission to professional practice.

This was identified by Greenwood; Fleming discussed "The professions as societies within societies and the reproduction of the profession"; and Wickenden explicitly referred to the Accreditation process which falls under the remit of the profession, the standard of professional qualifications reflected in the accreditation process and the Organisation of the professional group.

With a particular focus on the systematic body of theory and the skill in its application, each of these 4 attributes are discussed in the following sections in relation to Fire Safety Engineering.

3. A systematic body of theory and skill in its application

3.1 The engineering design process

Engineering design generally is the systematic generation and evaluation of specifications for artefacts whose form and function achieve stated objectives whilst respecting certain constraints [40]. The Fire Safety Engineering design process is no different – with the product of the design process being the specification of a 'Fire Safety Strategy' for a building that conforms to the drivers and constraints specific to the project [41]. The 'Fire Safety Strategy' comprises many components, including for example the detection and alarm system, the egress strategy, the smoke management strategy, provisions for first responder intervention, and the structural fire design. Each of these components has a particular body of theory that underpins their functioning. In achieving the objectives of the 'Fire Safety Strategy,' all of these components work together holistically and the performance of one component inevitably has an effect on the required performance of the other components in order to achieve the over-riding objectives of, for example, life safety of the building occupants and first responders, or avoiding disproportionate collapse of the structure; all whilst respecting any constraints.

Nominally Fire Safety Engineering in many jurisdictions is undertaken in an environment that permits both a prescriptive approach and a performance-based approach as a means of meeting the performance requirements. These performance requirements are a specific constraint to most projects which are imposed by the regulatory environment. When both a prescriptive and a performance-based approach is permitted according to one set of regulations this is usually under the guise of a performance based regulatory environment with the prescriptive solution being inscribed as a solution which is 'deemed to satisfy' the performance requirements.

According to Beck in the first Warren Centre project into Fire Safety Engineering [19]; and to Meacham in collaboration with the SFPE [42], a performance-based regulatory environment comprises three components:

- The code or codes, which explicitly state the societal goals (what we expect from the building), functional objectives (how the building or systems function to meet the goals) and Performance Requirements (a statement of the level of performance that must be met in order for the building to meet the societal goals and the functional objectives) that are a reflection of the expectations of all relevant stakeholders in society of the expected level of safety provided by a building;

- Guidelines, standards or practices that describe accepted methodologies for compliance with the code. These may be referenced in the code but should be separate documents; and

- Evaluation and design tools which comprise accepted methods for assisting in the development, review and assessment of designs. These may include for example engineering standards, practices, tools or methodologies and verification methods as may be used for assessment of compliance. These need not be specified as part of the regulatory environment, since they must be allowed to evolve to fit the needs of the profession, nevertheless they form an essential part of the environment.

The composition of this environment has been further expanded on and further detail added elsewhere, e.g. [43]. However the basic structure remains largely unchanged since it was first written about in the Fire Safety Engineering literature. In the performance-based regulatory environment, regulatory acceptance of a design is possible contingent on the ability to demonstrate that specified objectives as expressed in the performance requirements, which generally become the legislated legal requirements, have been met in the case of the performance-based approach.

Societal goals, functional objectives and performance requirements should be consistent between performance and prescriptive solutions. Thus, performance-based analysis of a prescriptive solution should demonstrate that the expected level of safety has been attained. By definition, there is a wider spectrum of solutions open to the designer in a performance-based regulatory environment than there is in a prescriptive regulatory environment – otherwise the complexity of the prescriptive environment becomes unmanageable. If thought in these terms, a prescriptive solution is, just one pre-analysed solution that meets the same requirements as the many equivalent performance solutions. These requirements are to be established by society and not by the designer [24]. However, in fire safety, in adopting a prescriptive solution, the achievement of this acceptable level of safety is never demonstrated and is implicit based on the adoption of the prescriptive provisions in the development of the specifications of the individual components that comprise the ‘Fire Safety Strategy’ [44]. The ‘Fire Safety Strategy’ and explicit performance requirements are never established and therefore the problem with performance-based design stems already from an ill-defined prescriptive framework. This is discussed in detail in the following sections.

