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Meacham Associates

Research to Support the Improvement of the Design Verification of Fire Engineered Solutions as Part of the Scottish Building Regulatory System

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The opinions expressed in this report are those of the author.

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This report is published electronically to limit the use of paper, but photocopies will be provided on request to Building Standards Division.

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1 Executive Summary

Based on the findings of this research, it can be concluded that while the building and fire regulatory, design and verification system in Scotland can be improved, the situation is not dire, and is generally on par with other countries which have implemented functional-, objective- or performance-based building regulatory systems. This is largely because both functional (objective- or performance-based) building regulations and fire safety engineering – in particular performance-based fire safety engineering – are not yet mature, and the sector at times becomes frustrated as it seeks to find balance in a regulatory system which has gaps and in a fire engineering discipline which is at an adolescent stage of development.

There were four principal tasks for this research:

- Establish a baseline of the current fire engineering position in Scotland.
- Identify areas of improvement for different ‘actor’ groups.
- Chair a workshop to discuss findings and explore possible improvements.
- Prepare a final report.

This document constitutes the final report. The workshop was held on 16 June 2016, in which preliminary findings were presented and the feedback summarized in Section 7 was obtained. A copy of the workshop slides are provided in Annex B.

Baseline of Current Fire Engineering Position

With respect to establishing a baseline of the current fire engineering position in Scotland, the situation is mixed. Some aspects are working well, but there is room for improvement in several areas. The issues are highlighted and discussed in Section 4 (feedback from stakeholders) and Section 6 (observations and discussion). The key aspects can be group and summarized as follows:

Functionality of the current system

There are challenges associated with the fact that there is no qualification system for fire engineers, including no benchmark in the market to help assess / determine competency, qualifications and experience. This leads to a range in quality in projects, uncertainty in terms of what level of reliance on expertise of fire engineers is appropriate, and how / at what levels reviews should be undertaken.

There is a lack of clarity in roles and responsibilities of actors – particularly around the review and approval process (verification) – and particularly with respect to the Scottish Fire & Rescue Service (SFRS). This leads to uncertainty in the design and review process, and has led to significant costs on projects due to decisions which are made at the end of design / during construction.

There are indications that the community is operating too much in isolation at times (in silos). Such working in isolation means issues can be missed and problems not identified until late in a project.

Fire engineering principles are also employed on too many ‘small’ deviations from technical guidance, which does not seem to be the best use of scarce resources.

There is widespread concern that too many projects focused more on saving a client money than on delivering safe buildings. This seems to particularly occur when fire engineers are engaged late in a project to help resolve a problem that a designer was unaware of and a solution is needed to ‘save’ the project. This can place designers, fire engineers and verifiers in a difficult position.

The system works well with good communications and respect, but there is indication of poor attitude by some actors.

Fire engineers / engineers

Due to the lack of a prescribed qualifications system, there is a wide range of competency in fire engineering community. As noted above, this leads to a range in quality in projects, uncertainty in terms of what level of reliance on expertise of fire engineers is appropriate, and how / at what levels reviews should be undertaken. The lack of students undertaking fire engineering degree programs contributes to this situation.

There is a lack of consistency and clarity in the application of fire engineering approach(es). While flexibility is a hallmark of a function-based regulatory system, it should be expected that appropriate means / methods of engineering be applied, and where a standard, guide or code of practice is used, it is followed in its entirety to a level appropriate to the project. There are numerous indications that this is not the case in Scotland.

There is a wide range in the quality of designs and associated documentation. This is in part a function of the lack of qualifications and consistent application of fire engineering guidance, but it is also an attribute of the building regulatory system, which could state more clearly the expectations of design reports and level of documentation required.

