Fire Safety Engineering

Education Report

THE WARREN CENTRE

ACKNOWLEDGEMENTS

The Warren Centre extends our gratitude to those individuals, government agencies, professional organisations, and corporations who shared their views and insights for this report.

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Warren Centre Fire Safety Engineering Project Kick-off, July 2018.

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The Warren Centre advocates for the importance of science, technology and innovation. Our 30 years' experience of leading the conversation through projects, promotion, and independent advice drives Australian entrepreneurship and economic growth.

The Warren Centre promotes excellence in innovation through delivering collaborative projects, supporting and recognising innovators across the profession, and providing independent advice to government and industry.

For more information about the Warren Centre visit www.thewarrencentre.org.au

FIRE SAFETY ENGINEERING PROJECT

This is the second research project of The Warren Centre at the University of Sydney relating to Fire Safety Engineering. The first project in 1989 paved the way for the creation of the Fire Code Reform Centre to co-ordinate fire research nationally in 1994 and gave major impetus to the development of the performance-based Building Code of Australia, published in 1996. This current Warren Centre Project on fire safety engineering will address many of the major challenges facing governments, regulatory authorities and practitioners in relation to fire safety engineering and community safety in buildings.

OUR PROJECT SPONSORS

The Warren Centre thanks our project sponsors who made this research and these reports possible. This report represents the technical judgment and opinions of expert authors in the field of Fire Safety Engineering and Education. These views are not necessarily endorsed or adopted by the sponsors.

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1. Executive Summary

THIS REPORT DISCUSSES THE CURRENT STATUS OF EDUCATION AND TRAINING OF FIRE SAFETY ENGINEERS; AS WELL AS THE COMPETENCIES WHICH ARE EXPECTED OF A FIRE SAFETY ENGINEERING PROFESSIONAL.

The report is generally written in an Australian context but takes a broader view of the state of fire safety engineering education internationally. The aim of the report is to prepare the ground for future work to promote a positive evolution of fire safety engineering education and the associated accreditation processes. This much needed introspective process aims to move the field away from the current status where it operates as a regulated trade towards a professional engineering discipline.

The report discusses the role of the fire safety engineer in the current regulatory environment. This role, it is argued, must be fulfilled by an individual or group of individuals who collectively possess the competencies, comprising professional attributes, skills and knowledge, required to design and to

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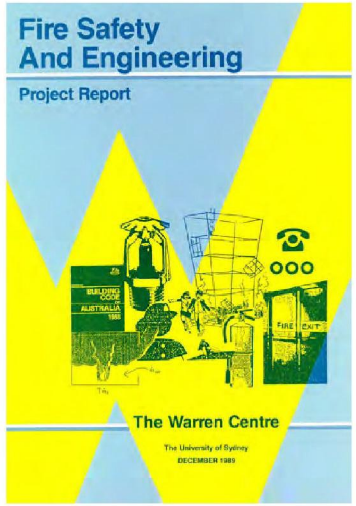
There is some consistency in model curricula which exist when describing the knowledge required of a fire safety engineer. Nevertheless, these curricula have remained largely unchanged over the past 30 years while the challenges which fire safety professionals face have continued to evolve. What is almost universally missing from existing curricula is the development of skills or attributes expected of a professional fire safety engineer. Further, there exists a confusion of what constitutes the competencies expected of these professional engineers and whether these comprise solely of a thorough understanding of the knowledge base of the field of fire safety engineering, or whether for example, skill in the application of this knowledge constitutes a requirement for competency. Through a discussion of existing frameworks that regulate the professional, it

Fire incidents have devastating consequenes for loss of life and destruction of property.

The Warren Centre's 1989 Fire Safety Engineering Report.



is argued that there is at present no agreed definition of what are the attributes and skills of a professional fire safety engineer.

A clear symptom of these issues is the fact that the accreditation process for the fire safety professional is misaligned with other engineering disciplines. Whereas in other engineering disciplines first tier accreditation would normally be granted to an individual who had successfully completed an accredited degree program. First tier accreditation through an assessment of the knowledge of an individual applicant by an accreditation body is the norm in fire safety engineering in Australia as opposed to the exception. A paucity of accredited degree programs in fire safety engineering, not just in Australia, but around the world, effectively means that accreditation of the fire safety engineering professional must operate under this alternative process. This results in the regulatory environment and approvals process for fire safety engineering resembling more the framework of a regulated trade as opposed to a professional engineering discipline.

Recent façade fires illustrate the pitfalls and dangers of continuing as the discipline has done for so long. The continued evolution of design practices and the introduction of new design goals, materials and technologies in the built environment will challenge the professionalism of fire safety engineers. Working in the current regulatory, educational and accreditation environment, the discipline is unable to address these challenges robustly and yet is forced to engage with them. Continuing with this status quo will have disastrous results for the profession, as well as for society and the built environment. This report concludes with a call to action, through a review of the competencies required of a fire safety professional, the educational and accreditation process through which competence is attained and acknowledged, and the regulatory environment in which a true fire safety engineering professional should work.

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2. Introduction

2.1. RATIONALE FOR WARREN CENTRE PROJECT ON PROFESSIONALISING FIRE SAFETY ENGINEERING

The motivations or reasons for undertaking this Warren Centre Project into Professionalising Fire Safety Engineering in the first place included:

- Awareness of Australian Government Productivity Commission reports[1] and ABCB goals of the benefits to Australia of greater market penetration of performance-based design of buildings,[2] including in the area of fire safety
- Recognition by the fire safety engineering profession of the need to lift professional practice standards through the Society of Fire Safety (SFS), Fire Protection Association Australia, and individual papers and reports by Kip,[3] Torero,[4] Johnson,[5] and others over a number of years
- Concerns by fire safety professionals about the findings of various Government inquiries into building quality and practice over the past 10 years such as the Lambert Inquiry in NSW[6] and Victorian Auditor-General's report[7]
- Issues arising and concerns expressed following the Lacrosse Building fire in Melbourne[8]
- Similar issues arising and concerns expressed following the Grenfell Building Fire in the UK
- Issues surrounding the role, competency, and professional practice of fire safety engineers arising from the Hackitt Inquiry[9] and Public Inquiry in the UK, and the Shergold/Weir Report[10] and various State Cladding inquiries in Australia (for example those in Queensland, New South Wales and Victoria)[11,12,13] following the Lacrosse and Grenfell fires.[14]

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[1] Reform of Building Regulation – Productivity Commission Research Report, Australian Government Productivity Commission, 17 November 2004
[2] Australian Building Codes Board, (1996), Economic Rationale for the draft Building Code of Australia 1996.
[3] Kip, S. (2004) A report card on Fire Safety Engineering in the Australian building industry – Has it achieved its objectives and where is it heading? Engineers Australia Society of Fire Safety FSE 2004 International Conference in Sydney, Australia
[4] J.L. Torero, "Fire Safety Engineering: profession, occupation or trade?" International Fire Professional Magazine Vol. 1 No. 1 July 2012, Institution of Fire Engineers, UK.
[5] Johnson, P. (2014) Performance-Based Design and Fire Safety Engineering in Australia, 10th International Performance-Based Conference for the Society of Fire Protection Engineers
[6] Lambert, M. (2015) Independent review of the building professionals act 2005, Draft report August 2015
[7] Victorian Auditor-General, "Report: Compliance with Building Permits", Melbourne, December 2011
[8] Genco, G. (2015) Lacrosse building fire, City of Melbourne
[9] Hackitt, J. (2018) Building a safer future, Independent review of the building regulations and fire safety: final report
[10] Shergold, P., Weir, B. (2018) Building Confidence
[11] Victorian cladding taskforce, https://www.planning.vic.gov.au/building-policy/victorian-cladding-taskforce, accessed 17th December 2018
[12] Queensland non-conforming building products taskforce, http:// www.hpw.qld.gov.au/construction/BuildingPlumbing/Building/Pages/NonConformingBuildingProducts.aspx, accessed 17th December 2018
[13] Fire Safety end External Wall Cladding, NSW Government, https:// www.finance.nsw.gov.au/fire-safety-and-external-wall-cladding, accessed 17th December 2018
[14] Grenfell tower inquiry, https://www.grenfelltowerinquiry.org.uk/, accessed 17th December 2018

A common theme running through a number of these inquiries and other activities is the need to re-examine the role of fire safety engineers, and to lift their competence through improved fire safety engineering education and training, as well as proper accreditation processes and consistent state and territory professional registration in line with best practice principles.

Some of the current challenges facing the building and construction industry are:

- The overall quality of buildings more generally has been a concern for a considerable period as evidenced through the various inquiries, including some concerns about fire safety.
- Governments and individual property owners are facing challenges as to how to deal with refurbishment of buildings with combustible facades
- Some are questioning the role of private certifiers where in some instances they appear to participate in the design process and do not act independently in the public interest
- There is a shortage of professional engineers in a number of areas of practice, including fire safety engineering, with insufficient new graduates and a lack of more senior leaders and managers in the area of fire safety engineering
- There are even more pressures on availability of more senior fire safety engineers because of current litigation and potentially a greater number of legal cases and class actions, taking some of these engineers as expert witnesses and therefore not available for design practice.
- Fire brigades, faced with budgetary challenges, are examining their roles in respect of their building advisory functions and their desire to fulfil their charter obligations
- There are challenges to building design and fire engineering analysis which will come with the introduction of the Fire Safety Verification Method (FSVM) in NCC Volume One (BCA) 2019. This will bring resultant demands on the competency of practitioners and the need to upskill leading into its implementation in 2020.
- In 2022, it appears ABCB are proposing further moves to quantify the Performance Requirements for a number of hazards in the NCC Volume One (BCA), requiring new challenges to competency for fire risk assessment

Not all of these issues by any means can be laid at the foot of the fire safety engineering fraternity as the Hackitt and Shergold/Weir Inquiries have illustrated. There are overall issues with the culture and practice within the building design and construction industry and problems with the regulatory frameworks leading to less than satisfactory outcomes in terms of building quality and performance overall.

In regard to the combustible facade issue, for example, issues of import controls on materials, material testing and certification, product selection and inspections, and certifier acceptance under DTS provisions are all matters outside the province of fire safety engineering in the past. However, there are suggestions of possibly a greater role for fire safety engineers in inspections and commissioning during construction, for example, in the future.

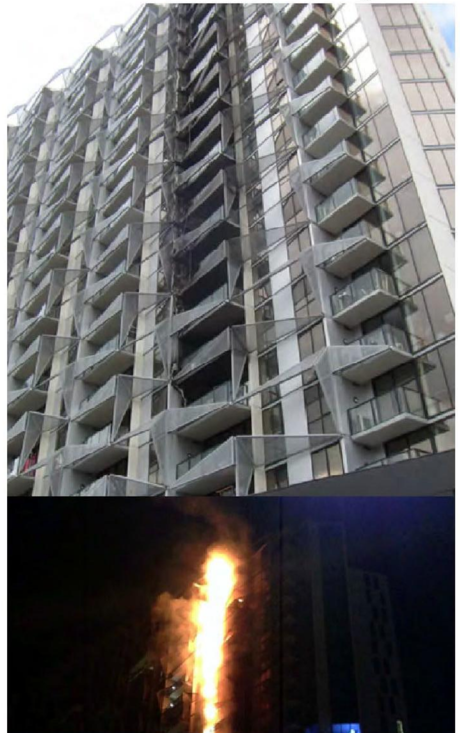
The statistics on fire risk in Australia indicate that the rate of fire casualties is trending down over the past 20 years, as are the property losses. The performance-based regime has also allowed innovative structures and buildings of wonderful design and aesthetics to be developed that would not have been possible under the former prescriptive building codes. Anecdotally it also appears that where serious fires have occurred, more often than not, they are buildings designed to the DTS provisions rather than buildings which have significant performance solutions or have failed for reasons other than performance-based fire safety engineering.

Nevertheless, audits and inspections of buildings, and review of fire safety engineering reports, have shown a significant number of buildings with major construction defects or lacking the proper fire engineering analysis, including:

- Poor compartmentalisation with numbers of services and other penetrations with no fire stopping
- Poor fire protection solutions for structural elements
- Complex smoke control systems which have been very difficult to commission or maintain
- Complex or inappropriate egress/evacuation provisions.
- Poor exit signage
- Fire detection and sprinkler system designs that are not in accordance with the BCA or Australian Standards
- Façade and other external and internal materials which do not comply with BCA requirements
- Fire safety reports with poor fire and smoke modelling or some other inadequate technical justification for Performance Solutions
- Fire safety engineering reports lacking in cause-consequence tables making any full integrated system checking for the proper sequence of alarms and fire suppression and smoke control problematic.

While there are major problems to be solved for the wider building design and construction industry, the Lacrosse and Grenfell incidents have helped prompt an examination of the role of fire safety engineers and the competence, education and accreditation to improve overall design practice, with the aim to lift the level of performance of fire safety engineers to that of a true profession.

Lacrosse building, Melbourne.



A gas pipe penetrates what should be a fire resistant wall opening, but the gap has been filled with combustible foam. Hazards in commercial and residential properties are introduced by building practitioners who lack competency in fire safety.

Computer cable installers have cut through a fireproof plaster board potentially allowing smoke and flames to breach the compartment where a fire originates thus spreading through a high rise tower building. Hazards in commercial and residential properties are introduced by building practitioners who lack competency in fire safety.

Proper safety systems require careful technical evaluation.

Given these considerations, the aim of this Warren Centre Project and its research agenda is to provide a nationally consistent set of reform proposals to address:

- The most appropriate role or roles for fire safety engineers in building design and construction
- The most appropriate set of competencies required for the roles to be undertaken
- The accredited education programs and training required to achieve first-tier accreditation.
- The second-tier accreditation with one or more professional bodies for fire safety engineer to control competencies
- Common registration (or licensing) programs at the state and territory levels
- Common language for adoption of all these recommendations into state and territory regulations for building and construction.
- A plan for transition to full competencies and professionalism, recognising the need to lift standards, but at the same time being able ensure there is sufficient supply of fire safety engineers to serve the industry over the transition period.

2.2. SCOPE OF THIS REPORT

This deliverable in the program for this Warren Centre project may be summarised as follows:

- A report on the current status of education, training and stated competencies for Fire Safety Engineers in Australia and internationally as part of the move towards effective professionalisation of Fire Safety Engineering.

In developing this report, it became clear that the role of the Fire Safety Engineer under discussion in Australia needed to be better defined. The various roles of Fire Safety Engineers in the design, construction and operation of buildings are therefore summarised in Figure 1. This illustrates the various roles of fire engineers in both the design and compliance processes. This report deals with those roles which are highlighted in yellow and which are typically or sometimes undertaken by professional Fire Safety Engineers in the BCA building regulatory process.

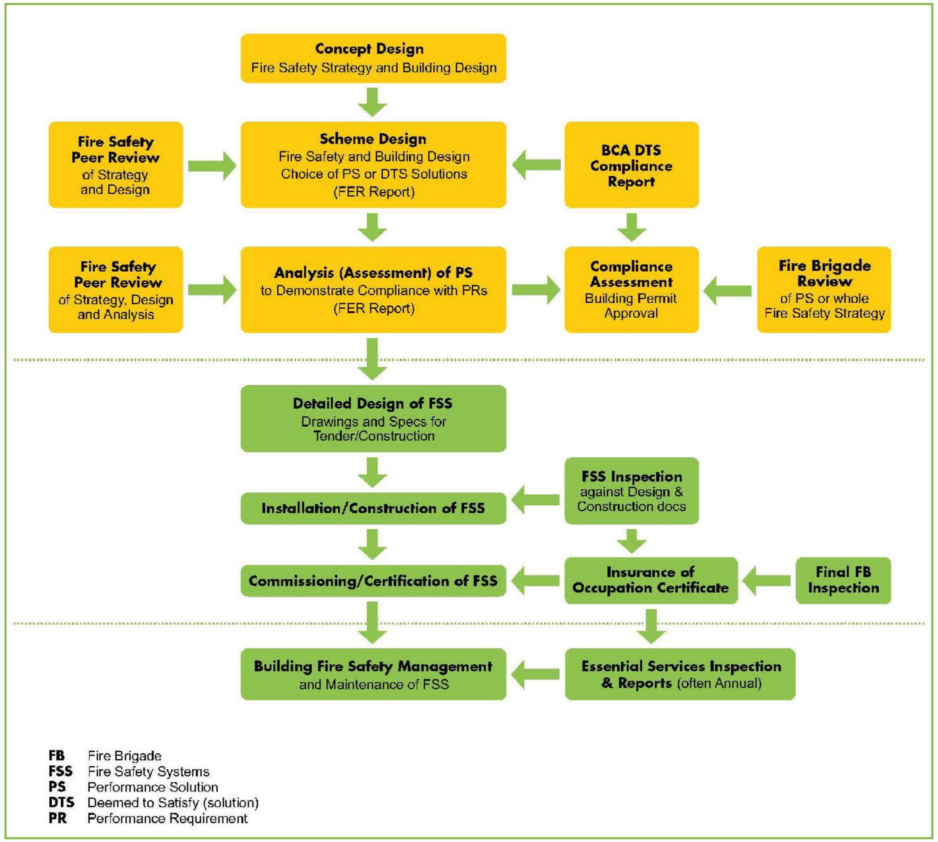


Figure 1. The various roles of Fire Safety Engineers in the design, construction and operation of buildings.