3.2 The role of the prescriptive provisions within the performance -based environment

Many building codes around the world include prescriptive provisions which if followed and incorporated in a building as a solution are a means to satisfy the performance objectives. These prescriptive provisions represent a ‘recipe book’ solution where the required performance of each design element is described in detail [45] and are a route to compliance for a designer that does not want to develop from first principles a means of achieving the Performance Requirements [46].

When the prescriptive approach exists in a performance based regulatory environment, this is possible by virtue of it being one of the many solutions that meets the explicit Performance Requirements of the code or codes. When exercising a prescriptive solution this needs to be combined with evidence of suitability, which normally takes the form of evidencing that the prescriptive solution is enabled by the classification of the building. This classification in many building codes is a function of parameters such as the building height, its use, floor area, location, materials of construction, etc. In application the classification therefore also imposes assumptions about the expected performance of certain elements or fire safety measures of the Fire Safety Strategy, thus limiting the fire scenarios to which the building could be exposed, and therefore removing the need to evaluate the ‘Fire Safety Strategy’ for these scenarios. For example:

- provision of spandrels and cavity barriers in a non-combustible façade are thought to remove the possibility for vertical flame spread for high rise buildings via the external building envelope [47],

- a lack of suppression will indicate an acceptance of total loss for buildings if little to no structural resistance to fire is provided,
- a defend in place strategy for hospitals will only be made possible through the provision of adequate compartmentation removing the need to analyse the response of the building structure to fire spread between compartments, etc.

If any of these provisions are changed then there is a necessary change to both the scenarios for which the building should be analysed, and to the required performance of the other provisions in order to ensure the overall objective of the 'Fire Safety Strategy' is achieved. An approach to design that is based on a prescriptive solution therefore only works when the building that is the subject of that design falls within the classifications available in codes [34]. These classifications are a proxy for the potential consequences of a fire in a building, and the prescriptive solutions are a means to mitigate the risk. The prescriptive solutions also serve to limit in many instances the range of hazards to which a building will be exposed, for example excluding vertical fire spread by preventing the use of combustible cladding, or limiting the spread of fire via internal linings through the Euroclass system [48].

However, being based on historical approaches and experiences arising from disasters, the ability to apply the prescriptive provisions to problems that were not conceived when the provisions were written relies on some mastery of the body of theory of fire safety engineering. Frequent solutions could be automated, however in a constantly evolving environment the implication of the application of existing rules in the acceptance of new products is lost. This is nowhere more evident than in the current debate in the literature surrounding the suitability of the fire resistance framework in the certification of cross laminated timber elements in construction [49, 50, 51, 52]. There is a degree of skill required in determining when a building falls outside of the scope that permits the prescriptive solution, or when the assumptions or limitations implicit in the background to the prescriptive provisions exclude the use of certain products, layouts, etc. Without some mastery of the body of theory, then the evidence of suitability, the only aspect of a prescriptive solution that requires any form of verification, cannot be adequately checked.

It is therefore a misconception, but common within practice, that the implementation of prescriptive solutions requires little to no skill in the application of the systematic body of theory that underpins fire safety engineering. Thus, application of prescriptive solutions is often undertaken without the involvement of a professional Fire Safety Engineer.

3.3 The application of performance-based design

Performance-based design is applied either when buildings fall outside of the classifications available in the codes or when the narrow prescriptive solution afforded by the prescriptive provisions is unsatisfactory to one or more of the stakeholders of a project. In this case, since either one, or both, of the classification and the design solution have now departed from the boundaries of the prescriptive solutions, the implicit assumption of achieving a tolerable level of safety based on these prescriptive solutions no longer applies. There is insufficient evidence for these complex buildings or these bespoke solutions to be able to make any assumptions or implicit determinations with regards to the level of safety. Complex, novel, or unusual aspects of specific buildings can challenge all aspects of the Fire Safety Strategy in unforeseen ways, and since the Fire Safety Strategy is intrinsically holistic in its implementation the need to explicitly demonstrate and evaluate the safety of the solution arises [5**3**].