Verification of fire engineered designs

The building regulatory system, and how it is implemented in relation to fire safety, is viewed as not being consistent in terms of what is ‘required’ and what is ‘guidance.’ Although the system is nominally a function-based system – with the only requirements being to comply with the Functional Standards – in practice the guidance documents (e.g., Technical Handbooks) are serving as the de facto requirements by some local authorities. The guidance in the Technical Handbooks refers to what might be allowable as ‘alternatives,’ when in fact the guidance within the Technical Handbooks themselves are alternatives (i.e., not required).Given the lack of clarity in the Technical Handbooks, the interpretation by local authority verifiers (LAVs) varies significantly, from only allowing fire engineered designs if they are benchmarked comparatively to the Technical Handbook – Fire guidance, to allowing any design if the LAV deems the fire engineering analysis, design and documentation appropriate. There is also the situation that a design which is accepted by one local authorities may not be acceptable in another, which is difficult to understand in a country with a national building regulatory system.

It appears that resources are lacking for the comprehensive review (verification) of ‘significant’ designs. There is a range of fire engineering capabilities within LAVs, although they can call upon fire engineers when deemed necessary. However, there are a limited number of fire engineers in the market, and therefore limited number available for independent third party / peer review. Furthermore, the SFRS fire engineering resources are limited. These limitations, coupled with a large number of fire engineering efforts on ‘simple’ projects can result in significant review times and inconsistency in approvals.

In addition, there do not appear to be any agreed guidelines for review and approval of fire engineered designs, for the use of third party / peer reviewers, or for the use (consultation) of the SFRS in the process. Each of these issues contributes to uncertainty and inconsistency in the verification process.

Regulations / regulatory system

As noted above, the building regulatory system, and how it is implemented, is not achieving the vision that underpinned the changes to the system in 2005. This has led to inconsistency in terms of what is required and what is guidance. Although the system is nominally a function-based system – with the only requirements being to comply with the Functional Standards – in practice the guidance documents (e.g., Technical Handbooks) are currently being used as the de facto requirements by some local authorities. The guidance in the Technical Handbooks refers to what might be allowable as ‘alternatives,’ when in fact the guidance within the Technical Handbooks themselves are alternatives (i.e., not required).

However, verifiers (and engineers) can find themselves in a difficult spot if they simply want to meet the Functional Standard as it is unclear what the target levels of safety / performance are, or how they should be measured and assessed. Moving forward, the issues of ‘what is required versus what is guidance’ and ‘how is ‘acceptable’ performance measured’ need to be resolved, provide greater clarity and aid national consistency.

The scope of the regulations – and therefore designs and the verification thereof – is not clear. The Building Act speaks to ‘sustainable development’ and ‘securing the welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings’ as well as health and safety of persons in and about buildings. It is hard to envision how one addresses ‘sustainable development’ without considering property protection (i.e., how is a building that is allowed to burn down and be replaced sustainable?) or how one can ‘secure the welfare… of persons’ without considering economic implications of fire (i.e., property protection and business continuity). However, the Technical Handbook does not clearly identify whether its focus is life safety or property protection. This creates a conundrum for all actors in the system in terms of what should be included in a fire engineered design to comply with the regulations.

Suggested Areas of Improvement for Stakeholder Groups

The Building Standards Division (BSD) have made significant gains in bringing the relevant parties together over the past year. However, even better communication between BSD, LAVs, SFRS, fire engineers, architects, insurers, owners and developers is needed. This is not just during facilitated meeting and workshops, but as part of normal business. Having respectful, transparent, timely and relevant discussions on projects will help foster better relations, projects and outcomes.

As for suggested areas for specific groups the following is suggested.

Fire engineers

Sort out the qualifications issue. It is in the best interest of the discipline to establish professional credentials and push the market upward. Considerations should include minimum education, experience, areas of competency, ethics, economics and regulatory environment.

Develop a definition of ‘fire engineer’ and of ‘fire engineering’ for use in Scotland. It will be needed for the qualifications system and the regulatory system.

Think about what types of projects require ‘fire engineering’ – what is needed, why is it needed, what will it involve. This will help educate the market and inform regulatory decisions (e.g., what is in the Technical Handbook – Fire, what might become ‘accepted alternatives,’ what is needed for a comprehensive fire engineered design).

As a discipline, discuss and provide recommendations as to what types and levels of fire engineering guidance are appropriate for use in Scotland. If a variation of BS 9999, what would it contain, why, and how would it be used. If BS 7974, self-enforce the complete application of the guidance, and consider supplemental information on scenarios, fires and related factors. Require QDR. Consider development of a Scottish equivalent to the New Zealand C/VM2 for ‘simple’ fire engineered designs. Generally, be proactive and positively influence the development of the discipline.