3. Background

The adequate implementation of fire safety is an essential aspect of the development and management of the built environment. Fire safety in the built environment is a social responsibility that can be met only through the effective use of a regulatory framework that guarantees that buildings and infrastructure provide a level of performance that is acceptable on a broad societal level. This framework, conceptually similar for all engineering disciplines, carefully balances the use of three complementary approaches: codes, standards and professional practice. The equilibrium point between these three approaches is largely dependent on the context of the fire engineering being undertaken.

For example, in structural engineering the demonstration of a solution to meet performance requirements of the building codes can be carried out using a range of different tools – with increasing complexity of the tool enabling a greater degree of freedom in design. At the prescriptive end these include construction specification and span tables specification. In an intermediate space is limit state design specification. At the other end these include performance-based design.

For a performance-based design to meet the requirements of the building regulations, there is a need to demonstrate that the individual Performance Requirements are met. This can be (but does not have to be) achieved using Verification Methods. As an example of these methods, the ABCB publish Verification Methods for structural reliability[15] and structural robustness.[16] These describe how designs can be shown to meet certain fundamental requirements of the Building Code of Australia and hence the state and territory building regulations. These methods are very loosely defined and allow the professional engineer exercising them to adopt any analysis method or tool at their disposal. All but the most prescriptive of these tools are written not as predefined solutions but as tools for a professional engineer. Structural engineering most definitely operates under the framework of a profession.

Fire safety design in principle operates in a similar manner. There is a prescriptive end to the spectrum of design solutions, and there is a performance-based end to this spectrum. However, in contrast to structural engineering, fire safety is heavily dependent on the prescriptive end – on codes and standards to achieve the desired level of safety. Codes provide a predefined solution given a specific classification that is intended to serve as assurance of a socially acceptable outcome. Standards will provide measures of necessary performance (i.e. pass/fail) for components and systems. Verification Methods, intended to serve the same function as those for structural engineering, are proposed.[17] However these verge on prescriptive in nature, with specific tools and methodologies incorporated in them as a means for the engineer to demonstrate that Performance Requirements are met. Even without direct reference to the Verification Methods, performance-based fire engineering solutions are effectively restricted in their scope by the existence of a codified means of solving fire engineering problems. This also takes away from the engineer the onus of possessing a good fundamental knowledge of the science behind, and importantly the limitations of

[15] ABCB Structural Reliability Handbook, 2015. https://www.abcb.gov.au/Resources/ Publications/Education-Training/Structural-Reliability
[16] ABCB Structural Robustness Handbook, 2016. https://www.abcb.gov.au/ Resources/Publications/Education-Training/Structural-Robustness
[17] ABCB verification methods for fire safety engineering

different tools and methodologies. It has elsewhere been argued, as a result, that fire safety more closely resembles a regulated trade as opposed to a profession.[18]

It must be acknowledged that structural engineering as a profession is significantly older than fire safety engineering. However, the comparison between fire safety engineering and structural engineering serves the purpose of illustrating the bias in fire safety engineering towards prescriptive rules in contrast to another engineering profession which is tasked with ensuring safety. In fact it has been argued that the practice of fire safety engineering is such that it can be more closely compared with the profession of architecture because of its multi-disciplinary nature.[19] A comparison of these two professions would be even more damning for the fire safety profession – since architects work in a framework that is very heavily biased towards professionalism as opposed to codes and standards.[20] Indeed while practitioners of other professions, including structural engineering and architecture, are permitted to self-certify after achieving some professional accreditation, fire safety engineers are always, in Australia and in many other jurisdictions, subject to certification against codes and standards by an external party.

When it comes to safety, it is fundamental to revisit constantly the regulatory framework to guarantee that technological innovation, public policy, architectural imagination and economic drivers are not moving performance assessment into a space where the existing framework can no longer guarantee safety. The analysis has to include the regulatory framework itself and also the way in which it

"Confusion of competency" and "design by disaster" drove the poor outcomes observed at Lacrosse and Grenfell.

Examples of iconic architecture that incorporates performace-based fire safety engineering. Left: Martin Place, Sydney. Right: National Portrait Gallery, Canberra.

[18] J.L. Torero, "Fire Safety Engineering: profession, occupation or trade?" International Fire Professional Magazine Vol. 1 No. 1 July 2012, Institution of Fire Engineers, UK.
[19] M. Woodrow, L. Bisby, J.L. Torero; A nascent educational framework for fire safety engineering; https://doi.org/10.1016/j.firesaf.2013.02.004
[20] P. Tombesi; The Carriage in the Needle: Building Design and Flexible Special Systems, Journal of Architectural Education, 52:3, 134-142, 1999.

is implemented. It is possible that the nature and demands of practice can deliver a poor outcome while rigorously complying with the regulatory framework. Revisiting the framework many times requires a redefinition of the boundaries of disciplines because the reality of practice can challenge the knowledge base of professions,[21] the objectives and methods embedded in standards as well as the classifications and solutions stipulated by codes.

Drivers of construction such as economics, sustainability and innovation are very strong and are constantly redirecting practice, and as a result, the balance between codes, standards and professional practice can shift in the wrong direction allowing weaknesses to creep in. It is important for a discipline to endeavour to identify systematically symptoms of emerging weaknesses. Indeed, this is part of the responsibility embedded in professional practice.

Professional practice is based in knowledge and a clear understanding of the bounds of knowledge; thus, professionals are required to re-evaluate constantly and update their knowledge to maintain currency with advancement and to refrain consciously from practicing outside the bounds of their competency. In a similar manner, codes and standards need to be revisited to determine if they remain fit for purpose.

Other more complex symptoms are more difficult to identify, and their identification requires a profound disciplinary introspection. Such proactive introspection for Fire Safety Engineering occurred in 2012.[22] This analysis identified two important symptoms which indicated that a thorough revision of the regulatory framework was necessary to match the practices. First, there was a very inconsistent perception of the role of fire safety engineering in design and construction, as expressed by other stakeholders in the construction industry. Second, it was clearly identified that three very different roles (Fire Safety Designers, Fire Safety Code Consultants and Fire Safety Engineers) coexisted under the umbrella of a single definition. In Australia, these different roles might be loosely projected to combinations of Fire Safety Engineers practicing design and/or fire engineering analysis, building surveyors or certifiers, and Fire Services Engineers designing systems such as, e.g. sprinklers.

These roles required very different skills and personal attributes but also should not exist under the same definition because they cross over between professional practice and the practice of a regulated trade. This, in retrospect, was a very important finding because it evidenced an entrenched confusion of competence that extends beyond the bounds of fire safety. This analysis showed that the confusion of competency deeply affected the expectations of other stakeholders as well as the structure of responsibility.

If these weaknesses are not addressed in a proactive manner, they can result in disasters. Disasters tend to wake society to the imbalance, and generally a correction follows. This is called "design by disaster." In order to avoid this reactionary approach to regulatory change, it is fundamental to establish public policies that enable a constant revisiting of the regulatory framework. As indicated above, these policies need to be supported by regular improvements of codes and standards to meet the new demands. It is also necessary to conduct a regular assessment of the competence framework that results in professional accreditation in a manner that

[21] S.G. Knowles, The Disaster Experts, Mastering Risks in Modern America, University of Pennsylvania Press, 2011.
[22] C. Maluk, M. Woodrow, J.L. Torero, The potential of integrating fire safety in modern building design, Fire Safety Journal 88, 104-112, 2017.

reflects the evolution of the practice. A brief description of these processes as applied to fire safety follows.

3.1. THE PRESCRIPTIVE FRAMEWORK

In fire safety, the prescriptive regulatory framework relies on building code-based solutions and standardised testing. Building codes are structured worldwide in a very similar manner. First, a building is classified based on a set of common features that enables the grouping of a set of buildings (for example its intended use and occupancy), and given these characteristics, buildings in a given classification will allow a similar solution that provides an adequate level of safety. Classifications in Australia, for example, tend to be based on the intended use of the building. Eight classes (Class 2 to 9) of buildings are defined in Australia in the NCC Volume One – Building Code of Australia, and within each of these classes there exist various sub-classes which further narrow down the intended use of the building in a manner related to the perceived risk to the occupants as a result of failure of the building to satisfy any of the general requirements of the BCA. Based on the type of occupancy of a building classification, simple and common rules of egress such as maximum egress distances can be specified. Furthermore, the building will be required to have certain features that encourage idealised evacuation. Such measures are proper design of egress

Fire safety engineers are responsible to provide proper egress, fire detection systems and alarm systems customised for unique building applications.

> The structure needs to maintain integrity during evacuation and through the activities of the fire service.

paths, detection and alarm systems as well as signalling. These maximum egress distances enable the quantification of the time for egress; thus, along with certain characteristics of the building occupants they define the Required Safe Egress Time (RSET).[23] While the quantification is not explicit, compliance with the rules assures that egress will follow a pre-defined process and egress times will be within certain bounds.

In a similar manner, the characteristics of the building, its fuel loads and basic geometry are all bounded by the classification. The codes will then require certain countermeasures (e.g. compartmentalisation, sprinklers, flammability of materials, etc.) to bound fire growth so that sufficient time is made available for egress. Once again, the evolution of the fire is not explicitly quantified, but if the rules are followed then experience and prior analysis shows that the fire will not lead to untenable conditions (i.e. temperature, toxic gases, etc.) before all occupants have evacuated spaces at risk. This is known as the Available Safe Egress Time (ASET). Again, the quantification of ASET when following these common rules is not explicit.

A final countermeasure that needs to be put in place is the protection of the structure. The structure needs to maintain integrity during evacuation and through the activities of the fire service. Given the uncertainty of both egress times and response and rescue times, codes have traditionally opted to protect the structure to withstand the worse possible fire until burn-out of the fuel.[24] The time necessary for burn-out of the fuel is intimately related to the fuel load, and thus to the classification.

Classification, as well as these Deemed-To-Satisfy Solutions in a fully prescriptive design, form together what is called the fire safety strategy. In a prescriptive design this strategy remains implicit. Nevertheless, it still provides sufficient assurance that, although not explicitly quantified, ASET is greater than RSET when applied appropriately. This exemplifies the concept of a certain acceptable level of life safety being implicit in the use of the prescriptive framework. It is just one of various objectives, set out as Performance Requirements in the BCA, which any building design solution for fire safety is required to meet. Others include fire fighter safety and the prevention of fire spread from building to building.

The prescriptive approach to fire safety is based on an implicit assurance of some level of safety on the basis of a building that delivers a complex solution for a specific classification. This level of safety is considered generally acceptable to society based on experience in implementation and on the costs associated with the implementation. Classification and solutions have many assumptions and limitations that need to be recognised by those who apply or evaluate prescriptive solutions.

[23] M.J. Hurley and E.R. Rosenbaum, Performance Base Fire Safety Design, CRC Press, 2015.
[24] L. Bisby, J. Gales, C. Maluk, A contemporary review of large-scale non-standard structural fire testing, Fire Science Reviews, 2, 1, 2013.

3.2. STANDARDISED TESTING

Most of the protection equipment and systems used for fire safety are very complex in nature, and models of performance are very complex and difficult to use. Therefore, the most common means of assessment of performance is through standardised testing, based in this country on Australian Standards or ISO Standards.

Some tests are simple tests of comparative performance where the use of a certain component is only allowed if it matches the performance of an acceptable instrument. This is the case of smoke detectors, where standard testing[25] is a comparison of product performance against a Measuring Ionisation Chamber (MIC). In other cases, such as sprinkler systems[26] or façade systems[27] standardised tests recreate a scenario that is consistent with the classification and test the product against this scenario before it can be sold in the market. In these cases, a pass/fail criterion is established, and therefore the applicability of the tests has to conform strictly to the classification. Extrapolation is very difficult, because in general the scenarios used for these tests are extremely complex.

Fire resistance is a slight variant on this approach. In this case, it is not a scenario but a representation of what is deemed to be a worst-case condition. ISO 834[28] prescribes a standard temperature-time curve that is intended to represent a worst-case fire scenario. While this curve is not specific to a classification and therefore can be used as a measure of performance for multiple classifications, it does have some assumptions and limitations that need to be respected. The fire safety requirements within a classification ensure that those assumptions are met.

Global best practices for equipment and systems are disseminated by the International Standards Organisation (ISO) and Standards Australia.

[25] UL-217 Standard for Smoke Alarms, Underwriters Laboratory, 2015.
[26] NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems, NFPA, 2017.
[27] BS 8414, Fire performance of external cladding systems, British Standards Institution, 2018.
[28] ISO 834-11:2014, Fire resistance tests - Elements of building construction -- Part 1: General requirements, International Standards Organisation, 1999.

3.3. THE APPLICATION OF THE PRESCRIPTIVE FRAMEWORK

Individuals executing a prescriptive fire safety strategy need to follow carefully the rules (in the BCA, the DTS Provisions). Nevertheless, given the wide range of buildings within a classification, the rules have necessary ambiguity. This means that the individual using the rules is not exempt from competency. The question of competency has long been the dilemma of fire safety and an issue that remains a sore point. Naturally, the fire brigades have been considered a competent authority. This cannot change because a building on fire is the work place of the firefighter. Thus, the fire service has responsibility over the occupational health and safety of their staff. In an environment of very rigid and adequate prescriptive rules, the ambiguity is small, and limited training and experience can allow the fire service to fulfil the role of competent authority. In a similar manner, generalist building approvals authorities have taken a similar role. In some countries there are specific authorities having jurisdiction, and for example, in some states and territories in Australia, private certifiers or council-based building surveyors with some fire safety training are required to evaluate fire safety measures. In some other states or other countries, there are general building certifiers and in others a combination of all of the above.

In an environment like Australia[29] or the United Kingdom[30], where the building code and standards are very general and ambiguous, thus allowing innovation and new products to enter the market, the dependency on competency is much higher. The training of the fire service and the generalist authority becomes insufficient to fulfil the role of competent authority, and there is a need to redefine the design process around a professional framework. Furthermore, roles and responsibilities need to change because stakeholders with limited understanding of fire safety (e.g. Architects, Structural Engineers, Certifiers / Building Surveyors, Building Services Engineers, etc.) are no longer capable of making decisions in an informed manner. A clear and adequate definition of competency becomes paramount for the correct assignment of roles in the design and construction process. Unavoidably, with a rigorous definition of competency appears the need for means to enforce such competency.

A clear and adequate definition of competency becomes paramount for the correct assignment of roles in the design and construction process.

[29] The National Construction Code; Australian Building Codes Board
[30] Statutory guidance Fire safety: Approved Document B - Building regulation in England covering fire safety matters within and around buildings, Ministry of Housing Communities and Local Government, United Kingdom, 2010.

3.4. THE NON-PRESCRIPTIVE FRAMEWORK

As explained above, at the core of a prescriptive fire safety strategy is the classification and the Deemed-To-Satisfy Provisions. If a building falls outside of the scope of available classifications, then it can either be modified so that it is within scope, or it needs to be treated by a professional. Professional treatment requires the explicit demonstration that not only is ASET greater than RSET but also that fire fighter safety will be ensured during any fire brigade interventions and that spread of fire between buildings will be prevented. Achieving this requires the analysis of both standardised and non-standardised test data to extract the information necessary to adequately address performance. In Australia, this means the determination of the right combination of BCA Performance Solutions and Deemed-To-Satisfy Solutions to demonstrate compliance with the BCA Performance Requirements relevant to fire safety.

There is no question that in the realm of performance-based design, problems are both complex and difficult to assess. Currently, building codes are generally falling behind worldwide. Even in the stricter environments, the forceful introduction of technology by economics (e.g. structural optimisation challenging the principles of fire resistance), by public policy (e.g. introductions of insulated plastic façade systems as a response to sustainability and energy efficiency requirements) or by aesthetics or functionality (e.g. large volume spaces as a challenge for smoke management and compartmentalisation) has resulted in a serious disconnection between the building codes and the reality of construction. This is of critical importance in developed and under-developed countries because technologies migrate rapidly but the speed for code reform is inversely proportional to development.

In this realm, fire safety solutions require the use of intricate tools within a very multi-disciplinary context. Only professionals should be entitled to develop fire safety solutions of this nature. Other approaches, such as Verification Methods, should by definition be more flexible and reliant on complex concepts enabling their application to buildings which fall outside of the classifications in the code. The use of a Verification Method should result in an explicit demonstration that a known safety target has been met. Thus, their use should also be limited to competent professionals. There is no substitute for professionalism.

Scaffolding at the Grenfell Tower site investigation.

4. Accreditation of Professional Engineers

A professional engineer is an individual that through their personal and professional attributes and competency is capable of using engineering tools, verification methods, codes and standards as input towards an explicit design. The Australian Standard Classification of Occupations (ASCO)[31] 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 the 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.

[31] Mclennan, W. (1997) Australian Standard Classification of Occupations Second Edition; Australian Bureau of Statistics

The professional has to be adequately accredited within a professional framework and by a group of likewise accredited professionals. The professional should have mastered the fundamental knowledge behind the discipline as well as have sufficient experience to be able to apply this knowledge towards design. To support a professional framework, it is essential to adequately structure mechanisms that will enforce professional monopoly.[32] In the absence of enforcement mechanisms confusion of competence prevails, weakening the role of the professional.