Now the Fire Safety Engineer must adopt some form of calculation method in order to demonstrate a balance between the drivers and constraints which they are working within. This may take the form of, for example, the development of a model or models and then their subsequent manipulation in the form of carrying out simulations to calculate the impact of different scenarios on specific aspects of a 'Fire Safety Strategy.'

It is here that the Mastery of the body of theory in Fire Safety Engineering and its application is demonstrated: in the development of design solutions to complex problems. This is in principle enabled by the performance based regulatory environment, which permits any solution to the problem so long as the performance requirements are met.

The role of the engineer in this instance therefore extends to being not only able to evidence applicability of the solution chosen; it now includes the creative responsibility for development of said solution and the determination of a suitable form of assessment of compliance with building code Performance Requirements.

Again, the co-existence of the prescriptive solution of the characteristics of those implemented for fire safety in an environment that permits a performance-based solution poses a problem. When exercising a Performance Solution, the level of safety provided by an artefact is often the de facto performance requirement of a Prescriptive Solution that has no explicit performance requirements and that is specified according to the nearest available classification . This is incorrect, since the prescriptive solutions have never been shown to provide an adequate level of safety for a building outside of the related classification. This is a product of the retention of unassessed prescriptive solutions in the performance-based building code and regulatory environment. It is important to restate that these solutions evolved from a prescriptive framework without a return to first principles of the design process or checking of the level of safety of the original prescriptive based designs.

The prescriptive solution also has another inescapable and important impact on the format of building regulations in many jurisdictions. The retention of the current prescriptive solution framework in the performance-based environment has meant that the structure of building regulations typically is driven by the specifications of the prescriptive solution. This means that performance-requirements are typically stated in reference to components of the 'Fire Safety Strategy,' and not to the overall 'Fire Safety Strategy' itself.

The question therefore arises for the performance-based solution as to what constitutes an adequately or tolerably safe design? It is here that the need to re-emphasise the role of the Fire Safety Strategy as the artefact being designed becomes clear, and in so doing the ability of the practitioner to apply the specialist body of theory to complex problems becomes of paramount importance. This responsibility can and should only rest with the professional who has the ability to apply the systematic body of theory.

The body of theory underpinning Fire Safety Engineering has been described in detail elsewhere. For example, by the Working Group on Fire Safety Engineering Curricula in 1995 [54] and by the more recent curricula published by the Society of Fire Protection Engineers [55, 56] However, the attributes that are required for professional practice go far beyond the body of theory alone, e.g. as in the process described by the International Engineering Alliance [57]. Therefore, those attributes that deem a Fire Safety Engineer competent go beyond the body of theory and need to be defined. Fire Safety Engineering is unique, within the engineering professions, in that these attributes have never been defined. There is therefore a need to define these competencies, along with a necessary revisiting of the curricula and pedagogy required to educate Fire Safety Engineers [34]. The systematic body of theory of Fire Safety Engineering and the skill of Fire Safety Engineers in its application are key attributes that are, or rather should be, reflected in the requirements and expectations for accreditation of practicing Fire Safety Engineers.

The practice of fire safety engineering varies significantly from jurisdiction to jurisdiction, with accompanying differences in the required education and ability of practitioners. For example, in Europe, many of the Member States have no requirements for any kind of registration or licensing of Fire Safety Engineering practitioners [58]. In Australia there are variations between the states in terms of how individuals performing fire safety engineering are regulated, where some states require accreditation of the practitioner and maintain a regulatory oversight of this, and others do not. This issue, the reasons and evidence for which is discussed in detail elsewhere [34], is summarised by Woodrow et al.[23], who attributes it to the small size of the discipline, the lack of rigour in licensing procedures, the reliance on prescriptive approaches to design and the educational programs which are a part of the professional culture that support this:

"Poor competency awareness within FSE is partly a consequence of the small size of the discipline and the lack of support for initial or continuing education, which necessitates the utilization of poorly educated practitioners to fill available positions; partly a consequence of the lack of rigorous [licensing] procedures for practitioners; partly a consequence of our reliance on prescriptive approaches to design, which permit (indeed promote) a lack of fundamental understanding of the principles upon which an integrated Fire Safety Strategy should be based; and partly a consequence of educational programmes which support all of the above."