Act as professionals and treat other professionals likewise. All actors in the system have different roles and responsibilities, and have expertise and experience suited to those positions. Different expertise is not somehow less expertise or lower value.

Local authority verifiers

Work with BSD to sort out what is ‘required’ and what is ‘guidance’ in terms of the regulations / Functional Standards – and consistently apply the outcome / agreement nationally.

Develop procedures for review of fire engineered designs (ideally in concert with the fire engineers and the SFRS) – and consistently apply the approach nationally.

Develop procedures for use of third party / peer review of fire engineered designs (ideally in concert with the fire engineers and the SFRS) – and consistently apply the approach nationally. This might also involve establishment of a ‘central’ resource for peer review, or at least guidance on how to select peer reviewers (including qualifications, experience, conflict of interest issues, etc.).

Agree with the SFRS how consultation and advice should be used – when are SFRS involved, what feedback is requested, and what might be done with that feedback. Consistently apply the agreement nationally.

Seek resources for training and technology (e.g., computers and software) to support level of expertise and capability needed to undertake review of complex fire engineered designs (particularly those using advance computational models).

Act as professionals and treat other professionals likewise. All actors in the system have different roles and responsibilities, and have expertise and experience suited to those positions. Different expertise is not somehow less expertise or lower value.

Scottish Fire and Rescue Service

Work with BSD and other relevant entities to clarify fire service input needed in building regulation, and to minimize overlap / competing requirements between building and fire regulations.

Work with BSD, LAVs and fire engineers to obtain clear requirements / objectives relative to SFRS involvement in review process – when in process, scope of involvement, expectations for action on feedback, etc.. Consistently apply the outcome nationally.

Seek resources for training and technology (e.g., computers and software) to support level of expertise and capability needed to undertake review of complex fire engineered designs (particularly those using advance computational models).

Act as professionals and treat other professionals likewise. All actors in the system have different roles and responsibilities, and have expertise and experience suited to those positions. Different expertise is not somehow less expertise or lower value.

Building Standards Division

BSD need to be clear on whether Scotland wants a Functional system with prescriptive alternatives, or a Prescriptive system with performance by exception, is desired. At present, the mix is creating confusion and inconsistency in the implementation of the regulations and guidance.

In the short term, BSD need to clarify the requirement is to satisfy the Functional Standards, with the guidance in the Technical Handbook being only one way to achieve this. Guidance is also required on how to benchmark expected performance (function) if the benchmark is not the Technical Handbook.

If furthering the Functional system is desired, consideration should be given to identifying target levels of performance (risk, safety) and development of quantified measures of performance (risk, safety) for use in regulation and for verification that designs comply with the regulations.

The scope of the regulations needs to be clarified. For example do they just cover life safety or is property protection included or not? How do the regulations foster 'sustainable development' and 'securing the welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings' as associated with fire (and other hazards)? Clarification will help ease concerns throughout the implementation of the regulations.

A review of the Fire provisions in the Regulations, and the associated guidance in the Technical Handbook, is suggested in light of the above issues. The focus of the review will likely be influenced by the direction selected for the regulatory system.

Architects

Work to minimize the engagement of fire engineers at the last minute to 'save' a design – better understand the regulations, and where needed, engage a fire engineer early to help minimize impacts.

Work with competent and qualified fire engineers. Pay for value – do not drive to the bottom. Consider the long term issues and not just the short term costs.

Better communicate with LAVs any changes to projects in a timely manner. Start communication early. If major changes occur (design, materials, etc.) inform the LAV. Delivering a design that does not match up with conceptual agreements (e.g., QDR) will increase the review time and likelihood for problems.

Owners and developers

Work to minimize the engagement of fire engineers at the last minute to 'save' a design – better understand the regulations, and where needed, engage a fire engineer early to help minimize impacts.

Work with competent and qualified fire engineers. Pay for value – do not drive to the bottom. Consider the long term issues and not just the short term costs.