Generally, professional accreditation requires a proof of basic knowledge and attributes, this is called **first-tier accreditation**. This proof is typically delivered by successfully completing a higher-education program accredited by a body of professionals practicing in the relevant discipline and/or by examination. Once the individual demonstrates 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. The professional body will 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 registration (but sometimes called accreditation) by a body such as Engineers Australia.[33] Maintaining a professional registration requires constant update of knowledge and experience, thus an individual's professional accreditation requires continuing professional education and review. Most professions have well established processes that are very similar to what is described above.

4.1. FIRST-TIER ACCREDITATION

According to the process described above, first-tier accreditation of engineers is typically achieved by following a degree program accredited by one of the national registration bodies around the world for engineers as providing the expected background knowledge and skillsets required for future professional registration. This means that the program has been determined and demonstrated to result in graduates who possess certain attributes expected of the professional. These include: a possession of engineering knowledge, a capacity for problem analysis, skills in the design / development of solutions, investigative ability, an ability to use modern engineering or analysis tools, an understanding of the engineers' role in society, an appreciation of the environment and sustainability, appreciation of their ethical responsibility, an ability for individual and teamwork, communication skills, project management and finance skills, and life-long learning.

The Washington Accord is an agreement among national organisations that provide first tier accreditation to tertiary educational programs. This agreement was based on the understanding that individual processes, policies, criteria and requirements for granting accreditation to university level engineering programs were substantially equivalent across international boundaries. These organisations agreed to grant the same rights and privileges to first tier accreditation to graduates of programs accredited by all other signatories of the agreement as they grant to their own accredited programs.

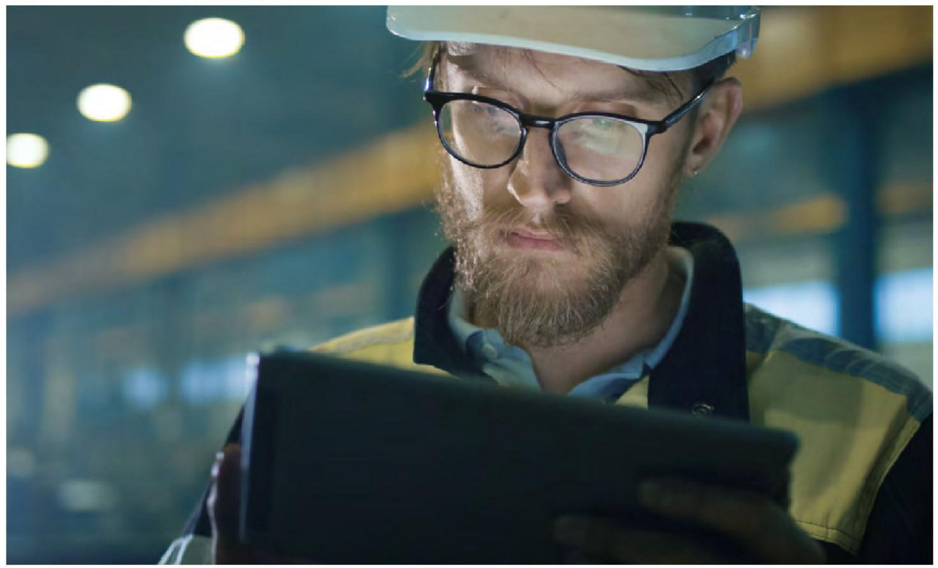
In 1989 the Washington Accord was founded by organisations from Australia, Canada, Ireland, New Zealand, the United Kingdom, and United States. To date organisations from Hong Kong, China, South Africa, Japan, Singapore, Korea, Chinese Taipei, Malaysia, Turkey, and Russia have also signed the agreement. Bangladesh, China, India, Pakistan, Philippines, and Sri Lanka hold provisional status.

Presently, the Washington Accord is an agreement signed by organisations that together accredit over 7,000 engineering programs around the world. The signatories undertake a process of periodic peer review to ensure each other's accredited programs are substantially equivalent and their outcomes are consistent.

Accredited degree programs usually last for between four and five years depending on the territory and result in an MEng degree or equivalent. Partial accreditation of degree programs is also achieved in some instances. In the UK, for example, the Engineering Council accredits some degree programs through the professional bodies as partially fulfilling the requirements for education. This means that in order for an individual to meet the requirements for first-tier accreditation further study is needed. The Engineering Council accredits other programs in the UK as providing the further education required.

Alternative routes are available for first-tier accreditation in lieu of an accredited degree. However, when pursuing these alternative routes, the applicant will need to demonstrate possession of these attributes by alternative means such as by passing an entry examination.

The Washington Accord sets international standards for first-tier engineering accreditation.



[32] J.L. Torero, "Fire Safety Engineering: profession, occupation or trade?" International Fire Professional Magazine Vol. 1 No. 1 July 2012, Institution of Fire Engineers, UK.
[33] International Engineering Alliance (2014) 25 years of the Washington accord 1989 - 2014

4.2. MULTI-TIER COMPETENCE FRAMEWORK

The Sydney Accord (signed in 2001) covers international recognition of educational programs for engineering technologists. According to the ASCO, an engineering technologist is someone who "applies and modifies established engineering practices such as the design and implementation of civil, mechanical, electrical or electronic engineering projects." The expected skill level of an engineering technologist is similar to that of a professional engineer, although the tasks performed are different.

The Sydney Accord covers degrees of three years duration post-secondary school. In some jurisdictions engineering technologists are referred to as incorporated engineers. The engineering council of the UK defines the difference a chartered engineer and an incorporated engineer as:

- 'Chartered engineers (CEng) 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.'[34]
- 'Incorporated engineers maintain and manage applications of current and developing technology, and may undertake engineering design, development, manufacture, construction and operation.'[35]

Engineering technologists and technicians are accredited paraprofessionals who support the design process.

[34] https://www.engc.org.uk/ceng
[35] https://www.engc.org.uk/ieng

The clear distinction being made here is not necessarily in the technical knowledge of the individual achieving these levels of accreditation, rather in the role of the individuals in the engineering team and the ability to apply new technologies or solutions creatively. Reflecting on the regulatory system discussed in the background section of this report, the role of the incorporated engineer is heavily biased towards application of codes and standards without accountability for the solutions, whereas the role of the chartered engineer may be biased more towards professionalism with a commensurate level of responsibility.

The Dublin Accord (signed in 2002) covers international recognition of engineering technician qualifications. These are diplomas of two years duration post-secondary school.

The existence of the Washington, Sydney and Dublin Accords enables a multi-tier framework for regulation of professional competence, one comprised of both chartered engineers who have achieved full accreditation via one of the routes described above, as well as engineering technologists and engineering technicians who may follow a slightly different path.

4.3. WEAKNESSES IN THE ACCREDITATION PROCESS

The most important weakness of fire safety engineering today is 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 scrutinised. 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 rationalised or kept up to date.[36]

Second-tier accreditation is currently granted, in many countries, through the exception scheme. Given that the majority of applicants fall within the exception and as will be discussed there is no well-defined framework of required knowledge or attributes, this process of second-tier accreditation also has questionable value.[37]

[36] M. Woodrow, L. Bisby and J. L. Torero, "A nascent educational framework for fire safety engineering," Fire Safety Journal, 58: 180-194, 2013.
[37] Spinardi, G., Bisby, L., Torero, J.L., A Review of Sociological Issues in Fire Safety Regulation, Fire Technology, 1-27, 2016.

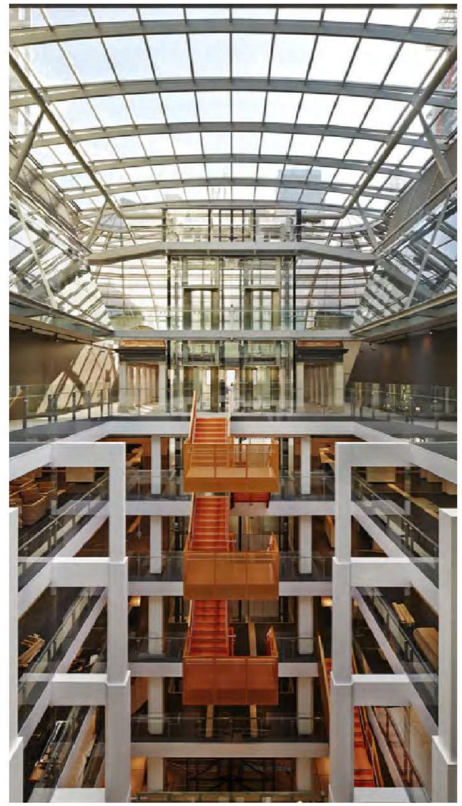
5. Educating the Fire Safety Professional

A Fire Safety Engineer should be able to design a robustly defensible fire strategy.

Many definitions exist for the fire safety engineer.[38,39,40] These are not incompatible, although often have a slightly different focus. A general definition of a professional Fire Safety Engineer may include an ability to apply science and engineering principles to specify fire safety needs or solutions. Note the use of the word 'specify'. A fire safety engineer is different from a building services or fire services engineer. While a fire safety engineer may specialise in a particular aspect of fire safety, they should be able to design a robustly defensible fire strategy accounting for all components which that strategy is composed of. In comparison, a fire services or building services engineer may have responsibility for detailed design and installation of specific systems such as sprinklers or HVAC systems for smoke control according to standards and specifications provided, e.g. AS2118 or AS1668. Although this report has a focus on fire safety engineering as it relates to the construction industry, it is also important to note that the role of fire safety engineering is not limited to buildings. It may also include transport, wildland and the chemical, process or manufacturing industries, amongst others.

In the United States the term Fire Protection Engineer is used, in reflection of the historical role of the profession in designing strategies with a focus on property protection. For the purposes of this report however, Fire Protection Engineer and Fire Safety Engineer are taken to be synonymous.

The role of the Fire Safety Engineer in the construction industry should be in designing and evaluating the overall fire strategy of a building; as well as in specifying the requirements of the components which are incorporated into this strategy. Typically, in Australia this is done when a building is



Martn Place Atrium, Sydney - an example of iconic architecture that incorporates performance-based fire safety engineering.

38 The Institution of Fire Engineers, https://www.ife.org.uk/ accessed 17th December 2018
39 Pathways to a career in fire protection engineering, the SFPE, 2017
40 H L Malhotra; The role of a fire safety engineer; in The Science of Building Fire Safety 1989

deemed to be outside of the scope of the Deemed-To-Satisfy Provisions of the BCA, implying that the relevant Performance Requirements need to be shown to be satisfied by a Performance Solution. An ability to do this effectively requires that in principle the fire safety engineer is involved at all stages of the life-cycle of a building, from conception through design, construction, commissioning, operation, alteration / modification and finally decommissioning / demolition.[41] However, in Australia and other countries, as highlighted in the Shergold/Weir report, fire safety engineers have been mostly restricted to concept and scheme design stages and have had a more limited role, if at all, in construction and commissioning.

The Fire Safety Engineer works under a number of disadvantages in comparison to other engineering disciplines. First, as discussed previously, an adequate level of safety requires all aspects of the fire safety strategy to function in a coordinated way. These components will all have individual performances, and their detailed design will fall within the domain of multiple disciplines. (For example, detection and alarm systems fulfil a fire safety function; nevertheless their design and development remains within the realm of fire services and electrical engineering; smoke extraction systems are intended to deliver tenability in the event of a fire, nevertheless their design is within the remit of the HVAC systems engineer; egress is a fundamental pillar of life safety, nevertheless building layout is the prerogative of the architect; a façade system is a critical part of the fire safety classification requirements of a tall building, nevertheless its design is within the remit of the façade engineer, etc.) It is therefore essential not only to provide adequate education to the fire safety engineer but also to deliver sufficient awareness to other professions of the role and performance that each component of the building design has on fire safety overall. Currently, there is insufficient education available to other professionals of the built environment in fire safety.[42]

The fire safety engineer is involved at all stages of the life-cycle of a building.

[41] H L Malhotra; The role of a fire safety engineer; in The Science of Building Fire Safety 1989
[42] Lambert, M. (2015) Independent review of the building professionals act 2005, Draft report August 2015

A consequence of this situation is that the evolution of the built environment, as well as the introduction of new technologies for the built environment, are currently driven by industries, interests and professionals that are mostly unaware of fire safety issues. Further, the providers of fire safety education cannot deliver sufficient graduates, which is certainly the case in Australia, and the definition of the knowledge and attributes required from all these professionals is not clear either within the profession or outside of the profession. Fire Safety Engineers are therefore constantly in a position where they have to catch-up with the risks associated with innovation. In the absence of a critical mass of competent Fire Safety Engineers, this process of catch-up becomes unmanageable and insufficient for meeting the social responsibility of providing a working and living environment that is safe from fire.

5.1. MODEL CURRICULA IN FIRE SAFETY ENGINEERING EDUCATION

The first step in a robust and fit for purpose accreditation process is the process of education. This however relies on the agreement of expected knowledge and attributes of the professional. Here, as previously alluded to, there has also been insufficient attention paid over the past decades in Australia and internationally.

5.1.1. WORKING GROUP ON FIRE SAFETY ENGINEERING CURRICULA

In 1995, the International Working Group on Fire Safety Engineering Curricula proposed a model curriculum designed to deliver a professional fire safety engineer for the needs of the market at that time.[43] This helped to identify the discipline of Fire Safety Engineering and to define the technical skillset expected for a professional fire engineer. In this process it also distinguished fire safety engineering from other engineering disciplines. It was also intended as a possible basis for the development of new educational programs and as a means to evaluate existing programs.

This curriculum was composed on a knowledge base comprising four basic modules:

- fluid mechanics,
- thermodynamics,
- heat and mass transfer, and
- solid mechanics.

[43] Magnusson, S.E.; Drysdale, D.D.; Fitzgerald, R.W.; Mowrer, F.; Quintieri, J.: Williamson, R.B.; Zalosh, R.G.; A proposal for a model curriculum in fire safety engineering; Fire Safety Journal Volume 25, Issue 1, July 1995, Pages 1-88

While not discussed in the model curriculum, by including these subjects as a knowledge base, the implication for the required background knowledge of a student before embarking on a degree in fire safety engineering is that a good grounding in maths as well as physics is essential. The bulk of the specialist courses in fire safety engineering as outlined in the curriculum are grouped under five modules:

- fire fundamentals,
- enclosure fire dynamics,
- active fire protection,
- passive fire protection, and
- interaction between people and fire.

In addition to these modules, two applied modules are also included:

- risk management for fire and explosions, and
- industrial fire and explosion protection.

The topics covered are briefly summarised in *Appendix 1*. The intended end product of a student following this curriculum is a fire safety engineer who is able to engage at all stages of a project's execution. While the model curriculum defines the required fundamental knowledge, it does not discuss the attributes that a Fire Safety Engineer should possess to be able to deliver the intended outcomes. It has often been the problem with Fire Safety Engineering that the discipline is confused with the underpinning knowledge.

5.1.2. SFPE CURRICULA

The Society of Fire Protection Engineers (SFPE) proposed an update to this curriculum in 2010. This was done in two stages. The first was intended as a curriculum for a four-year BSc level degree.[44,45] The second was a proposal for an MSc level degree which either built on the level of knowledge of the BSc degree program or which developed the competences of a fire safety engineer onto a student with a degree in a related engineering discipline.[46]

As well as the core fire engineering courses identified in the former, the SFPE document went on to detail the general background knowledge requirements of such a degree, including Physics, Chemistry, Maths, English and General elective courses. This was not included in the earlier model curriculum but was included in this curriculum as subjects to be taught at university. It also identified the engineering fundamentals, or core engineering subjects, which would be expected to be taught to students enrolled in a fire protection engineering degree program. These engineering fundamentals were also not identified in the original curriculum proposed. These included statics, dynamics, engineering economics, and computer aided drafting. Both this background knowledge and the engineering fundamentals are included in the BSc curriculum proposed but omitted from the MSc curriculum.

It is not explicitly stated what is the intended product of either of these curricula. However, since these are based on the model curriculum proposed by the International Working Group, it may be assumed that the intended product, certainly of the MSc program, is as above.

It should be noted that in all of these curricula, the focus is on the underpinning knowledge not on the necessary professional attributes. With a technical focus, these curricula and the educational programs that follow them therefore do not impart all of the skills expected or required of a competent professional fire engineer today.

[44] Society of Fire Protection Engineers (2010) Recommendations for a Model Curriculum for a BS Degree in Fire Protection Engineering (FPE)
[45] Milke, J.; Davis, R. (2012) New model curriculum for a BS degree in fire protection engineering; Fire Protection Engineering, Quarter 1 2012
[46] Society of Fire Protection Engineers (2013) Recommended Curriculum Content for an MS/ME in Fire Protection Engineering

A summary of the structure of these curricula is given in *Appendix 1*.

5.1.3. WOODROW ET AL.

A further example of a fire safety engineering education was developed following a series of workshops with the Lloyds Register Educational Trust (LRET).[47] This approach highlights the importance of drawing a distinction between training and education of engineers. Training is defined as the imparting of knowledge, and education is defined as the development of skills in students. The former refers to the ability to apply code-based solutions to fire safety problems – a level of application which could be seen to be consistent with that expected of an engineering technician. Whereas the latter refers to the ability to apply first principles to engineering problems, working outside of prescriptive codes to achieve a desired level of safety. As discussed above, this ability to apply science and engineering first principles is a fundamental attribute of a professional fire safety engineer.