All of the above is not to say that there is not a body of theory that underpins Fire Safety Engineering. For example, the SFPE Handbook of Fire Protection Engineering is a substantial synthesis of a significant portion of this knowledge, and while it contains many examples, the focus in this handbook and in the majority of curricula noted above is not on their application to complex engineering problems. Yet the application of the theory to complex problems is an essential and explicit aspect of the professional engineer. For example, the Engineering Council UK defines Chartered Engineers as those who "develop solutions to engineering problems using new or existing technologies through innovation, creation and change and they may have technical accountability for complex systems with significant levels of risk." Consistent with this, Woodrow et al [23] write that the focus of education should not be on the solution to the problem but on its definition. Knowledge is still required to achieve a solution, but this knowledge will be acquired and applied as and when necessary. This is not to say that on the job education in Fire Safety Engineering is sufficient, since it is the skill in the systematic theory that enables the professional to orient themselves towards the acquisition of new knowledge as and when it is needed.

While the knowledge base is a focus of existing curricula in the literature [54 – 56], this concept of its application to design is not. This is with the exception of the framework proposed by Woodrow et al [23]; who highlights the importance of drawing a distinction between training and education of engineers. Training being defined as the imparting of knowledge, and education being defined as the development of skills in students. The former refers to the ability to apply code-based solutions to fire safety problems, or to carry out engineering calculations to calculate the performance of a system or component – a level of application which does not reflect a mastery of the body of theory underpinning the profession. Whereas the latter refers to the ability to apply first principles to engineering problems, working outside of prescriptive codes and applying a creative process to achieve a desired level of safety.

Professionals in Fire Safety Engineering require purpose, autonomy and structure. Nevertheless, it is clear that to attain the necessary autonomy required to solve novel problems higher education needs to be centred on purpose. The role of prescriptive solutions to the fire safety problem - their codification and their use as de facto levels of safety for benchmarking prescriptive solutions - obscures the need to properly understand and to fluently apply the body of theory.

4. Professional authority

4.1 Assumed professional authority

It is the mastery of the systematic body of theory and the skill in its application described in the previous section which gives the professional the ability to assume authority over the discipline. This authority forms the relationship between the professional and the client and is reflected by the expectation that the expertise and the good will of the profession are to be taken on trust. Evidence of a lack of trust in the expertise of the profession of Fire Safety Engineering is clear in recent reviews of building regulations and regulatory systems in countries around the world, e.g. the report into the Hackitt enquiry in the UK [59], the Shergold / Weir enquiry in Australia [60] or in recent research in Sweden where a lack of clarity in roles surrounding fire safety has also been identified [61]. Furthermore, this lack of trust is encouraging other professions to attempt to occupy the professional space of the Fire Safety Engineer. This is the case in the UK where RIBA has set and Expert Advisory Group on Fire Safety where architects are being discussed as the designers with primary responsibility for fire safety [62], or IStructE that has recently published a document where structural performance in fire is treated not considering that adequate performance of a structure is an integral part of an overall ‘Fire Safety Strategy’[63].

As a result of the regulatory framework and the way in which fire safety is implemented around the world, we assert that Fire Safety Engineers have customers more often than they have clients. There are only a limited number of cases in which Fire Safety Engineers seek to or are invited to review, as a whole, the ensemble of features of a building that comprise a Fire Safety Strategy and to provide advice as to an overall solution. This is enabled by the current environment in many countries where the performance requirements are not stated holistically, but in reference to the components of a prescriptive solution.

At this point it is interesting to draw a comparison between the role of trades and the role of professions. Trades can be said to have customers whereas professions have clients. Customers determine what service or commodity that they want and shop around for them. Customers have the capacity to determine what it is that they want and to judge the ability of the source to deliver that need. Clients however are led by professionals in determining what it is that is required for them in their current situation. Clients seek advice, whereas customers seek a service or a specific solution. The Fire Safety Engineering process and the involvement of the Fire Safety Engineer is often only triggered as a result of an inability to implement the prescriptive specifications to a *specific* component of the Fire Safety Strategy. This often results in customers seeking a solution to only a specific aspect of the problem in Fire Safety Engineering.