Involve insurers early, especially if there are property protection and/or business operation issues – important to the fire safety strategy – which are not addressed specifically in the building regulations. It is better to have all fire safety goals and objectives on the table and addressed rather than meet the code yet have to do more after construction to get insurance and/or otherwise manage risks.

Better communicate with LAVs any changes to projects in a timely manner. Start communication early. If major changes occur (design, materials, etc.) inform the LAV. Delivering a design that does not match up with conceptual agreements (e.g., QDR) will increase the review time and likelihood for problems.

Insurers

Communicate issues / concerns to owners, managers, fire engineers, SFRS and BSD. If parties understand issues then perhaps they can be addressed.

Provide data on issues of concern (e.g., competing objectives between sustainability and fire protection). Evidence is helpful in fostering change.

Help to educate the stakeholders in relevant areas, as based on fire loss history and other perspectives unique to the insurance sector.

Academics

It is not clear that any particular change is needed. However, it seems that more university programs in fire engineering may be needed to underpin a fire engineering qualifications system, and to provide more engineers into the market.

Overall resourcing needs

In order to work in a functional system, there is a high reliance on expertise to be able to assess engineered designs. This places a high burden on LAVs and the SFRS, which need to have personnel (or access to them) who are educated in fire engineering, trained on software and related technology used by fire engineers, and be adequately supported with technology (computers) on which software used by engineers can be run so as to assess and verify the appropriateness of designs based on such software.

With a lack of fire engineers in the market, and in particular employed by LAVs, it is prudent to consider formation of some sort of central review body for fire engineered designs, for the sole purpose of supporting LAVs with review and approval (verification) of complex fire engineered designs.

Concluding Remarks

The fire engineering situation in Scotland is at a crossroads. While not in dire straits, there are issues which warrant attention, and critical decisions need to be made relative to the future form and content of the regulatory system and supporting infrastructure. A variety of suggestions have been made. There is an opportunity here to craft changes to the regulatory system that will help to achieve the vision that underpinned the changes to the system in 2005. It is hoped that the research, observations and suggestions will help foster a more efficient building regulatory system and fire engineering environment into the future.

2 Background and Introduction

In recent years Scotland has seen an increase in fire engineering (FE) solutions being presented to Local Authority Verifiers (LAV) for approval. Through the Ministerial 'Views' process, enquiries and correspondence, the Building Standards Division (BSD) have come across examples where fire engineered solutions are presented with limited information and/or justification. In addition, with the increasing use of FE solutions, the Scottish Fire & Rescue Service (SFRS) are concerned not only about means of escape for occupants, but also the risk to their fire fighters when carrying out rescue and firefighting operations.

It has been reported that many of the FE solutions are not developed from 'first principles,' but are essentially variances from the guidance in the Technical Handbook, Section 2: Fire (TH-Fire) for specific aspects of the building fire safety design. The solutions are nominally proposed as being equivalent (or better) than the recommendations set forth in the THF, with BS 7974 (2001), Application of fire safety engineering principles to the design of buildings, being most often applied to demonstrate equivalent safety through comparative analysis.

In June 2015, BSD carried out a survey of LAVs and members of the Inter-jurisdictional Regulatory Collaboration Committee (IRCC) on how FE designs are undertaken both in Scotland and Internationally. This was followed up by a workshop which examined the current fire engineering position in Scotland, with members of the IRCC highlighting how FE is practiced in their respective countries. The outcome of the survey and workshop identified the following issues:

- Who can practice as a fire engineer / competency level
- Level of education and ongoing training required
- How best to foster the exchange of ideas across fire engineers, regulators and academics
- How to highlight "Best Current Practice" – International guidance & approaches

The above issues were discussed at a workshop held in April 2016 with representatives from the LAV, FRS and the FE community. In addition to the above, a number of additional matters were identified which impacted on the effective operation of fire engineering in Scotland. These included:

- A lack of awareness of the services provided by Local Authority Building Standard Scotland (LABSS), an umbrella group representing Scottish Local Authority building standards services
- Limited understanding by the fire engineering community of the Building (Scotland) Act and supporting legislation
- A limited awareness (and lack of consistency) of the information LAVs look for when determining if the functional standards have been satisfied