Attention to detail is critical so that fire safety concepts are realised in the final construction delivery.

In the development of their educational approach, the authors of this curriculum highlight accreditation of educational programs as being a problem faced by the fire safety engineering profession, and perhaps arguably symptomatic of this is the poor competency awareness within Fire Safety Engineering:

> *"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 utilisation 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 programs which support all of the above."*

In this approach, likely expectations in terms of foundational or background knowledge and technical skill are summarised – similar to the other curricula highlighted above. However, this curriculum goes further and identifies the professional skill and intangible attributes expected of a professional fire engineer.

[47] M. Woodrow, L. Bisby, J.L. Torero; A nascent educational framework for fire safety engineering; https://doi.org/10.1016/j.firesaf.2013.02.004

The foundational background proposed includes maths, physics and chemistry – being the prerequisite for studying fluid mechanics, heat and mass transfer, thermodynamics and solid mechanics. In reference to the SFPE and Magnussen curricula described previously, this foundational background covers some of the general courses in the SFPE curricula and the background courses identified by Magnussen. Nevertheless, the suggestion is that not all of the requisite fundamental knowledge required to understand general engineering should necessarily be a part of the degree program itself.

In terms of the underpinning knowledge expected of a fire safety engineer, Woodrow et al. conclude that the Magnussen curriculum (which was also the basis for the proposed SFPE curricula) remains current. This is with the possible need for more emphasis on the role of computer models in fire safety engineering as well as the introduction of courses or modules on structural fire engineering.

Woodrow et al. therefore do not focus on the underpinning knowledge expected of a fire engineer since this is covered elsewhere. Rather there is a focus on the professional attributes expected of a Fire Safety Engineer and the pedagogy necessary to attain these attributes. Over the past three decades, innovations in structural design, building management, and material science have created new problems and highlighted cases where known solutions for fire safety can no longer be applied with confidence or do not represent optimised solutions. In this context Fire Safety Engineering cannot be defined as a mature discipline because the expected problems will experience significant changes in a period that is much shorter than the *life-expectancy* of professional knowledge and tools. Indeed, for this very reason, fire safety engineering may very well never be deemed to be a mature discipline. Thus, the continuous application of well-defined methods through the professional life of an individual is not possible; a combination of fundamental knowledge, agility and adaptability are paramount.

Therefore, an alternative approach for Fire Safety Engineering proposed by Woodrow et al. is to focus education not on the solution but on the *definition of the problem*. Knowledge is still required to achieve a solution, but this will be acquired and applied as and when necessary. 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. It is the solution to a specific, novel problem that drives the acquisition of contextual knowledge.

In this approach students acquire *knowledge by doing*, and thus at the same time develop the desired *skills* and in many cases *attitudes*. Defining engineering problems encourages students to criticise, create, learn, and use knowledge in order to solve real problems. The knowledge they *choose* to learn is in a sense up to them and will be a function of their critical and creative thought, their resourcefulness, and their engineering judgement. In a way, *they* will learn how to self-define, research, and acquire the 'fundamentals' required by specific design problems.

Woodrow et al.'s model of education subordinates underpinning knowledge to the skills and attributes acquired through purpose-based learning. This form of education is more related to the education process followed by architects than by other engineering disciplines. It is worth noting that the Magnussen curriculum also suggests that the fire safety engineer's role is similar to the architects.

It is also fundamentally important to review education, training and accreditation practices within the fire service.

5.1.4. A CONFUSION OF COMPETENCY

As highlighted above, proposals for underpinning knowledge and educational methodologies exist as well as several higher education offerings. Nevertheless, it is still unclear what the appropriate definition is and what are the required attributes and knowledge that produce a competent Fire Safety Engineer. This problem seems to be less about education and more about the current environment for practice.

At the core of this problem is what Woodrow et al. labels "the special role of the fire services as the perceived competent authority." Many, however, have criticised the involvement of the fire service in building approvals and inspections, and in many jurisdictions, their role has diminished as a result. Criticism resulted from a strong feeling, within the construction sector, that firefighters were not delivering an adequate service related to fire safety engineering and buildings reviews and approvals. This is a phenomenon that has happened worldwide. The construction industry has questioned the timeliness of response as well as the quality of the fire safety assessments and inspections. The result was a push for exclusion. The fire service has recurrently objected to losing control, nevertheless public policies have been following market demands pushing for a more devolved process of approvals and inspections. This has resulted in confusion and tension because the fire service cannot, for health and safety reasons stated above, entirely be excluded from these processes.

Total exclusion would take away responsibility from the fire service because they would no longer be involved in the delivery of a building that should operate, during a fire, according to plan. The exclusion of the fire service from all those building related matters creates an expectation that others (e.g. engineers, builders, tenant management organisations, etc.) have the responsibility to deliver a building that generates only a fire the firefighters can fight. Given that full exclusion is not possible, this has once again resulted in confusion and an inadequate definition of responsibility. This further contributes to diminish the importance of those within the fire service with competencies in building behaviour.

The fire service will have a similar accreditation process to that described above for the task of fighting fires. Nevertheless, with very rare exceptions this will not include a component of understanding building performance. The education and training structure of the fire services is consistent with a professional practice, and the two levels of certification appear in numerous instances of the career of a fire fighter.[48] Nevertheless, the view that dominates among the fire services is that their education should primarily contribute to developing practical professional skills in the form of familiarity with equipment, methods and techniques to enable them operationally to handle various kinds of accidents in a confident and safe manner.[49] Furthermore, the internal image of the competent firefighter has arguably until very recently been largely tied to practical experience, a well-trained

[48] R. Holmgren, Nordic Journal of Vocational Education and Training Vol. 4 2014. 49 See footnote 15.
[49] ABCB Structural Reliability Handbook, 2015. https://www.abcb.gov.au/Resources/ Publications/Education-Training/Structural-Reliability

Site engineers review construction progress at the Birmingham New Street railway station in England.

body[50] and to someone of concrete use to society through damage-limiting initiatives.[51] When it comes to the capability of fire fighters to assess building performance, the focus on operational orientation and prescriptive approaches is not considered to meet contemporary safety and preparedness requirements in societies undergoing rapid change.[52,53] Of course, this traditional view does not reflect the evolving role of the fire brigade in many jurisdictions. For example, in Australia the fire brigade serves two roles – the traditional role of intervention and response which elicits the above image, and one of a referral body which is invited although not mandated to weigh in on complex fire safety issues as part of the regulatory framework. Given that it is not possible to circumvent the fire services role in fire safety engineering practice in either of these roles, it is also of fundamental importance to review education, training and accreditation practices within the fire service.

Firefighter training is clearly insufficient to understand the intricacies of modern buildings and in particular all potential forms of behaviour in the event of a fire. The profile of those recruited to the service is aligned with the activities of a first responder, and therefore individuals entering the service generally are more focused on, and afford more value to, direct interaction with the fire. It is therefore expected that they will not have a tendency to develop knowledge and understanding in the technical intricacies of building performance. This is reinforced by years of training and tradition. As noted above, this situation is

[50] Ericson, M Jämställdhet och mångfald inom kommunal räddningstjänst. Myndigheten för samhällsskyddoch beredskap, 0024-09. Karlstad: MSB, 2010.
[51] Baigent, D. One More Last Working Class Hero. A Cultural Audit of the UK Fire Service. Fitting-in Ltd & The Fire Service Research and Training Unit, Anglia Polytechnic University, 2001.
[52] Baigent, D., Hill, R., Ling, T., Skinner, D., Rolph, C. & Watson, A. Training Firefighters today as tomorrow's emergency workers. Cambridge: Fire Service Research and Training Unit at APU, 2003.
[53] Childs, M. Beyond training: new firefighters and critical reflection. Disaster Prevention and Management, 14 (4), 558-566, 2005.

evolving, and fire brigades do now employ fire engineers required to fulfil their role as a reviewing body. It must be noted that while commonplace in Australia, this is definitely currently the exception to the rule. Further, this role as reviewer requires the fire service to possess a skillset which enables them to function as such – this requires the further definition of a knowledge base and skillset which enables them to technically challenge the competent fire engineer.

An attempt to address these issues was introduced through higher education programs in several institutions around the world (e.g., in the UK at Glasgow Caledonian University and the University of Central Lancashire, in the USA through Fire Technology programs, etc.) These programs introduced design, regulatory and engineering principles to enhance the technical competency of firefighters so that, in principle, they will be able to direct activities such as design review or building inspection required by this evolving regulatory role. Educational programs provided by these institutions have never introduced the same entry barriers and assessment filters as those of recognised fire engineering programs. Therefore, in their role as reviewer, their ability to challenge the professional fire engineer is not strictly guaranteed. This is true of any reviewing or certifying body in the current framework except arguably for peer review.

Other examples of this practice include the Graduate Certificate or Graduate Diploma courses in fire engineering offered to fire fighters at the Western Sydney University, Victoria University and the University of Queensland, and previously at the Queensland University of Technology. While it is unquestionable that some firefighters had the attributes to reach the highest level of competency, their numbers have been small given the unfavourable context. The unfortunate result is that development of these programs has reinforced a confusion of competency.

5.2. EXPECTED COMPETENCIES OF A FIRE SAFETY PROFESSIONAL

The SFPE summarise the minimum desired competencies of a fire protection engineer according to four headings: fire safety science, human behaviour and evacuation, fire protection systems and fire safety analysis.[54] These competencies are defined according to the knowledge base associated with them and are demonstrated by means of a comprehensive understanding of that knowledge base – acquired through a period of study. These headings are further subdivided by the SFPE according to a number of different knowledge areas – knowledge areas which are consistent with those proposed by the International Working Group on Fire Safety Engineering curriculum as well as with the curriculum proposed by the SFPE. This is thus a definition of competence based on knowledge alone.

[54] SFPE (2018) Recommended minimum competencies for fire protection engineering

In contrast, however, the International Engineering Alliance define a professionally competent person as someone with the attributes necessary to perform the activities expected of them within the profession or occupation and to the standards expected in practice.[55] This definition of competence goes beyond the underpinning knowledge and includes the *ability to apply* one's knowledge to complex engineering problems. Engineers Australia, consistent with the IEA, also reflect in their competency standard for professional engineers an ability to apply the fundamental knowledge acquired through study.[56] Engineers Australia's competencies for membership to the association include aspects related to the knowledge and skill base; the engineering application ability; and the professional and personal attributes of a graduate.

This desired competency in application expected of an engineering professional is not in fact explicitly reflected in either of the curriculum proposed by the SFPE or the accompanying competency statement; or in the model curriculum proposed by the International Working Group on Fire Safety Engineering Curricula. The International Working Group however, as noted above, does define the expected role that the graduate of a fire safety engineering degree program may be expected to fulfil. This missing acknowledgement of an ability to apply knowledge attained through study as a key component of competence is a focus of the curriculum proposed by Woodrow et al., and described above. However, the role of education as the first stage in professional accreditation can only go so far, and while, as suggested by Woodrow et al., some ability should be imparted on engineers in the educational process, the competence in application must be further developed while undergoing the process to achieve second tier accreditation.

The relative dates of publication of the SFPE curricula and competencies suggest that the competencies were developed and elaborated after the curricula. This is further supported by the similarity between the curriculum of the International Working Group and the stated competencies of the SFPE. The implication of this is that professional competencies are defined to justify the existing educational programs. This is a fundamentally backwards approach. Expected competencies of the fire safety professional first need to be defined, and then educational programs and curricula, and the accompanying professional accreditation process need to be developed to deliver the expected competencies.

[55] International Engineering Alliance (2013) Graduate Attributes and Professional Competencies Version 3: 21 June 2013
[56] Engineers Australia (2017) Stage 1 competency standard for professional engineer

5.3. AVAILABLE EDUCATION PROGRAMS

A comprehensive review of all of the educational programs and courses in fire safety engineering internationally is neither needed nor relevant for the discussion in this report. A summary of the programs offered in some of the key institutions, including those offering accredited degree programs, is given in *Appendix 2*, along with a brief introduction to some of the other institutions' educational activities. For a more comprehensive list of institutions engaged in fire safety engineering, the reader is referred to the website of the International Association for Fire Safety Science (IAFSS).[57]

In Australia there is a history of educational programs for fire safety engineering, at Victoria University, the Western Sydney University, University of Melbourne and more recently the University of Queensland. With the exception of the program at the University of Queensland, all of these programs are restricted as a result of a lack of critical mass in both the numbers of academics delivering the program and as a consequence of this a restricted knowledge base – with many programs existing only through the use of invited or guest lecturers. Only the program at the University of Queensland does not suffer from this and has achieved full accreditation through Engineers Australia. This is the only program in the region that delivers a level of education which is recognised as providing the required background for first tier accreditation of individuals. In the Australasian region, the University of Canterbury in New Zealand also offers degree programs in Fire Safety Engineering, however up until now they have not attempted to achieve accreditation of their degree program.

Internationally, there are relatively few programs which are known to provide the level of education required. These include programs at the universities which were represented in the International Working Group on Fire Safety Engineering Curricula noted above. These include the University of Lund; The University of Edinburgh; Worcester Polytechnic Institute; The University of Maryland; and The University of California, Berkeley. In addition to this list, institutions including the University of Ghent, Edinburgh and Lund also deliver the International Masters of Fire Safety Engineering program, which is accredited through the Dutch-Flemish accreditation body. There are of course other examples of accredited courses, however these are vastly outnumbered by unaccredited courses. This means that the majority of individuals seeking admission to one of the professional fire engineering organisations as an accredited professional engineer are unable to achieve first tier accreditation on the basis of their education and that alternative means of competence demonstration must be followed.

[57] http://iafss.org/links/; accessed 22nd August 2018

6. The Current Accreditation Process

6.1. THE ROLE OF THE PROFESSIONAL ORGANISATIONS

It is the role of the professional organisation to define the necessary competency to participate in the profession. This competency being a combination of the technical knowledge, skills and the personal attributes expected of a fully accredited professional. Professional organisations have been unable to act on the need for an adequate and concerted definition of competency or on the development of an adequate accreditation process for Fire Safety Engineering higher-education programs. The absence of a true, established professional framework severely limits the progress of Fire Safety Engineering and fuels confusion of competency from the perspective of those outside the field. Individuals that do not have a deep understanding of the discipline will misunderstand the competency differences between the Fire Safety Engineers, fire services engineers, the fire brigade personnel and other fire related practitioners.

Given the absence of a true definition of competency, it is very easy to challenge professional practice. Challenges come particularly from the fire services/brigades or certifiers which, from an approvals or referral role, question decisions made by engineers. What has followed is a systematic deterioration of the practice of Fire Safety Engineering because anyone felt entitled to question professional decisions. In an atmosphere of this nature, it is inevitable that the trend will be towards the lowest standards.[58] Fire safety being a constraint in a market driven economy; responsible, ethical and competent engineers will be overruled by lower-cost solutions produced by individuals who lack the competency to understand the potential impact of their actions. This is an unfair market for a quality product.

Given the inherent barriers with regards to consistency and speed of approval imposed by a regulatory certification authority, being the certifier as the approval agency and fire brigade as a referral agency, this part of the process became the natural target of all those who demand a more consistent, fast and effective process of project realisation. However, instead of clearing the confusion by resolving the problem and defining a required competency, the result was devolution of approvals and inspections. Once again, in this devolution no adequate measure of competency was required for those executing the tasks necessary to guarantee the wellbeing of the public, and today it is common practice that generalists, with no professional credentials in fire safety engineering, will conduct reviews and inspections as part of the approvals process. These individuals have limited capacity to identify complex performance issues within buildings and furthermore have almost no capacity to withstand the challenges imposed by building owners, developers, the fire service and Fire Safety Engineers.

[58] J. Hackitt, Building a Safer Future – Independent Review of Building Regulations and Fire Safety: Final Report, Crown Copyright, May 2018.

1 Bligh Street, Sydney is an example of the remarkable architectural creativity possible with performance-based FSE.

6. The Current Accreditation Process

Until the Grenfell Tower fire, many failure events could have been perceived as symptoms that evidenced the need for substantial reforms, nevertheless the perception has prevailed that simple changes are all that is needed. This has mostly been due to the lack of sufficient competency to comprehend the severity of the problem implied by these events. The Grenfell Tower fire in London and the Lacrosse Building fire in Melbourne provided evidence that rapid development in high-rise construction has affected fire safety in a manner that challenges the capacity of society to deliver safe living environments. It has become evident that existing approaches to building regulation, in their ambiguity and reliance on competency, are not capable of delivering safety in the absence of competent professional practice. Buildings and infrastructure associated with vulnerable populations (e.g., Higher Risk Residential Buildings, HRRBs have limited budgets and therefore, safety related provisions are inevitably a target for cost reduction.

Given that there is no proper definition of competency, market drivers are free to employ more reputable engineers (i.e. competent) when the funds are available and use individuals with little or no competency when resources are limited. In the absence of a true definition of necessary competency, competency is an easy target for cost reduction, i.e. "deregulation by incompetency".[59] This drive for cost reduction results in many of the non-compliance issues being bundled into the construction phase, a situation that occurs because the deregulated incompetency enabled it to. Competency, thus, becomes a driver for social inequality and a means to disable entire organisations such as the fire service.[60] All this has occurred in a climate where there was no perceived need for major changes in public policy or education.