The current framework often disables Fire Safety Engineers from working in projects with clients. It is common that the competency of the Fire Safety Engineer is not recognized and thus those commissioning the work carry the perception that they know what they need, i.e. they are customers. There are notable exceptions and these statements are clearly not universal. There are many examples of buildings where the Fire Safety Engineer has been involved from the outset of the process and where they have had a key role in the realisation of the building. Almost universally this is through the recognition on the part of developers and architects as to the unique skills that professional Fire Safety Engineers can bring to a project. Nevertheless it is currently common that client relationship are often undermined by customer relationships, in many case driven and promoted by fire safety practitioners. These fire safety practitioners allow themselves to operate within the framework of a trade, and the regulatory environments that they work in promulgate this. This is evidence of a lack of assumed professional authority. The role of professional bodies in this cannot be understated, and as will be discussed in the following section those bodies which represent the profession have a role in promoting both the importance of Fire Safety Engineering and the superior skill required.

4.2 Granted professional authority

State granted professional authority comes with a number of different responsibilities. Of primary importance is the license to practice in a sanctioned monopoly, which comes as a result of granting of the professional title, *sina qua non*. Administered by an organisation representing the body of the profession, this licensing system is reflective that the holder has attained the competence and attributes that are required in order to be able to perform in the role with a high degree of efficacy in regard to the expectations of that role.

Normally, the granted authority of a profession over their domain of practice is a result of a representative body demonstrating that the effective performance of the duties of the occupation requires specialised education, and that the importance of the activity being undertaken is such that the superior skill implied by the specialised education justifies the granting of a monopoly to those who have the skill. The provision of Fire Safety Engineering is of such importance.

While there are nominal professional bodies which represent Fire Safety Engineers, for example the Institution of Fire Engineers (IFE), or the Society of Fire Protection Engineering (SFPE), as discussed above, membership of such a body is not always a requirement to practice. Therefore, in contrast to many other established professions, Fire Safety Engineering as a profession has very little evidence of granted authority over the domain of practice in many jurisdictions.

All of this is a result of the apparent lack of complexity in the development of the specifications of a Fire Safety Strategy through the implementation of prescriptive provisions. Their promulgation, as noted, apparently simplifies the process of developing the specifications of a Fire Safety Strategy for all but the most complex buildings and so we cannot argue that superior skill is required.

5. A regulative code of ethics

Typically, as part of the professional accreditation process, professional engineers have to sign up to ethical codes of conduct. Examples include: the Engineering New Zealand Code of Ethical

Conduct [64]; Engineers Australia's code of ethics [65]; the SFPE Code of Ethics for Fire Protection Engineers [66]; and the IFE code of conduct [67]. Some jurisdictions, such as New Zealand, require annual reaffirmation of the professional's continued observance of the code of ethics [64].

The regulative code of ethics may be challenged by many of the actions that the Fire Safety Engineer may take. The discipline has responsibility for the development of solutions which under normal operation are never tested and therefore errors in the process, either deliberate or accidental, only in relatively few instances become apparent.

For example: in application of partial Performance Solutions to the development of a Fire Safety Strategy without due consideration of the overall impact of the deviations on the overall level of safety afforded by the resulting solution; or through failure to comment on matters of potential concern that fall outside of the remit of the brief of the practitioner, but which fall within the area of expertise that may be expected of the practitioner based on the mastery of the body of theory. Clearly, a professional cannot be expected to have complete competence either in terms of awareness or skill in application of the entire body of theory underpinning the profession, but this recognition serves to highlight the importance of the ethical practice and the ability of the professional to recognise and to work within the bounds of the limitations of their own competence. Obviously, this latter example has at its core the expected competence of the practitioner and so is also related to the professional culture as will be discussed.