- The FE community is highly fragmented and does not speak with one voice

- In practice, fire engineers generally check compliance against the guidance contained in TH-Fire. This allows them to establish where deviation(s) from the Handbook exists and identify potential approvals risk for their client

- There can be significant delays in processing of fire engineering solutions by the LAV

- Those that carry out the verification on behalf of local authorities need to have appropriate skills, knowledge and experience

While there seems general agreement that the above issues exist, there was no clear direction from stakeholders on how to take these issues forward. There was, however, general consensus about the use of a standardised format/template for fire engineers to follow and general acceptance of the need to scrutinise competence / qualification of all parties involved in the process.

Given the lack of a specific plan forward, it was decided by BSD to engage an outside consultant, Brian Meacham, to undertake a short-term (3-week) research project to explore the situation in more detail, and to make suggestions and recommendations on a path forward.

The aims of the research project were identified as follows:

- **Establish a baseline of the current fire engineering position in Scotland.** Through discussions with key stakeholders (actors) in the sector, including FE practitioners, BSD, SFRS, LAVs, and university faculty / researchers, to seek their views on the current state of FE practice, including the process(es) used in analysis and design, reporting, review and approval. Suggestions on how best to engage with developers and architects, who generally have little knowledge in this field, are also desired.

- **Identify areas of improvement for different 'actor' groups.** After meeting with and collecting information, suggest possible areas for improvement within each stakeholder (actor) group. This should consider, where appropriate, reference to the situation in Australia, New Zealand and any other relevant jurisdiction that might be beneficial in identifying and prioritising actions that will deliver greatest improvement.

- **Chair a workshop to discuss findings and explore possible improvements.** Present findings, suggest possible improvement actions, and facilitate discussion amongst attendees.

- **Prepare a final report.** The report is to include a compilation of the information collected, output from workshop, and suggested improvement actions for future development regarding the design verification of fire engineered solutions as part of a Scottish building regulatory system.

In conducting the research, it was requested that the following items be included:

- Provide advice based on international experience on risk based methodologies for the design and verification of fire engineered solutions

- Provide advice based on international experience of regulation or registration of fire engineers and how this may be adapted for Scotland

The following sections reflect the outcomes of the research. These sections are laid out as follows:

- Section 3: Questions posed to the various stakeholder groups.

- Section 4: Summary of discussions with stakeholder groups, based on overall scope and questions provided.

- Section 5: Summary of situation in other countries with respect to similar issues, including qualification / competency targets for practitioners (engineers, approval authorities, etc.), fire engineering methodologies / verification methods, documentation, and design review and approval (including 3rd party / peer review).

- Section 6: Preliminary findings for presentation to stakeholder groups.

- Section 7: Feedback resulting from presentation to stakeholder groups.

- Section 8: Findings and conclusions.

- Annexes: Details / supporting material relative to the above.

3 Stakeholder Questions

A key component of this research was to obtain views from various stakeholder groups as to what is working, and not working so well, with respect to fire engineering solutions, and how the system might be adjusted, if necessary, to facilitate a better process and better outcomes for those involved.

In order to obtain a comparable set of information from the various stakeholder groups, the below set of questions was developed for use during stakeholder meetings. The list was also left with each group so that additional feedback could be provided.

The meetings were not so structured as to address every question in order, or every question, for that matter. Rather, the intent was to have a guided discussion, but to allow the discussion to develop around the major issues / concerns of the actors. Discussions from the various stakeholder meetings are summarized in Section 4.

1. What is your general sense of the state of fire engineering in Scotland? What is working well? What is not working so well?

2. On what types of projects is fire engineering most used?

3. What are the main triggers for using fire engineering (e.g., make the design work at 11^{th} hour, remove FP features, address occupant vulnerabilities, address unique hazard, …)?

4. What percentage of projects would you estimate are variances from the Technical Handbook provisions, or conversely, from first principles?

5. What are the most common triggers for one route or the other?

6. Do you think only qualified fire engineers are undertaking fire engineering designs?

7. How would you define a ‘qualified’ fire engineer?

8. Do you think there are enough qualified fire engineers in Scotland – across all areas (design, review and approval, peer review, enforcement, etc.)?