6.2. THE REGISTRATION AND ACCREDITATION PROCESS IN AUSTRALIA

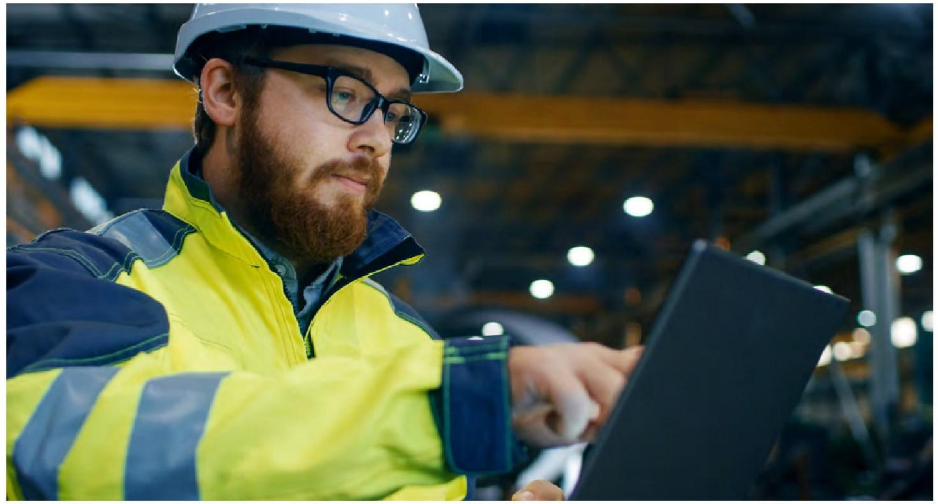
6.2.1. REGISTRATION PATHWAYS

Fire safety engineers are generally required to be registered in some form or another in each of the states and territories in which they will be practicing, although not every state and territory has such a scheme or requirement. In some states the process is referred to as accreditation and in others certification. These state-based schemes are different to and separate from the accreditation processes of the individual professional bodies, although in some states achieving accreditation through one of the professional bodies is one route to registration. A summary of the requirements in some states is given in *Table 1*, overleaf. Note the different terminology used in the different states for what should in principle be a similar process. In Queensland there is a licensing system, and in Victoria there is a registration process. In Tasmania there is an accreditation process, and in New South Wales there is a process for accreditation as a certifier.

[59] J.L. Torero, Grenfell Tower Inquiry, Phase One Report, June 4th, 2018.
[60] S. G. Knowles, Learning from Disaster?: The History of Technology and the Future of Disaster Research, Technology and Culture, 55, 4, 2014.

TABLE 1 - SUMMARY OF REQUIREMENTS TO PRACTICE IN SOME STATES IN AUSTRALIA

STATE	REQUIREMENT TO PRACTICE	RELEVANT LEGISLATION	QUALIFICATIONS OR EXPERIENCE REQUIRED	COMMENTS
QLD	Registration leading to licensing	Compulsory registration of engineering professionals is required under the *Professional Engineers Act 2002.*	Assessment of qualifications and experience for registration is based on the same criteria as for accreditation by one of the professional organisations.	Mutual recognition bypasses the strict educational requirements for accreditation via one of the professional organisations.
NSW	Accreditation as a certifier	Engineers wishing to issue certificates related to construction or compliance must be accredited by the Building Professionals Board under the *Building Professionals Act 2005* (NSW).	Educational requirements include a degree of any kind, including an associate degree; that is an undergraduate degree awarded after a period of studies of usually two years.	The accreditation process enables persons without a three or four-year engineering or science degree to be accredited in NSW.
TAS	Accreditation	Implementation of the *Tasmanian Building Act 2000* results in a system whereby building practitioners have insurance and are accredited.	Membership of the NER or holding a CPEng qualification is sufficient evidence of educational background for accreditation. Alternatively, accreditation may be afforded to someone with an appropriate degree (bachelor level) as well as a graduate diploma or higher qualification in Fire Safety Engineering followed by a period of supervised practice.	The period of supervised practice required is not verified by any professional body and is subject only to certification by a senior engineer in the field.
VIC	Registration	The *Victorian Building Act 1993* covers registration of building practitioners in the state. A new scheme was proposed for implementation in Victoria based on the *Engineers Registration Bill 2018*. This scheme was modelled on the scheme in Queensland.	Required qualifications for accreditation as a fire engineer in Victoria includes some form of tertiary qualification as well as a period of practical experience. Alternatively, registration may be offered to someone who has the total equivalent of the above in work experience.	The precise nature of the tertiary qualification required for accreditation as a fire engineer is not specified and this may be covered in the case of Fire Engineering by people without an undergraduate degree but with a graduate diploma.
WA	None	At present Western Australia does not have a requirement for registration of fire safety engineers.		There is an expectation that performance solutions are implemented by suitably qualified practitioners.



Engineering accreditation processes are inconsistent across Australian states and territories.

There are two pathways for fire safety engineers to be accredited by so-called professional bodies in Australia, which is generally a first step towards State or Territory Registration. These are Australia's current attempts at Second-Tier Accreditation as described in principle earlier.

The first option is to obtain a CPEng status with Engineers Australia and be registered as a fire safety engineer under the National Engineering Register (NER) scheme. These two qualifications are accepted as a means of accreditation in all states of Australia which may lead to registration in one of the individual states via one of the state-based schemes. The process in this case is similar to that described above, with a first and a second-tier accreditation scheme for individuals, based on education and the required supervised experience in practice.

The second pathway is through achievement of Chartered Engineer (CEng) status through the internationally recognised Institution of Fire Engineers (IFE), which operates its engineering registration scheme as a licensed "Professional Engineering Institution" of the Engineering Council UK, again based on education and experience.

6.2.2. CHARTERED PROFESSIONAL ENGINEERS

CPEng status is exclusive in Australia to Engineers Australia. Professional engineers with Chartered Status enjoy recognition by government, business and the general public worldwide. Chartered Status is open to those in the Member, Fellow and Honorary Fellow grades of each occupational category.

Achieving CPEng status and NER status in the category of fire safety engineering through EA is however dependent on the ability of the individual to demonstrate a degree of knowledge commensurate with an accredited degree program. As discussed in the previous section, there are very few fire safety engineering programs around the world accredited by any of the professional fire engineering organisations; and in Australia only one at the time of writing has accreditation through Engineers Australia. This is not only a reflection on the minority nature of the profession, but also on a lack of agreement within the profession of what constitutes a suitable degree program.

6.2.3. NATIONAL ENGINEERING REGISTER (NER)

The National Engineering Register (NER) has been created by Engineers Australia to provide a means of presenting registered engineers and their services to the public. It is intended to provide assurance to consumers that engineers engaged from the NER meet the high standards of professionalism expected in the engineering profession within a particular discipline or category such as fire safety engineering. It is the largest Engineering Register in the country delivering a uniform national benchmark standard of professionalism in the broadest areas of engineering practice, both general and specialised.

The NER is a publicly searchable database providing a national system of 'registration' for the engineering profession in Australia of professional engineers, engineering technologists and engineering associates in both the private and public sectors. It is expected that the NER will facilitate access to existing state/territory registers and to new registers, as and when they are developed. The NER is aimed at removing any current inconsistencies across state/territory jurisdictions.[61]

The NER caters for nine (9) general and ten (10) special areas of practice aligned to demonstrated professional competence and experience. There is a special area or practice or category of registration for Fire Safety Engineers, which has been in place for some 20 years. Registration on the 10 special areas of practice is restricted to Chartered members of Engineers Australia (CPEng) and registrants who have successfully completed Engineers Australia's Chartered assessment process.

Despite having the NER category for fire safety engineering in place for more than 20 years, Engineers Australia have no full and proper competencies against which to judge professional practice. Like IFE they have been using a set of simple knowledge-based criteria as the basis for assessment of fire safety engineers through a report and interview process.

6.2.4. STATE AND TERRITORY-BASED REGISTRATION

State and Territory registration generally requires a demonstration that an applicant is listed on the Engineers Australia NER scheme or is listed as part of the IFE CEng scheme. They also generally need to show they have the required Professional Indemnity Insurance and agree to participate in an approved on-going Continuing Professional Development Scheme (CPD).

The alternative route is to be registered or licensed as applicable in a particular state or territory-based on some level of education (not necessarily in the field of engineering and not even a three-year degree in some cases) and some level of demonstrated competency and experience. The process and competencies required vary from state to state, and this is a reflection of the perverse nature of a profession which works according to both a National Construction Code (BCA) and also state and territory-based building regulations which vary between jurisdictions. Examples of individual state-based accreditation/registration schemes and corresponding educational requirements are

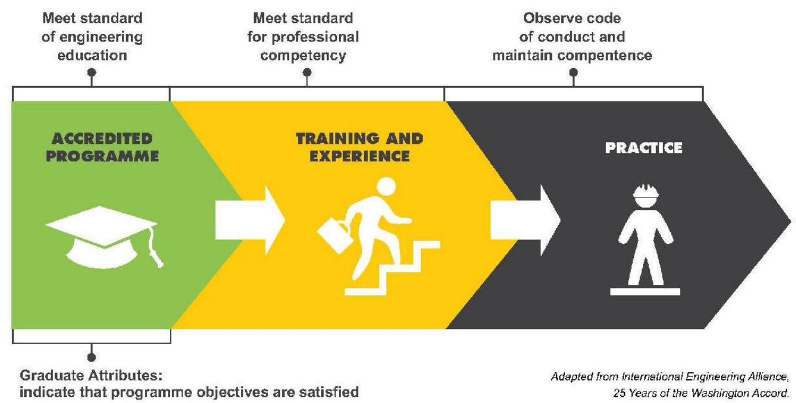
[61] Engineers Australia, National Engineering Register Application Guidelines 2017

provided in Table 1 above and in more detail in *Appendix 3* for NSW, VIC, QLD, TAS and WA. The fact that a three-year degree is not required in every state clearly challenges the definition of Fire Safety Engineering as a profession according to the definition of an engineering professional given by ASCO and pushes the discipline in the direction of an associate profession or trade according to ASCO's definitions as discussed previously in this report and elsewhere.

Once accredited/registered in one Australian jurisdiction, the Fire Safety Engineer may get accreditation/registration in another Australian jurisdiction. The Mutual Recognition Act 1992[62] establishes a regime for the interstate recognition of registration in occupations declared by Ministerial Declaration pursuant to that Act to be equivalent occupations. It entitles people holding an occupational licence or registration in one state or territory to an equivalent licence in another state or territory provided the work is licensed in both. Although this does not necessarily apply to every state, it is normally the case. This lack of clarity and lack of equivalence between the states promotes a lack of parity in the quality of engineers between the different States and Territories. This also results in the situation whereby an engineer can shop themselves between states, achieving registration in one state and then using this to obtain registration in another state or territory where they would not otherwise have been able to, based on their knowledge and skills alone. While this has been deemed in the past to be an acceptable method of gaining registration and increasing competition between practitioners,[63] the potential impact of this on the quality of service offered is undeniable.

All of the above contributes to significant variations in the level of competence of Fire Safety Engineers available for any particular project. This situation is illustrative of the situation described by Woodrow et al.[64] A lack of rigour in licensing procedures results in the utilisation of poorly educated practitioners to fill available positions. Further, enabling these engineers to practice professionally in an apparently regulated environment contributes to a professional hubris with many practitioners arguably practising outside of their own competence.

EDUCATION & TRAINING IN THE FORMATION OF A PRACTICING ENGINEER



Adapted from International Engineering Alliance, 25 Years of the Washington Accord.

[62] Mutual Recognition Act 1992
[63] Mutual Recognition Schemes Productivity Commission Research Report (2015)
[64] M. Woodrow, L. Bisby, J.L. Torero; A nascent educational framework for fire safety engineering; https://doi.org/10.1016/j.firesaf.2013.02.004

7. Conclusions

Currently, we are observing a scenario of significant and recurrent failures that should serve as a warning to the construction industry that building codes have fallen behind.

Dramatic examples such as the external façade fire that occurred on the Lacrosse Building in Melbourne have warned us that it is necessary for Australia to revisit its current practices. Internationally, The Grenfell Tower Fire[65] was also an external façade fire which claimed many victims and which yielded a tragic example of an inadequate fire safety strategy. This is very strong evidence of the pitfalls of the fire safety engineering process only being 'triggered' by the development of a non-conformance list emerging from a certifier's/ surveyor's code interpretation and application of the code's general rules. This approach overtly bypasses hazard identification, safety design and complexity issues. Furthermore, it establishes fire safety engineering as a sub-set discipline of code prescription. We may be also currently marching towards a similar scenario with many other innovations such as the use of engineered timber and tall timber buildings with an architectural expression of the construction material. These are simply outside of the scope of current fire safety codes and standards. This situation tips the equilibrium point of the regulatory framework heavily towards professionalism, a trait which relies on the presence of a fit for purpose accreditation process.

The Grenfell Disaster.

[65] www.grenfelltowerinquiry.org.uk

Grenfell along with the Lacrosse Building fire in Melbourne were just two of a string of external façade fires in the last decade, any one of which should have been a warning to the industry. However very little was done because we have still to understand fully that the introductions of new processes and new technologies are not only challenging the solutions proposed by building codes and standards but also the basic assumptions and principles behind them. When the basic assumptions and principles of building codes are challenged, it is only the professional who can deliver, through the use of knowledge, skills and attributes, an appropriate analysis. Thus, the definition of what is a Fire Safety Engineering Professional becomes paramount.

Given the evolution of the construction industry, we have no alternative but to professionalise the practice of fire safety. Society demands the same efficiencies and quality measures that other professions deliver. These drivers are strong and relentless, and the trend towards innovation, efficiency and sustainability will not change. If we remain stuck within a framework where building codes and standards are used as rules and within a trade context that has no guarantee of competency, we will see fire safety crumble in front of our own eyes. This is the time to take proactive action and develop the necessary framework and educational activities that deliver an adequate professional context.

Given the need to transform fire safety engineering into a true profession to meet all the challenges of this emerging area of practice, this report on the Australian and international status of fire safety engineering points to the following actions needed by this Warren Centre project in the remaining research efforts:

- A clear and comprehensive set of properly constituted competencies for fire safety engineering that covers knowledge, skills and other professional attributes needs to be written and agreed as the basis for a move to full professionalisation of the discipline in Australia.
- These properly constituted competencies for fire safety engineering that cover knowledge, skills and other professional attributes need to differentiate clearly between the needs for the different roles that the practice of Fire Safety Engineering in Australia demands (Fire Safety Engineers practicing design and/or fire engineering analysis, building surveyors or certifiers, Fire Services Engineers designing systems such as sprinklers, etc.)
- Degree programs which reflect these competencies and meet all Washington Accord principles need to be developed and agreed for fire safety engineering. These degree programs will be defined as a part of a first-tier accreditation pathway.
- Such degree programs need to be suitably designed to ensure that they can be appropriately accredited in Australia.
- The basis for professional accreditation schemes for fire safety engineers need to be developed to assist professional bodies such as Engineers Australia and IFE to ensure their schemes are consistent with other international engineering best practices and that they incorporate all first and second tier accreditation requirements.

- A suitable educational pathway to be undertaken and experience to be gained by fire safety engineers during their supervised experience period leading up to professional accreditation must be identified. This pathway has to ensure that all professional attributes required for professional practice have been achieved before admission to the profession.
- A transition plan must be developed to take fire safety engineering practice and its practitioners from the current inadequate state to full professionalism. This transitional plan needs to recognise the challenges that will be faced by current practitioners of fire safety, the changes to the current Australian educational offer, the implementation of new accreditation practices and the timeframes involved. Extrinsic aspects such as the current shortage of fire safety engineers, the demands of the design and construction industry, the costs of transition and the risks to the public and the fire services as well as the building owners and managers have also to be considered.