One such example of the above is the result of the Victorian Civil and Administrative Tribunal, VCAT, ruling into Lacrosse Building fire in Melbourne in 2014, where the judge ruled that, despite the fact that the combustible Aluminium Composite Panel, ACP, cladding did not fall under the brief of the Fire Safety Engineer on the project, there was a failure to exercise due care and skill in failing to advise their customer of the inherent risks of this material [68]:

"failing to conduct a full engineering assessment of the Lacrosse tower in accordance with the requisite assessment level dictated within the [International Fire Engineering Guidelines] and failing to include the results of that assessment in the Fifth [Fire Engineering Report (FER)]; [and] failing to recognise that the ACP proposed for use in the Lacrosse tower did not comply with the [Building Code of Australia] and failing to warn at least LU Simon (and probably also Gardner Group, Elenberg Fraser and PDS) of that fact, whether by disclosing these matters in the Fifth FER or otherwise."

This ruling is also of relevance to one of the findings of the Shergold Weir enquiry [60]:

"Many building practitioners focus narrowly on issues of technical compliance with the NCC [the National Construction Code, of Australia} *and regulations while overlooking or ignoring their wider responsibility to ensure fitness for purpose on buildings."*

The relation of the public to the profession clearly has the potential to be one of Caveat Emptor, let the buyer beware. This is also reflective of the decomposition of the objectives of the Fire Safety Strategy as discussed above into the performance of the individual components as given in the building regulations. The recommendations from both the Hackit Enquiry and the Shergold / Weir enquiry strongly promote a culture of Credat Emptor, let the buyer have trust.

6. A professional culture

Generally, professional accreditation requires a proof of certain common knowledge, skills and attributes. According to the International Engineering Alliance (IEA) this is a two-stage process comprising a first stage which includes a mastery of the body of theory and its application and a second stage which comprises a period of supervised professional practice during which an engineer obtains certain professional attributes and experience that cannot be taught at University [69]. This first stage is, in most professions, achieved by successfully completing a higher-education program accredited by a body of professionals practicing in the relevant discipline. Where the body accrediting the degree program is located in a country that is a signatory to the Washington Accord then this first tier accreditation of the practitioner is recognized and transferable between jurisdictions. Alternatively, an individual can seek assessment of their basic competencies and provide evidence that they possess the same attributes as would be expected of an individual with a Washington Accord accredited degree. Regardless of which route is followed, the result is the same and that is that first tier accreditation of an individual according to the process outlined by the IEA is recognition that an individual possesses a common set of attributes required to enter practice.

Once the individual demonstrates this mastery of the basic knowledge and skills then the individual can enter practice under the supervision of an accredited professional. What follows is a demonstration of competent practice during which the individual obtains certain professional attributes. The relevant professional body will then make an assessment to determine whether or not the individual can exercise technical competence in practice, as well as ensuring the professional has the ethical attributes expected of a practising professional engineer. This is called second tier accreditation. After successfully completing this process, the individual is admitted to professional practice and offered professional accreditation (sometimes called registration) by the same relevant professional engineering body [69]. Generic first and second tier attributes are listed by the IEA [70], and recognizable in the competencies that are looked for before admission to practice in Washington Accord signatory countries. Again, these competencies are rarely discipline dependent. A list of signatories to the Washington accord is given elsewhere [71].

As previously discussed, frameworks in different countries around the world do not always require Fire Safety Engineering to be practised by accredited practitioners. On this basis, some have argued that Fire Safety Engineering functions as a trade as opposed to a profession [72]. The acceptance of this argument however requires the drawing of a clear distinction between these two terms, which is difficult to find. Above, this has been argued based on our assertion that Fire Safety Engineers often have customers rather than clients. Elsewhere this has been argued based on the level of education that permits an individual to professional practice [34].

This specific issue of education has also been highlighted as a problem in, e.g. Europe [23].

This challenges the definition of Fire Safety Engineering as a profession according to the definition of an engineering professional given by, e.g., the Australian Standard Classification of Occupations (ASCO) [73]. ASCO defines an engineering professional as someone who "perform[s] analytical, conceptual and practical tasks in relation to the chemical and physical properties of the universe, life forms and the environment and the design and function of machines, production systems and structures." According to ASCO, most occupations which constitute an engineering profession require a level of skill commensurate with a bachelor's degree in the subject of practice and some period of relevant experience. This is consistent with the process for accreditation described by the IEA.