9. Do you think the existing mechanism(s) for professional qualification/certification are adequate?

10. If not, what would be your recommendation for qualification / certification / licensing?

11. Do you think specialist certification would be helpful, such as CFD or evacuation modelling competency?

12. What are your views on the current approval process(es) for fire engineered designs?

13. What percent of fire engineered designs are reviewed by qualified fire engineers?

14. When peer review is used, how well do you think the approach is working?

15. What are your views on the role of the fire service in the review process?

16. If you could change something in the review and approval process, what would it be?

17. Do you think some sort of ‘expert’ review panel, comprised of members from inside or outside of the Scottish fire engineering design community, could be helpful in any way?

18. Do you think more / different guidance for design / review is needed? If so, comprising what?

19. What are your views on the current formulation of the Building Regulations with respect to fire?

20. Any other thoughts, issues, benefits, concerns, enhancements, etc. related to the Building Regulations or fire engineering within the building regulatory system that you would like to share.

4 Summary of Stakeholder Discussions

This section provides summaries of the various stakeholder discussions, as interpreted and recorded by Brian Meacham. While BSD have the names of participants of the various meetings, names are not attributed to specific comments. It should be noted that the participants of the various meetings did not review the below summaries.

Fire Engineering (FE) Practitioners

A two-hour meeting was held with ten FE practitioners at Denholm House in Livingston on 2 June. The attendees were invited by BSD. The attendees were welcomed by Jim McGonigal of BSD, who overviewed the purpose of the meeting, introduced Brian Meacham, and then left the meeting for about one hour before re-joining. The list of questions was distributed and discussion ensued.

In essence, three general themes emerged about the state of FE practice:

- The environment is not really functional based, but is ‘prescriptive with functional (performance) alternatives.’

- There is a wide range of capability amongst LAVs, with most local authorities not having any FE staff, and the approval process being driven by comparison against the TH-Fire provisions.

- There is a wide range of policies, practices and expertise applied to review and approval of FE designs.

Discussion suggested that the environment is driven by a lack of surety in the review process, which forces a ‘deviation from prescription’ approach as a means to de-risk projects. This in turn is driven by a lack of resources at the LAV level, where in many cases neither the expertise nor the processes are in place to support timely and appropriate review of FE designs.

Inconsistency in the review of FE designs imposes impacts on the market, since uncertainty exists in approval from project-to-project and jurisdiction-to-jurisdiction. Some LAVs simply follow a ‘tick-box’ approach to review of designs, looking for how each requirement in the TH-Fire is addressed. Some LAVs employ third-party reviewers. Other LAVs essentially utilize the SFRS as reviewers, which is not their legislated role (should only be consultation role). Some reviews are relatively fast, while others have taken up to a year. It was noted that two offices, under the same authority, had differing views on the same solution to a particular problem. There is no uniform / consistent approach to expectations for FE submittals, including when the various stakeholder parties are engaged, how FE solutions get reviewed, by whom, and how long the reviews will take.

It was broadly felt that when all parties were engaged early, and good communication was maintained throughout the project, that outcomes were generally better. Concern was noted that when SFRS are consulted at the end, it can be very hard to incorporate their comments.

When exploring triggers to use of FE solutions, there was no particular type of building or occupancy which was predominant. Rather, it is mostly a function of client objectives / project needs. There was recognition that fire engineers are sometimes called in late in a project to 'find solutions' to non-compliances with the TH-Fire. These situations are often the most difficult, but are also a practical reality. There was widespread agreement that engaging fire engineers early could help alleviate some of the issues associated with 'late fixes.'

With respect to measures that could be helpful, clearer guidance was the general theme. This includes for design and review. Specific areas included: agreed acceptance criteria for designs (e.g., tenability limits), which even though exist in BS 7974, are not always agreed to; clear review and approval processes to be used by LAVs; consistency in the SFRS consultation (timing and expectations); consistent framework for peer review (what criteria for selection, when used, what process they should follow, etc.); more FE resources, training and education for LAVs.