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9. Glossary of Terms

TERM	DEFINITIONS AND NOTES OF EXPLANATION Where definitions are included in the NCC Volume One Building Code of Australia, they are in **bold**. Other definitions or notes of explanation have been developed in this Warren Centre Project as a means to use consistent language throughout the Project reports.
ABCB	The Australian Building Codes Board (ABCB) is a Council of Australian Government (COAG) standards writing body that is responsible for the development of the NCC, comprised of the BCA and PCA. The ABCB is a joint initiative of all three levels of government in Australia. *(ABCB)*
Accreditation	Refers to professional accreditation from organisations like EA NER and IFE, which look at educational achievements and supervised experience plus CPD *(Peter Johnson)* This also applies to accredited education courses for fire safety engineering, which there is one at UQ *(Peter Johnson)* A scheme that captures appropriately qualified practitioners, sets minimum standards of professional practice and requires appropriate levels (if any) of insurance for consumers. (See *the Warren Centre's forthcoming Report on the State of Fire Safety Engineering Regulation, Control and Regulation in Australia, the "Task 1.1 Report".*) Products (Certificate of Accreditation) - A certificate issued by a State or Territory accreditation authority stating that the properties and performance of a building material or method of construction or design fulfil specific requirements of the BCA *(NCC, vol 1, amdt 1)*
Administrative Provisions	These are usually covered in the enabling or subordinate legislation and/or regulations at the State and Territory level and include (NCC): • Plan submission and approval procedures • Issue of permits • Inspections and audits • Provision of evidentiary certificates • Issue of certificates • Review and enforcement of standards • Fees and charges
Appropriate Authority	**The relevant authority with the statutory with the statutory responsibility to determine the particular matter.** *(NCC, vol 1, amdt 1)*
Appropriately Qualified Person	**A person recognised by the appropriate authority as having qualifications and/or experience in the relevant discipline in question.** *(NCC, vol 1, amdt 1)* The person does not necessarily need to be licensed or registered unless required by the State or Territory regulatory system. *(NCC, Guide, amdt 1)*
Assessment Method	**Means a method that can be used for determining that a Performance Solution or Deemed-to-Satisfy Solution complies with the Performance Requirements.** *(NCC, vol 1, amdt 1)* The means by which a building proponent proves that a solution achieves the Performance Requirements. These include: • Evidence to support that the use of a material or product, form of construction or design meets a Performance Requirement or a Deemed-to- Satisfy Provision as described in A2.2 • Verification Methods • Expert Judgement • Comparison with the Deemed-to-Satisfy Provisions *(NCC, vol 1, amdt 1)*
Building Code of Australia (BCA)	Forms part of the National Construction Code, which contains technical provisions for the design and construction of buildings and other structures. The BCA addresses structural adequacy, fire resistance, access and egress, services and equipment, energy efficiency and sustainability, and provisions for the health and amenity of occupants. *(NCC, vol 1, amdt 1)*

TERM	DEFINITIONS AND NOTES OF EXPLANATION
Building Solution	**A solution which complies with the *Performance Requirements* and is a:** • ***Performance Solution*** • ***Deemed-to-Satisfy Solution*** • ***Combination of both solutions*** *(NCC, vol 1, amdt 1)* This term has been replaced with the terms Deemed-to-Satisfy Solution and Performance Solution. It has been retained as some jurisdictions still refer to this term. *(NCC, Guide, amdt 1)*
Certification	In NSW, such "licensed" engineers are called C10 certifiers in FSE with the emphasis on certification rather than design *(Peter Johnson)*
Deemed-to-Satisfy Provisions	Make up the bulk of the NCC. **Means provisions deemed to satisfy the *Performance Requirements*.** *(NCC, vol 1, amdt 1)*
Deemed-to-Satisfy (DTS) Solution	**A method of satisfying the *Deemed-to-Satisfy Provisions*.** *(NCC, vol 1, amdt 1)* Should be used if any designer, builder or the like, does not want to develop a new means of compliance with the Performance Requirements. *(NCC, Guide, amdt 1)*
Design fire safety engineer	A building practitioner who prepares (designs) a performance solution in relation to any fire safety matter in the BCA.
Equivalent	**Equivalent to the level of health, safety and amenity provided by the *Deemed- to-Satisfy Provisions*.** *(NCC, vol 1, amdt 1)*
Fire Brigade	**Means a statutory authority established under an Act of Parliament having as one of its functions the protection of life and property from fire and other emergencies.** *(NCC, vol 1, amdt 1)* It may be a professional brigade with full-time firefighters or a volunteer brigade. Many companies employ their own private fire services. The standard of these private fire services varies greatly. They are excluded from the definition of a fire brigade. *(NCC, Guide, amdt 1)*
Fire Safety Engineer	An appropriately qualified and experienced practitioner who, through sound and robust engineer practice, provides services that achieve reductions of risk for life for people in buildings, reduction in property and environmental damage from building fires and the implementation of cost-effective fire safety codes and regulations.
Fire Safety System	**One or any combination of the methods used in a building to:** • **Warn people of an emergency** • **Provide for safe evacuation** • **Restrict the spread of fire** • **Extinguish a fire** **and includes both active and passive systems.** These systems may be active, passive or any combination of the two. **Active Systems** • Sound systems and intercom systems for emergency purposes • Emergency lighting • Exit signs • Sprinkler systems • Fire hydrant systems • Fire hose reel systems • Smoke and heat vents • Mechanical smoke-exhaust systems • Portable fire extinguishers **Passive Systems** • Fire-isolated stairways, ramps and passageways • Fire walls Other fire-resisting building elements *(NCC, Guide, amdt 1)*

9. Glossary of Terms

TERM	DEFINITIONS AND NOTES OF EXPLANATION
Licensing	A government legislative scheme that captures appropriately qualified practitioners, to the exclusion of any other persons or practitioners and sets minimum standards of professional practice and requires appropriate levels (if any) of insurance for consumers. Persons not licensed are prohibited from practice (i.e. plumbing, electrical or driving licensing schemes)
National Construction Code (NCC)	The NCC provides the minimum necessary requirements for health, safety, amenity and sustainability in the design and construction of new buildings throughout Australia. It comprises of the BCA plus the PCA and is given legal effect by relevant legislation in each State and Territory. *(ABCB)*
Peer review fire safety engineer	A building practitioner who independently reviews a performance solution design not prepared by them, in relation to any fire safety matter in the BCA.
Performance-Based Design Brief (PBDB)	A document that is developed in collaboration with key stakeholders as part of a proposed performance-based design and approval process. When completed, the PBDB becomes the platform upon which the proposed design is constructed. It records fundamental activities and outcomes of the performance-based design process, as agreed during key stakeholder negotiations. When finalised, all critical activities and outcomes would have been identified. *(NCC)*
Performance Requirement	**Means a requirement which states the level of performance which a Performance Solution or a Deemed-To-Satisfy Solution must meet.** *(NCC, vol 1, amdt 1)* Performance requirements outline the levels of accomplishment different buildings must attain. There are three options to comply with the Performance Requirements: Deemed-to-Satisfy Solutions, Performance Solutions or a combination of both *(NCC, vol 1, amdt 1)*
Performance Solution (Alternative Solution)	**Means a method of complying with the Performance Requirements other than by a Deemed-To-Satisfy Solution.** *(NCC, vol 1, amdt 1)* A Performance Solution is unique for each individual situation. These solutions are often flexible in achieving the outcomes and encouraging innovative design and technology use. It is a route which is not included in a DTS Solution. It complies with the NCC when the Assessment Method demonstrates compliance with the Performance Requirements. If it is demonstrated to be at least equivalent to a DTS Provision, the Performance Solution is deemed to have achieved compliance with the relevant Performance Requirement. *(NCC, vol 1, amdt 1)*

10. Appendix 1

Model Curricula in Fire Safety Engineering

10.1. THE INTERNATIONAL WORKING GROUP MODEL CURRICULUM

MODULE	TOPICS COVERED
Fire fundamentals	• Polymers and polymer decomposition; chemical processes • Flames and fire plumes; Incomplete combustion processes
Enclosure fire dynamics	• Chemistry of room fire combustion, vent flows, heat flow calculation, ceiling flames and ceiling jets • Basic concepts of room fires, post flashover fires, smoke accumulation, zone models of room fires, smoke and heat venting
Active fire protection	• Fire detection systems • Automatic suppression systems • Manual suppression systems • Smoke management systems
Passive fire protection	• Building Construction Fundamentals • Traditional code procedures • Rational fire design
Interaction between fire and people	• Human Behaviour in Fires and Other Emergency Situations and the Effect of Human Beings on Fire Occurrences • Escape

Combustion, flames and fire plumes follow fundamental processes of chemistry, heat transfer and mass transfer.

10. Appendix 1

10.2. THE SFPE MODEL CURRICULA

10.2.1. THE BSC CURRICULUM

GENERAL	GENERAL ENGINEERING	SPECIALIST ENGINEERING
Physics	Statics	Fire chemistry
Chemistry	Mechanics of materials	Fire hazard and risk analysis
Maths	Dynamics	Water-based suppression
English	Engineering economics	Special hazards – Non-water-based suppression
General electives	Fluid mechanics	Fire dynamics
	Thermodynamics	Fire modelling
	Heat transfer	Fire protection related codes & standards
	Computer-aided drafting	Structural fire protection
		Storage & transportation of hazardous materials
		Egress and life safety analysis
		Fire testing
		Fire investigation
		Detection, alarm & smoke control
		Explosion prevention & protection
		Fire risk management
		Senior capstone project

10.2.2. THE MSC CURRICULUM

CORE FPE TOPICS	FOCUSED TOPICS OR COURSES
Fire dynamics and fire chemistry	Fire modelling
Fire risk / hazard analysis	Fire testing
Performance-based design	Water-based suppression
Building fire safety	Special hazards - non-water-based suppression
Fire protection systems	Detection, alarm and smoke control
	Explosion prevention and protection
	Fire investigation
	Fire protection related codes and standards
	Egress and life safety analysis
	Storage and transportation of hazardous materials
	Fire risk management
	Management of wildland-urban interface fires
	Consequence analysis
	Risk-based land use planning
	Degree project in fire safety / fire protection engineering

11. Appendix 2

Overview of existing eduction programs

11.1. THE UNIVERSITYOF QUEENSLAND (AUSTRALIA)

11.1.1. PROGRAMS ON OFFER

The University of Queensland offer two programs on fire safety engineering: a BEng(Hons)-MEng in Civil Engineering and Fire Safety Engineering[66] and an MEngSc in Fire Safety Engineering[67].

The former is a five-year full-time program (80 units) that combines Civil Engineering with additional courses in Fire Safety Engineering. In year 5, students are required to take an 8-unit Research Thesis in the area of Fire Safety Engineering.

The latter is a 1.5 years full-time program (24 units) in Fire Safety Engineering. The program covers 8 units of courses in other engineering disciplines. In addition, during semesters 2 and 3, students are required to take a 4-unit Research Thesis in the area of Fire Safety Engineering.

11.1.2. CURRICULUM FOLLOWED

The curriculum of both of these programs covers the knowledge base identified by both the International Working Group on fire safety engineering curricula and the SFPE. There is a substantial part of the course associated with developing the skills in application of the knowledge learned.

11.1.3. ADMISSIONS CRITERIA

Degree equivalent to an Australian bachelor's degree in engineering (in the relevant field of study for which they wish to enrol) with a GPA of at least 4.5 on a 7-point scale. All applications for admission to postgraduate coursework programs are assessed in line with the entry requirements advertised for each program. Overseas qualifications will be assessed to determine that they are equivalent to the Australian standard required. Grade Point Averages will be converted to the 7-point UQ scale for the purposes of determining eligibility for admission.

11.1.4. ACCREDITATION

Full accreditation from Engineers Australia for the BEng-MEng program.

11.2. VICTORIA UNIVERSITY (AUSTRALIA)

11.2.1. PROGRAMS ON OFFER

Victoria University offers only post-graduate study, through the Centre for Environmental Safety & Risk Engineering (CESARE)[68]. The programs offered are;

- Graduate Certificate in Performance-Based Building and Fire Codes (industry persons generally; certifiers, engineers, fire-fighters etc.)
- Master of Engineering (Research)
- Doctor of Philosophy (Engineering)

There are bridging subjects in maths and science offered to students who do not have

66 https://my.uq.edu.au/programs-courses/plan.html?acad_plan=CIVFSX2350
67 https://my.uq.edu.au/programs-courses/plan.html?acad_plan=FIRSAX5529
68 https://www.vu.edu.au/centre-for-environmental-safety-and-risk-engineering-cesare

an undergraduate degree in Engineering but successfully complete the Grad Cert and want to progress further.

11.2.2. CURRICULUM FOLLOWED

The structure of the program in Victoria University is such that it follows closely the state building regulations.

11.3. WESTERN SYDNEY UNIVERSITY (AUSTRALIA)

11.3.1. PROGRAMS ON OFFER

Western Sydney University offer a three-year part-time master's program in fire safety engineering. The program aims to provide professionals with the special skills and knowledge to develop, assess and evaluate fire safety engineering solutions for built environment.

11.3.2. CURRICULUM FOLLOWED

The course covers fire safety science and engineering principles. It is relevant to professionals developing alternative solutions using the fire engineering guidelines to meet the objectives and performance requirements of building regulations. Graduates also acquire the skill to independently appraise the literature and address fire safety engineering issues faced by the building industry. This course has been designed primarily as a Distance Learning course. However, a select unit (one in total) has a five-day intensive block style compulsory workshop that requires students to attend. Many of the other units have non-compulsory workshops and students are encouraged to attend these workshops to gain the benefit of the face to face interaction within the course.

11.4. THE UNIVERSITY OF CANTERBURY (NEW ZEALAND)

11.4.1. PROGRAMS ON OFFER

The University of Canterbury offers a Master of Engineering in Fire Engineering.[69] This program can last between 16 months and three years (full-time). The program is made up of six courses and a thesis. In the first half of the degree, students take block courses in areas such as fire dynamics and fire safety and systems. Online learning software is used to allow flexible study. At least two courses each year are offered through a combination of guided self-study and intensive block courses. The second half of the degree requires a thesis or project.

11.4.2. CURRICULUM FOLLOWED

The curriculum follows the following course structure:

- Fire Engineering
- Structural Fire Engineering
- Fire Dynamics
- Fire Safety Systems
- Fire Design Case Study
- Advanced Fire Dynamics
- Special Topic in Fire Engineering
- Human Behaviour in Fire
- Fire Project
- Thesis

[69] https://www.canterbury.ac.nz/study/qualifications-and-courses/masters-degrees/ master-of-engineering-in-fire-engineering/

11.4.3. ADMISSIONS CRITERIA

The minimum requirement is a three-year bachelor's degree from a New Zealand university or a qualification or combination of qualifications considered to be equivalent.

Candidates must normally have completed one of the following:

- Bachelor of Engineering with Honours with first or second-class honours;
- Postgraduate Certificate in Engineering with a GPA of 5 or more; or
- Bachelor of Science with Honours in appropriate subjects.

11.4.4. ACCREDITATION

At the time of writing, the program at the University of Canterbury was not accredited.

11.5. LUND UNIVERSITY (SWEDEN)

11.5.1. PROGRAMS ON OFFER

Fire protection engineer, a three-and-a-half-year course comprising 210 'High School Points'.[70] In Swedish the course results in the title of Brandingenjör, which translates into English as Fire Engineer. In terms of equivalence under the Bologna process this degree program results in a Bachelor of Science (BSc) in Fire Protection Engineering.

11.5.2. CURRICULUM FOLLOWED

Amongst other basic engineering courses, the program adheres to the following structure:

- Year 1 – introduction to fire science
- Year 2 – Fire chemistry – heat transfer, thermodynamics and fluid mechanics, fire dynamics, risk analysis in fire technology
- Year 3 – Fire protection systems, industrial fire protection, human behaviour in fire, fire risk evaluation
- Year 4 – Thesis project in a related field of study

11.5.3. ADMISSIONS CRITERIA

In order to enrol in the degree program students are expected to have a background in Maths, Physics and Chemistry. The entry requirements are the same as for a civil engineering program.

In addition to the BSc program in fire protection engineering, Lund University also offer an MSc program in Fire Safety Engineering. Courses required to be followed in this program include: advanced fire dynamics, human behaviour in fire, risk assessment, and simulation of fires in enclosures.[71]

11.5.4. ACCREDITATION

Neither of the above two programs appear to be accredited and according to the Swedish Council for Higher Education engineering professionals are not regulated.[72] Upon completion of one of the above programs a graduate is entitled to use the title Fire Engineer.

Lund is also one of the partner universities of the IMFSE program.

[70] Fire Protection Engineering. 3,5 years; http://www.lth.se/utbildning/brandingenjor/; accessed 10th August 2018
[71] MSc in Fire Safety Engineering; http://www.brand.lth.se/education/msc_in_fire_safety_engineering/, accessed 10th August 2018
[72] https://www.uhr.se/en/start/recognition-of-foreign-qualifications/before-you-apply/i- want-to-work-in-sweden/regulated-professions/; accessed 10th August 2018

11.6. THE UNIVERSITY OF EDINBURGH (UK)

11.6.1. PROGRAMS ON OFFER

The University of Edinburgh offers both a Bachelor of Engineering (BEng) and a Master of Engineering (MEng) undergraduate program in Structural and Fire Safety Engineering.[73] These are a four and a five-year course respectively.

11.6.2. CURRICULUM FOLLOWED

The degree program follows the same structure as a typical civil engineering degree from the university, with courses related to fire being introduced in the third year. The structure of the program is then:

- Year 3 - Fire Safety Engineering
- Year 4 - Fire Science & Fire Dynamics, Fire Safety Engineering, Fire Science Laboratory
- Year 5 - Fire Safety Engineering Design Project, Structural Design for Fire, Fire Safety Engineering Analysis & Design, Fire Investigation and Failure Analysis

11.6.3. ADMISSIONS CRITERIA

Students enrolling in the program are expected to have a strong grounding in Maths and Physics, Engineering Science or Design and Technology. Entry requirements are the same as for a civil engineering program.

11.6.4. ACCREDITATION

The course is accredited to meet the education base for Chartered Engineer with the Engineering Council of the UK through the UK's professional Engineering Bodies.

11.6.5. OTHER

In addition to the undergraduate program, The University of Edinburgh also offers a postgraduate MSc in Structural and Fire Safety Engineering. This two-semester course has a similar, although more condensed structure to the undergraduate program:

- Semester 1 - Steel Structures, Structural Design for Fire, State-of-the-Art Review in Fire Safety Engineering, Fire Science and Fire Dynamics, Finite Element Analysis for Solids, and one of either Fire Investigation and Failure Analysis or Fire Safety, Engineering and Society
- Semester 2 - Pre-Dissertation Project in Fire Safety Engineering, The Finite Element Method, Structural Dynamics and Earthquake Engineering, Fire Science Laboratory, Fire Safety Engineering Analysis and Design

A research dissertation continues in the summer months after the second semester. Edinburgh is also one of the partner universities of the IMFSE program.