Fire Safety Engineering falls well short of the standards of the accreditation process of many of the more established engineering disciplines and the most important weakness of Fire Safety Engineering today is arguably the lack of a robust first tier accreditation process. Most professions will have a path for individuals with no first-tier accreditation to enter the professional realm. Nevertheless, these are exceptions that are rigorously scrutinized. In the absence of first tier accreditation there is no guarantee that the individual has the fundamental knowledge or that all the scrutiny and filters common of tertiary education have been enacted.

Professional institutions are therefore very careful when admitting someone to practice without such first-tier accreditation. Currently, only a few Fire Safety Engineering programs hold first tier professional accreditation globally, but even for these institutions, the process followed for accreditation has not been fully rationalized or kept up to date [23].

Second tier accreditation is currently granted, in many countries, through the exception scheme (either when an engineer moves from a country that is not a signatory to the Washington Accord to one that is, or when an engineer simply does not possess an accredited degree), then there needs to be an assessment of their competencies as part of this alternative path to accreditation. Given that the majority of Fire Safety Engineering applicants fall within the exception and since there is no well-defined framework of required knowledge or attributes, this process of second tier accreditation also has questionable value [74].

7. Conclusions

The Fire Safety Engineering community globally has an opportunity before it, unlike at any time since the introduction of performance-based regulation, to formalize the profession.

In this article we have compared the practice of fire safety engineering with attributes that have been identified elsewhere that define a profession. We have focused largely on the practice of fire safety engineering, evaluating the role that prescriptive solutions implemented in their current form play in the need for competency in the development of the ‘Fire Safety Strategy,’ the impact of this on assumed and granted authority of the profession, the ethical standards that the profession holds itself to, and the professional culture.

The authors do not disagree with the deeming principle that supports the application of prescriptive fire safety design. However, when departures from the prescriptive provisions are necessary, the evaluation of whether or not a performance solution achieves the performance requirements of the regulations through the demonstration of equivalence with a part of the prescriptive solution cannot be done. This also applies to the use of a mixture of performance-based approaches and prescriptive provisions, where the use of a performance-based approach should draw into question whether the remaining prescriptive provisions are still applicable within the altered classification.

All of the above requires a re-emphasis of the ‘Fire Safety Strategy’ as the artefact that is being designed. This requires the skill and competency of a true professional. However, the need for this is obscured by a reliance on prescriptive solutions for both specification and verification. With a re-emphasis of the fire safety strategy as the artefact that is being designed the necessity for competency in practitioners, knowledge of the systematic body of theory and skill in its application, becomes clear.

The lack of a well-defined set of competencies for fire safety engineering has led to a situation whereby the value of Universities in enabling the reproduction of the profession has been diminished. The profession and practice enables itself to reproduce almost exclusively from within, through on the job training, the pitfalls of which have been discussed in this paper.

A professional culture is lacking. This lack of a professional culture could also be likened to a culture of ignorance, one which does not benefit from fundamental knowledge, or from the generation of new knowledge but which seeks to continue to propagate or even to evolve prescriptive solutions without all adequate checks and balances which come from rigorous academic research.

Robust professional accreditation frameworks cannot exist without a transparent process, and this process cannot be consistent without agreed upon competencies that reflect the needs of the profession. Likewise, the process cannot be effective if the practice admits people without the necessary attributes and yet it is the practice and implementation of fire safety that often focusses on deviations from prescriptive solutions that enables this.

While it can be argued that Fire Safety Engineering has a long way to go before it can be deemed a profession on the same level as other engineering disciplines, this is a critical time to change the course of its evolution. Recent incidents have provided significant impetus for Fire Safety Engineering to redefine the cycle of ‘failure – concern – response’ from regulatory reform to properly formalize and define the profession. Fire safety engineering has a systematic and adequate body of theory that can enable higher education institutions to deliver the necessary skill in its application. A change in focus towards the appropriate definition of the competencies and attributes as well as a focus on a comprehensive ‘Fire Safety Strategy’ with clear performance objectives that meet societies requirements will enable the development of a regulative code of ethics. As a result an appropriate professional culture will develop granting Fire Safety Engineers the professional authority required for a proper, fair and equitable practice.

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