[73] https://www.fire.eng.ed.ac.uk/teaching/undergraduate-degrees, accessed 15th August 2018

11.7. GLASGOW CALEDONIAN (UK)

11.7.1. PROGRAMS ON OFFER

The course at Glasgow Caledonian is BEng (Hons) in Fire Risk Engineering.[74] It can be studied full time or part time.

11.7.2. CURRICULUM FOLLOWED

The first year of the program covers engineering foundation level courses. Subsequent years, follow the structure of:

- Year 2 - Principles of Fire Safety Analysis & The Practice of Fire Safety Design & Regulation, Computer-Aided Modelling Techniques, Risk Management
- Year 3 - Work placement or external study at a partner university; Fire Dynamics, Structural Fire Protection, Suppression Systems Design, CAD and Computational Fluid Dynamics
- Year 4 - Honours Dissertation, further study of topics such as Smoke Control Systems Design, Evacuation Systems Design, Fire Risk Assessment, Fire Engineering Design.

11.7.3. ENTRY REQUIREMENTS

Entry requirements to the program expect a grounding in Maths and either Physics, Technological studies or engineering science.

11.7.4. ACCREDITATION

The program is accredited by the Institution of Fire Engineers as meeting the requirements for academic exemption for membership at Member level. It is also approved by the Engineering Council in the UK for membership of the engineering council at Incorporated Engineer (IEng) level and is recognised as partially fulfilling the educational requirements required for Chartered Engineer (CEng) meaning that further learning is required to achieve CEng status.

11.8. ULSTER UNIVERSITY (UK)

11.8.1. PROGRAMS ON OFFER

The University of Ulster offers a Post Graduate Diploma (PGDip) and an MSc in Fire Safety Engineering.[75] The two programs are linked, with students progressing from the PGDip which lasts for one year (when studied full time or two years when studied part time) to the MSc. The PGDip is taught, whereas the MSc requires the completion of a dissertation thesis.

11.8.2. CURRICULUM FOLLOWED

The courses studied include:

- Heat Transfer and Thermofluids, Fire Dynamics, Structural Fire Engineering, People and Fire, Fire Engineering Laboratory, Active Fire Control Systems, Fire Safety Engineering Design, Dissertation, and one of either Computer Modelling in Fire Engineering or Industrial Fire Safety

11.8.3. ADMISSIONS CRITERIA

Entry requirements include either an engineering or related undergraduate degree or equivalent standard in another form of postgraduate study; as well as a grounding in Mathematics.

[74] https://www.gcu.ac.uk/study/courses/details/index.php/P02924; accessed 15th August 2018
[75] https://www.ulster.ac.uk/courses/201819/fire-safety-engineering-15834, accessed 15th August 2018

11.8.4. ACCREDITATION

The course is accredited by the Institution of Fire Engineers and the Chartered Institution of Building Services Engineers as meeting the educational requirements for membership of the UK's engineering council at Incorporated Engineer level. Further learning is required for admission to the engineering council at CEng level.

11.9. UNIVERSITY OF CENTRAL LANCASTER (UK)

11.9.1. PROGRAMS ON OFFER

University of Central Lancashire offer a range of undergraduate degrees, including a BEng in Fire Engineering, a BSc in Fire and Leadership studies, a Foundation Science (FdSc) degree in Fire Safety Engineering and a certificate in Fire Investigation.[76] They also offer MSc degrees in Fire Safety Engineering, Fire Investigation, Fire Scene Investigation and Fire and Rescue Service Management.

11.9.2. CURRICULUM FOLLOWED

With a focus on the Fire Engineering degrees, the undergraduate BEng follows a three-year structure:

- Year 1 - Introduction to Combustion and Fire, Safety and Fire Law, Energy Transfer and Thermodynamics, Engineering Design Practice Buildings, Materials and Fire, Engineering Analysis, Skills for Fire Studies
- Year 2 - Fluid Dynamics of Fire; Fire and the Built Environment; Accidents and Catastrophes Safety, Health and Environmental Management; Project Management; Computational Engineering; Engineering Analysis
- Year 3 - Enclosure Fire Dynamics; Fire Protection Engineering; Fire Investigation; Probabilistic Risk Analysis; Engineering Design Project; Fire Science Dissertation

The MSc in Fire Safety Engineering is offered full time over one year or part time over two years. It comprises the following compulsory modules:

- Advanced Engineering Dissertation, Research Methods, Advanced Engineering Design Project, Fires in Buildings, Computational Fluid Dynamics, and Fire Engineering Solutions.

There are also optional modules in a range of subjects including Fire Protection Strategies.

11.9.3. ADMISSIONS CRITERIA

Entry requirements to the BSc include a grounding in Maths, Physics, Chemistry and either Environmental Science or Applied Science. For the MSc it is expected that applicants will have an undergraduate degree in a related engineering discipline; or equivalent experience.

11.9.4. ACCREDITATION

The BSc course is accredited by the Energy Institute and the Chartered Institution of Building Services Engineers as meeting the educational requirements for membership of the UK's engineering council at Incorporated Engineer level. Further learning is required for admission to the engineering council at CEng level. The course is accredited by the Institution of Fire Engineers as meeting the educational requirements for admission at the grade of MIFireE. The MSc course is accredited as meeting the further learning requirements for admission as CEng to the Engineering council by the IE and the CIBSE. It is also recognised as fulfilling the educational requirements for admission to the IFE as MIFireE, as per the BSc course.

[76] https://www.uclan.ac.uk/research/explore/groups/centre_for_fire_and_hazard_science.php, accessed 15th August 2018

11.10. UNIVERSITY OF GHENT (BELGIUM)

11.10.1. PROGRAMS ON OFFER

Ghent University offer a Master of Science in Fire Safety Engineering.

11.10.2. CURRICULUM FOLLOWED

This two-year program follows the following structure:[77]

- Year 1 - Fire dynamics; thermodynamics, heat and mass transfer; basics of structural engineering; explosions and industrial fire safety; fluid mechanics; fluid mechanics applications in fire; risk management; interaction between people and fire
- Year 2 - Computational fluid dynamics; passive fire protection active fire protection including detection and suppression and smoke and heat control; fire safety and legislation and performance-based design

There are also a number of elective courses required to fulfil the degree program requirements.

11.10.3. ADMISSION CRITERIA

Admission to the program is subject to the entry requirement of a BSc in a related engineering field.

11.10.4. ACCREDITATION

The program is accredited by the NVAO (Dutch-Flemish Accreditation Organ).

11.10.5. OTHER

Ghent is also one of the partner universities of the IMFSE program.

11.11. UNIVERSITY OF MARYLAND (USA)

11.11.1. PROGRAMS ON OFFER

The Department of Fire Protection Engineering is part of the A. James Clark School of Engineering at the University of Maryland. The department offers undergraduate and graduate degrees. Including a Bachelor of Science in Fire Protection Engineering, Master of Science in Fire Protection Engineering and a Master of Engineering in Fire Protection Engineering.

The Bachelor of Science in Fire Protection Engineering is geared for undergraduate students and follows a four-year program similar to other engineering programs in the United States. The department also offers Master of Science, Master of Engineering, as well as combined bachelor's and master's programs (BS/MS and BS/MEng). Doctoral degree programs are offered through enrolment in other departments of the school

[77] https://studiegids.ugent.be/2018/EN/FACULTY/E/MABA/EMFSEN/EMFSEN.html, accessed 15th August 2018

of Engineering with an emphasis in Fire Protection Engineering and the supervision of Fire Protection Engineering faculty.

The Master of Science degree is administered through the Department of Fire Protection Engineering and requires admission through the University of Maryland Graduate School. The program has a minimum coursework requirement in addition to a research thesis and it is only offered as an on-campus only degree. The normative time for the program is 1.5 years. Graduation requirements include a minimum GPA of 3.0[78] in a 4.0 scale, submission of research thesis and a successful oral examination. The program requires students to complete a research thesis.

The Master of Engineering degree is administered through the Office of Advanced Engineering Education at the University of Maryland and it aimed at professionals or engineers who need to refresh their skills. The main difference with the MS degree is the lack of a research thesis and the substitution with other engineering electives. Admission to the program is similar to that of the MS program. The lack of a research thesis enables students to take courses online.

11.11.2. CURRICULUM FOLLOWED

The Bachelor of Science program is a four-year engineering degree with a requirement of 121-125 semester credit hours. Admission to the program requires admission to the University of Maryland and admission to the A. James Clark School of Engineering. Admission to the University of Maryland is not enough for enrolment into the degree program. Throughout the degree students are required to take general education and engineering course work in addition to fire protection engineering courses. The first two years introduce general engineering fundamentals and principles of fire safety engineering. The last two years of the program are focused on primarily on fire protection engineering course work and advanced electives. The combination of required courses and technical electives provides students with a wide exposure to fire safety engineering throughout the course of the degree.

To obtain the Master of Science, graduates are expected to complete eight (8) courses (24 credits) depending on their admission path, a minimum of six (6) credits of thesis research, and a minimum GPA of 3.0 out of a 4.0 scale. The curriculum is broken into required classes, engineering electives, and approved electives. Students in the BS/MS program take eight (8) approved courses and two (2) elective courses at higher elective level (fourth year level and above). Students in the MS program with a BS in Fire Protection Engineering have the same requirements as BS/MS students. All other MS students must enrol in eight (8) approved courses and four (4) fire protection engineering courses at the graduate level.

In the MSc, there are numerous courses offered ranging from advanced topics on traditional topics to highly specialised topics. The department offers in 14 graduate level courses that count towards graduation. Topics include fire dynamics (Fire induced flows, fire dynamics laboratory, diffusion flames and burning rate theory, advanced fire dynamics), human response to fire, suppression, smoke management, special topics (wildland fires, fire and explosions, industrial fire safety), material flammability, fire modelling and structural fire safety engineering.

For the Master of Engineering there are two curriculum tracks, one for on-campus students and one for online students. On-campus

[78] In the U.S. system a GPA of 3.0 would require a student to average 80/100 which is equivalent to a B mark.

students can complete 10 approved courses, with at least six (6) must be fire protection engineering courses. Two (2) courses are higher-level electives, with the remaining courses being technical electives that may or may not be related to fire protection engineering.

Online students also have to complete 10 courses, five (5) required courses such as advanced fire modelling, smoke detection and management, advanced fire dynamics, fire assessment methods and advanced fire suppression. Online students are also expected to take one course from restricted electives (human response to fire, industrial fire safety, forensic analysis, performance-based design and advanced risk modelling). The remaining courses must be approved by the academic advisor.

11.11.3. ADMISSION REQUIREMENTS

Admission to the BSc program is a two-stage process. Initially students apply for admission to the University of Maryland. Admission to the University of Maryland requires a High School diploma with a minimum course work including four years of Mathematics, three years of Science, four years of English, and thee years of Social Studies. Additional criteria used for determining admission to the university includes standardised test scores, class ranking, extracurricular activities and work experience among other factors. Once admitted to the university, students must apply for admission to the A. James Clark School of Engineering after completing 45 semester hours of course work, typically half-way through the second year. Admission to the school of engineering requires completion of minimum course work with a minimum grade of C- (approximately equivalent to 72/100).

There are two main routes to apply for admission to the MSc program. University of Maryland students enrolled in the Bachelor of Science Fire Engineering degree can apply to the program in the third year. Admission to the program requires a minimum GPA of 3.5 in a 4.0 scale, completion of standardised testing (GRE) and three letters of recommendation. All other applicants are required to hold a Bachelor of Science in a related field, a minimum GPA of 3.0 in a 4.0 scale, demonstrated English proficiency, completion of standardised testing (GRE) and three letters of recommendation.

There are two main routes to apply for admission to the MEng program. University of Maryland students enrolled in the Bachelor of Science Fire Engineering degree can apply to the program in the third year. Admission to the program requires a minimum GPA of 3.5 in a 4.0 scale, and three letters of recommendation. All other applicants are required to hold a Bachelor of Science in a related field, a minimum GPA of 3.0 in a 4.0 scale, demonstrated English proficiency, and three letters of recommendation.

11.11.4. ACCREDITATION

The program is accredited through the Engineering Accreditation Commission of ABET.

11.12. WORCESTER POLYTECHNIC INSTITUTE (USA)

11.12.1. PROGRAMS ON OFFER

The Worcester Polytechnic Institute (WPI) Fire Protection Engineering Department offers Master of Science and Doctoral degrees. The Master of Science in Fire Protection Engineering program is a 30 credits program, 21 credits of coursework and 9 credits allotted for a mandatory research thesis.

11.12.2. CURRICULUM FOLLOWED

The curriculum is broken into core courses, restricted electives and research thesis. All students are required to enrol in Fire Dynamics I (3 credits), Building Fire Safety (3 credits) and Fire Protection Systems (3 credits). Restricted electives are broken into two groups. In the first students must choose between Performance-Based Design (3 credits) and Industrial Fire Protection (3 credits). In the second group students must select three (3) out of the following courses, Fire Modelling (3 credits), Advanced Fire Suppression (3 credits), Detection, Alarm and Smoke Control (3 credits), Failure Analysis (3 credits), Explosion Protection (3 credits), and Special Topics (3 credits). All students must complete nine (9) credits of research thesis prior to graduation. A complete list of courses offered may be accessed visiting *https://web.wpi.edu/academics/catalogs/grad/fpecourses.html*

11.12.3. ADMISSION REQUIREMENTS

Admission to the MS program requires a Bachelor of Science in engineering discipline, completion of statement of purpose, three letters of recommendation, and standardised test scores (GRE) for international applicants. Depending on the applicant's academic background additional pre-requisites may be required as part of the program.

11.13. INTERNATIONAL MASTER OF SCIENCE IN FIRE SAFETY ENGINEERING (EUROPE)

11.13.1. PROGRAM OVERVIEW

The International Master of Science in Fire Safety Engineering (IMFSE) is a two-year full-time Master of Science program organised by six (6) universities. Throughout the first three semester of the program students complete their coursework at three different European universities (Ghent University, Lund University, The University of Edinburgh) and on the last semester they complete a research thesis. For the thesis research students are able to return to any of the participation European institutions in addition to associated partner universities that include The University of Queensland (Australia), ETH Zurich (Switzerland) and The University of Maryland (USA). Requirements for admission include a Bachelor of Science with a minimum knowledge in specific topics,

an English proficiency test, and two (2) letters of recommendation. A research thesis in the last semester is mandatory for all students.

11.13.2. CURRICULUM FOLLOWED

The international nature of the IMFSE provides different alternate routes for completing the required course work. The program consists of 120 ECTS, 90 credits are allotted for coursework and 30 credits are allotted for a research thesis in the last semester. In the first semester of the program participants attend Ghent University or The University of Edinburgh and complete courses related to the fire safety engineering fundamentals. In the second semester all students attend Lund University and complete courses in risk assessment, advanced fire dynamics, human behaviour in fire and simulation of fires in enclosures. In the third semester students are offered the choice to return to either Ghent University to focus on active fire protection, fire safety legislation and performance-based design or The University of Edinburgh to focus on fire science laboratory, failure analysis and structural fire safety engineering. In the fourth and final semester students conduct a research thesis that may be supervised by any of the three European institutions, the three IMFSE associated partners or an industry company.

Courses are distributed across the three European institutions and deliver a broad array of fire safety engineering courses. The table below summarises the courses offered depending on university and term. Additional information may be found by accessing *http://www.imfse.ugent.be/index.asp?p=604&a=603*

TERM	INSTITUTION	REQUIRED SUBJECTS	OPTIONAL SUBJECTS
Semester 1	Ghent University	• Fire dynamics • Basics of structural engineering • Explosions and industrial fire safety • Thermodynamics, heat and mass transfer	Choose from: • FSE Firefighting • Modelling of combustion and turbulence • Computational fluid dynamics • Turbomachines
Semester 1	The University of Edinburgh	• Fire dynamics • Fire safety, engineering and society • Fire safety engineering principles • Structural Mechanics	
Semester 2	Lund University	• Risk assessment • Advanced fire dynamics • Human behaviour in fire • Simulation of fire in enclosures	
Semester 3	Ghent University	• Passive fire protection • Active fire protection I: Detection and suppression • Active fire protection II: Smoke and heat control • Fire safety and legislation • Performance-based design	Choose from: • FSE Firefighting • Modelling of combustion and turbulence • Computational fluid dynamics • Turbomachines
Semester 3	The University of Edinburgh	• Fire science laboratory • Fire investigations and failure analysis • Finite element analysis • Structural design for fire	
Semester 4	Any of the participating institutions or industry	• Research thesis	

11.13.3. ADMISSION CRITERIA

Admission to the program requires Bachelor of Science (three years min/180 ECTS) in an Engineering, Science or related discipline. Applicant are expected to be familiar in the subjects of Physics, Mathematics, Thermodynamics, Statistics, Chemistry and Structural Engineering. An English proficiency test is required for all applicants except those hold a degree with an equivalent qualification to a United Kingdom degree. Additional requirements include two (2) recommendation letters, transcripts and a statement of purpose.

11.13.4. ACCREDITATION

The IMFSE program is accredited by the NVAO (Dutch-Flemish Accreditation Organ).

11.14. THE HONG KONG POLYTECHNIC UNIVERSITY (HONG KONG)

11.14.1. PROGRAMS ON OFFER

Hong Kong Polytechnic offer an MSc in Fire and Safety Engineering. This is a one year full-time or 2.5 years part-time program (30 credits) in Fire and Safety Engineering.[79]

11.14.2. CURRICULUM FOLLOWED

- Intelligent Building and Associated Fire Safety
- Fire Services
- Fire Fundamentals
- Computational Fire Modelling for Building Design
- Fire Engineering Systems
- Fire Dynamics
- Legislation Aspects of Fire Safety Management
- Design Considerations for Fire Safety Management

11.14.3. ADMISSIONS CRITERIA

A Bachelor's degree with Honours in architecture, fire engineering, safety engineering, building services engineering, construction, building surveying, building technology, applied science, engineering, physics or chemistry. Alternatively, a professional qualification plus relevant work experience that is related to the construction industry, such as full membership of the HKIE, HKIS, HKIA, CIBSE, CIOB, IMechE, ICE, IStructE or IEE. Mature candidates who have experience in fire and safety engineering, but who lack formal qualifications, may be admitted subject to an interview and a review of their experience.

11.14.4. ACCREDITATION

Accredited by the Chartered Institution of Building Services Engineers (CIBSE) as suitable further learning to meet the academic requirement for CEng registration.

[79] http://www51.polyu.edu.hk/eprospectus/tpg/2018/04001-fem-fsm

11.15. CITY UNIVERSITY OF HONG KONG (HONG KONG)

11.15.1. PROGRAMS ON OFFER

The programs offered by CityU are jointly delivered with University of Central Lancashire (UCLan) through the School of Continuing and Professional Education (SCOPE).[80] Programs are specially designed to lead students to obtain professional recognition as a Chartered Engineer.

Courses include a BEng (Hons) Fire Engineering which is a two or three-year full-time program in Fire Safety Engineering. The duration of the program depends on the route which depends on the prior qualifications of the applicant.

They also offer an MSc in Fire Safety Engineering which is a 2-year part-time program in Fire Safety Engineering.[81] Each taught module comprises 36 hours of face-to-face teaching delivered by a combination of UCLan instructors and/or local instructors plus on-line learning. Modules delivered by UCLan instructors are conducted intensively over 2 weeks while those delivered by local instructors will be evenly spread over in a regular part-time evening mode.

City U also offer an FDSc (Foundation Degree in Science) in Fire Safety Engineering which is a two-year part-time program in Fire Safety Engineering.[82]

[80] http://www.scope.edu/Home/Programmes/BachelorsDegreeTop-up/FireEngineeringProgrammes/BEngHonsFireEngineering.aspx
[81] http://www.scope.edu/Home/Programmes/PostgraduateProgrammes/FireEngineeringProgrammes/MScFireSafetyEngineering.aspx
[82] http://www.scope.edu/Home/Programmes/BachelorsDegreeTop-up/FireEngineeringProgrammes/FDScFireSafetyEngineering.aspx

11.15.2. CURRICULUM FOLLOWED

The BEng adheres to the following structure:

- Introduction to Combustion and Fire
- Safety and Fire Law
- Energy Transfer and Thermodynamics
- Buildings, Materials and Fire
- Introduction to Engineering Analysis
- Community Fire Safety
- Skills for Science and Engineering
- Fluid Dynamics of Fire
- Fire and Built Environment
- Fire Safety Management & Legislation
- Structures, Materials and Fire
- Community Fire Safety Strategies
- Fire Science Project

The MSc adheres to the following structure:

- Fires in Buildings
- Fire Engineering Solutions
- Computational Fluid Dynamics
- Fire Protection Strategies
- Risk Assessment and Management
- Advanced Engineering Design Project
- Research Methods
- Advanced Engineering Dissertation

11.15.3. ADMISSIONS CRITERIA

Admissions criteria for the BEng are:

- Level 3 or above in HKDSE Chinese and English; and Level 2 or above in Mathematics, Liberal Studies and an elective subject; or
- Grade E or above in 2 HKALE subjects (or 1 HKALE and 2 HKALE AS subjects) and grade E or above in both AS Use of English and AS Chinese Language and Culture; or
- UCAS 280 points including Maths and a Science/Technology subject at A2 or AVCE, plus 5 GCSE's including Maths and English at C; or
- A Higher National Certificate (HNC) in a relevant discipline, such as building services and mechanical engineering with mathematics courses studied.

Admissions criteria for the MSc are:

- Holders of bachelor's degree in Fire Engineering, Building Engineering or other related disciplines.

Admissions criteria for the FDSc are:

- Level 2 or above in 5 HKDSE subjects including Chinese Language, English Language and Mathematics; or
- Grade E in 1 HKALE subject; or E in 2 HKALE AS subjects, including Use of English; and E in 5 HKCEE subjects including English Language (Syllabus B); or
- An academic qualification from a local post-secondary institution (e.g. CityU SCOPE Certificate in Fire Science Studies) or a professional qualification acceptable to UCLan; qualifications attained by study at a local international school or a non-local high school, at Grade 12 or equivalent, are also acceptable; or
- UCAS 180 points at A2 level or the equivalent, plus 5 GCSE's (including a numerate subject at Level C or above)

11.15.4. ACCREDITATION

Graduates from the BEng must also pursue the MSc program to satisfy the current academic requirement for Membership of the Hong Kong Institution of Fire Engineers (Fire Discipline) and Chartered Engineers of the UK Engineering Council.

The MSc program is accredited by the Energy Institute (EI) on behalf of the Engineering Council as further learning for the academic requirement for registration as a Chartered Engineer.

The FDSc program is accredited by the Energy Institute (EI) on behalf of the Engineering Council as partially meeting the academic requirement for registration

as an Incorporated Engineer. It also satisfies the academic requirements for Member Grade of the Institution of Fire Engineers (MIFireE).

11.16. LULEÅ TECHNICAL UNIVERSITY (SWEDEN)

Luleå Technical University offers a BSc course in Fire Safety Engineering resulting in the same degree title as for Lund University.[83] They also offer an MSc equivalent program in fire safety engineering, which results in the title of Civilingenjör Brandteknik.

11.17. THE UNIVERSITY OF WESTERN NORWAY (NORWAY)

The western Norway University of applied sciences offer BSc and MSc degree programs in fire safety engineering.

11.18. CALIFORNIA POLYTECHNIC STATE UNIVERSITY (USA)

California Polytechnic State University, more commonly known as Cal Poly, offers a Master of Science in Fire Protection Engineering. The program caters to online as well as on-campus students requiring completion of 45 credits, ten (10) 4-credit courses consisting of mandatory and elective courses and a 5-credit culminating experience that is presented and defended in front of a review committee. There is no research thesis requirement, students may choose to do a thesis in lieu of the culminating experience. Admission into the program requires bachelor's degree in Science or Engineering with a minimum GPA of 3.0 in a 4.0 scale in the last 90 quarter units or 60 semester units.

Students are required to complete the following mandatory courses: fundamental thermal sciences, fire dynamics, flammability assessment methods, fire modelling, egress analysis and design, fire detection, alarm and communication systems, water-based suppression, structural fire protection and culminating experience in fire protection engineering. Students are also required to choose two courses from the following list as technical electives: fire safety regulation and management, smoke management and special hazards, forensic fire analysis, fire protection management in the wildland-urban-

[83] https://www.ltu.se/edu/program/TYBRG/TYBRG-Brandingenjor-1.76954, accessed 15th August 2018

interface (WUI), advanced heat transfer III, advanced thermodynamics and computational heat transfer.

11.19. UNIVERSITY OF WATERLOO (CANADA)

The University of Waterloo Master of Engineering Fire Safety is a coursed-based graduate program within the Mechanical and Mechatronics Engineering Department. The program takes between one to two years to complete. Courses are delivered in a week-long course format one course at a time. There is no thesis requirement for this program. Admission into the program requires a bachelor's degree in Engineering, Science, Mathematics or equivalent from a recognised university, and a minimum overall standing of 75% in the last two years of the Honours Bachelor's Degree. The University also recommends a three-year post baccalaureate engineering experience. Additional requirements include two (2) letters of recommendation and proof of English proficiency.

The degree requires completion of eight (8) courses consisting of three (3) mandatory courses, three (3) technical electives, two (2) graduate engineering courses, and one (1) communication course. The three (3) mandatory courses are fundamental fire dynamics, advanced fire dynamics and fire modelling. The list of restricted electives consists of risk analysis, fire resistance, advanced concepts in design for fire safety, human behaviour in fire, fire testing and fire risk analysis.

The university also offers a Master of Applied Science in Fire Safety which requires completion of four (4) courses in fire safety engineering listed above as well as the completion of a research thesis. Admission requirements are same as those for the Master of Engineering in Fire Safety.

11.20. LAWRENCE TECHNOLOGICAL UNIVERSITY (USA)

The Master of Science in Fire Engineering consists of a 30-credit program, with 18 credit allotted to core courses and a research project. Admission into the program requires a bachelor's degree in civil engineering, architectural engineering, or mechanical engineering from an accredited program, a minimum GPA of 3.0 in a 4.0 scale, three (3) letters of recommendation, statement of purpose and professional resume.

The core courses include fundamentals of fire engineering, fire dynamics, fire modelling, fire testing methods for materials, structural analysis and design for fire safety and graduate project. For electives students will choose two (2) out of the following courses: large scale fire testing methods, fire protection systems, failure analysis, fire analysis and design in steel structures and advanced fire engineering for structural applications.

11.21. OTHER INSTITUTIONS

Some universities may also offer structural engineering courses with a focus on fire. However, the university will not offer a degree in fire safety engineering. For example, the Civil Engineering Department at the University of Michigan (USA) offers courses focused on structural engineering and fire, but it does not offer a degree. Case Western Reserve University has recently launched a 27-credit master's degree with a focus on fire science covering aspects such as fire dynamics, protection and suppression systems, fire behaviour, and polymeric materials structure.

Aside from the institutions listed in this document the Society of Fire Protection Engineering has identified the following institutions offering Master of Science degrees in fire protection engineering in the North American region: Carleton University (CANADA), University of New Haven (USA) and University of St. Thomas (USA).

12. Appendix 3

Examples of State-Based Accreditation Schemes

12.1. NEW SOUTH WALES (NSW)

Accreditation in NSW is managed by the Building Professionals Board Accreditation Scheme (the Scheme).

The Scheme is made in accordance with the *Building Professionals Act 2005* (the Act). The Scheme establishes the criteria to be met by any individual seeking a certificate of individual accreditation as an accredited certifier under the Act. Applicants for a certificate of individual accreditation must demonstrate that they have the qualifications, skills, knowledge and experience required by the Scheme.

Fire safety engineers are accredited as *"C10 Accredited certifier – fire safety engineering compliance"*.

12.1.1. EDUCATIONAL REQUIREMENTS

For category of accreditation C10, the Board recognises **a degree** in fire safety engineering from a university within the meaning of the ***Higher Education Act 2001***.

Higher Education Act 2001 defines a degree as:

> *"A degree of any kind, including an* ***associate degree*** *and, in particular, the degrees of doctor, master and bachelor."*

An **associate degree** is an undergraduate academic degree awarded by colleges and universities upon completion of a course of study intended to usually last *two years* or more.

This particular approach allows persons *without* a three or four-year engineering or science degree to be accredited as fire safety engineers in NSW.

12.2. VICTORIA (VIC)

The Victorian Building Authority (VBA) is responsible for administering the scheme for the registration of building practitioners in Victoria. The term 'building practitioner' is defined in section 3 of the *Building Act 1993* (the Act), and includes an engineer engaged in the building industry.[84] There are four prescribed classes of engineer within the building practitioner category of 'engineer', including the class of engineer (fire safety).[85]

1. holds the prescribed qualification for registration, or
2. unless the regulations otherwise provide in relation to a particular category or class, holds a qualification that the VBA considers is, either alone or together with any further certificate, authority, experience or examination equivalent to a prescribed qualification.

The VBA cannot grant a natural person an application for registration as a fire safety engineer, unless it is satisfied that the applicant (among other things):[86]

To maintain consistency in the standards applied across the two pathways to registration in a class of engineer, the VBA considers that a degree in engineering to be a four-year degree (honours) in engineering.

[84] Building Act 1993 (VIC) s 3.
[85] Building Regulations 2018 (VIC) sch 9 pt 2
[86] Building Act 1993 (VIC) s 171.

The prescribed qualification for registration as a fire safety engineer is the successful completion of:[87]

a. a Graduate Certificate in Performance-Based Building and Fire Codes from Victorian University and any prescribed qualification for registration in the class of engineer (civil), engineer (mechanical), or engineer (electrical); or

b. a Master of Engineering (Building Fire Safety and Risk Engineering) from Victoria University; or

c. a current certificate of registration as a fire safety engineer on the National Engineering Register (NER); and

d. at least three years of practical experience.

Practical experience must have been obtained in the seven years before the application for registration was made.[88]

Proposed changes to the registration arrangements for engineers in Victoria were introduced into the Victorian Parliament in 2018 through the Engineers Registration Bill 2018 (Bill). The Bill failed to pass both houses of Parliament by the final sitting day before the election in November 2018. As a result, the Bill expired.

The Bill proposed the establishment of a mandatory registration scheme for all engineers in Victoria, including engineers registered as building practitioners registered in the category of engineer under the *Building Act 1993*, to be administered by the Business Licensing Authority (BLA).

The Bill proposed that persons applying for registration as an engineer will be able to apply for an endorsement that they are permitted to practice as an engineer in the building industry (in an equivalent capacity to that of persons currently registered as a building practitioner in the category of engineer). The Bill also provided for the transition of persons registered as a building practitioner under the *Building Act 1993* in a class of registration in the category of engineer to the proposed scheme.

12.3. QUEENSLAND (QLD)

Queensland is currently the only Australian jurisdiction to apply a comprehensive registration system for engineers. Registration as a RPEQ is formal recognition of the qualification and competency of an engineer.

Applying for mutual recognition of registration Applications under Mutual Recognition will be accepted from engineers registered with another state's engineer registration authority, such as NSW Building Professionals Board, Victorian Building Authority, Northern Territory Building Practitioners Board. (NOTE: By-passing the strict educational requirements of CPEng and NER).

[87] Building Regulations 2018 (VIC) sch 9 pt 3
[88] Building Regulations 2018 (VIC) reg 258(2).

12.4. TASMANIA (TAS)

The *Building Act 2000* provides for the accreditation of building practitioners as builders, building surveyors and designers.

Fire Safety is unrestricted in the field of Fire Safety Engineering and includes Alternative Solutions. Fire Safety Engineering is defined in Tasmania as the application of engineering principles, rules and expert judgement based on a scientific appreciation of fire and its effects, and of the reaction and behaviour of people in the event of fire in order to:

- save life, protect property and preserve the environment and heritage from destructive fire;
- quantify the hazards and risk of fire and its effects;
- mitigate fire damage by proper design, construction,
- arrangement and use of buildings, materials, structures,
- industrial processes and transportation systems;
- evaluate analytically the optimum protective and
- preventive measures, including design, installation and maintenance of active and passive fire and life safety
- systems, necessary to limit, within prescribed levels, the consequences of fire.

Class Requirements for Accreditation Engineer as a Fire Safety Engineer require either:

- Listing on the National Professional Engineers Register (NPER) with the specific area of practice of Fire Safety;
- Recognition by Engineers Australia as a Chartered Professional Engineer in the specific area of practice of Fire Safety; or
- An appropriate degree (AQF 7) with a Graduate Diploma or higher qualification in Fire Safety such as the Graduate Diploma of Building Fire Safety & Risk Engineering from Victoria University or Master of Fire Safety Engineering from the Western Sydney University and three years design experience in the area of fire safety engineering attested to by a senior engineer within the area of practice of Fire Safety[89]

[89] In addition to engineering degrees, 'an appropriate degree' may include degrees in Architecture or Building Surveying and persons without an undergraduate degree but with a Grad Dip in FSE can obtain registration.

12.5. WESTERN AUSTRALIA (WA)

Western Australia does not currently have a requirement for registered fire engineers. However, it is expected that fire safety Performance Solution designs are carried out by fire engineers with sufficient skills, qualifications and experience for the specific project. This is similar to structural engineering being carried out by a suitably qualified and experienced structural engineer. Fire engineering may include qualifications such as an undergraduate degree in Fire Safety Engineering, a post graduate qualification in fire engineering and may also include registration with a relevant association such as the National Engineering Register or being a registered fire engineer for the purposes of Building Code compliance in another State.

FOR MORE INFORMATION ON STATE-BASED ACCREDITATION SCHEMES, SEE THE WARREN CENTRE'S FORTHCOMING REPORT ON THE STATE OF FSE REGULATION, CONTROL AND ACCREDITATION IN AUSTRALIA.

DISCLAIMER

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This report is one in the Warren Centre's current series of research reports of the state of Fire Safety Engineering in Australia. For the latest project information, additional reports and public events on this critical topic, visit https://thewarrencentre.org.au/publications/

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ISBN-13: 978-0-646-99787-2 • wc4575-16 Education Report

The Warren Centre for Advanced Engineering, University of Sydney. Sydney, Australia. January 2019.

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THE UNIVERSITY OF SYDNEY

Restoration of the heritage-listed 50 Martin Place, Sydney required specialist fire safety designs for the 1925 banking landmark.