With respect to FE resources for LAVs, the concept of a 'central' review panel of sorts was raised. There was some support for this idea as being helpful. Questions of resourcing, selection and operation were raised. The involvement of the SFRS was raised, but the feeling was that they could not participate due to their legislated consulting role. It was questioned whether the LAVs could pool resources and 'share' one or more fire engineers to undertake reviews on behalf of all LAVs.

There was quite a bit of discussion around the issue of qualifications and competency. It was generally desired that some type of qualifications / registration system be applied to both engineers and reviewers, such that those undertaking reviews have the required competencies to look for the right issues, ask the right questions, and understand and appropriately act on the answers. Most attendees felt that Chartered Engineer (CEng) level is needed for FE practitioners. Some discussion was held as to whether Incorporated Engineer (IEng) level is acceptable for some designs and for review (questions were raised as to whether someone not engaged in design could obtain CEng status). There was no appetite that fire engineers be licensed by government. There was a sense that some sort of definition / description / set of criteria for identifying 'qualified' and/or 'competent' fire engineers is needed. Some discussion of the role of the Institution of fire Engineers (IFireE) was held. An offer was made to the assembled group to meet with the IFireE in the future.

There was interesting discussion about the fact that energy and acoustic practitioners have more controls placed on them than fire engineers, and yet fire engineers play an important life safety role. There was not a desire to allow fire engineers to self-certify, like energy and structural engineers. It was felt that some type of review, due to the life safety nature, is warranted. (Observation: This might be reflective of the adolescent nature of fire engineering as a discipline and lack of broadly accepted minimum competencies, processes and the like.)

It was noted that groups should self-regulate, to some extent, but not practising outside of their area of competency. However, for some groups, it is not clear that this is followed or how it is addressed in practice (e.g., what happens when a Building Surveyor is faced with a FE solution).

It was also noted that Chartership is not itself enough. The practitioners need to have an understanding of the local regulatory environment as well. (Note: It was mentioned to the group that a similar discussion was held in New Zealand, where although CEng status through the IFireE is acknowledged, one also has to demonstrate understanding of fire engineering practice in the New Zealand context before obtaining a Professional Engineer (PEng) designation from the Institution of Professional Engineers New Zealand (IPENZ).)

The lack of educational resources was noted, including BEng programs[1] and graduate programs. Discussion about fire engineers providing education / training to LAVs was held, and while some education in specific areas was being provided when asked (particularly CFD modelling and structural fire engineering), there was some sense that LAVs could view education from fire engineers as 'self-serving' in a way (i.e., for marketing more than for education). It was generally felt, however, that having more fire engineering education opportunities, formal as well as continuing professional development (CPD), would be beneficial across the sector.

It was noted that this session was helpful in identifying issues and opportunities.

Note: Additional feedback was provided to the questionnaire after the meeting. Two completed survey responses provided can be found in Annex A.

Scottish Fire and Rescue Service (SFRS) Personnel

A two-hour meeting was held with six members of the Scottish Fire and Rescue Service Fire Engineering Group (SFRS FEG) at the SFRS facilities in Cambuslang on 2 June. Jim McGonigal and Colin Hird of the BSD attended as well. The attendees were welcomed by the SFRS FEG, who introduced themselves. Jim McGonigal introduced Brian Meacham and overviewed the purpose of the meeting. The list of questions was distributed and discussions ensued. It was noted that the intent was not to address all questions in the session, but have them as guidance for the discussion. The key was to obtain perspectives from fire engineers on the situation. Attendees were encouraged to send any additional feedback they might have by email after the meeting.

The SFRS FEG noted that they enjoyed generally good communication with BSD, LAVs and the FE community. The SFRS FEG focus is on appropriate fire and life safety for all – occupants and the fire service. When consulted they provide feedback from this perspective within the scope of their remit. While the group is well-qualified, they aim to continually increase their knowledge, capabilities and capacity.

Variability between FE firms, and between people within the same FE firm, has been observed. In general the system works well when qualified fire engineers are engaged early and the SFRS FEG is consulted early. The system does not work so well when fire engineers come in late and it is perceived that they are there to save the client money more so than to undertake good design.

It was noted that some FE designs have been reviewed which are inadequately developed, supported and/or documented. Issues of concern include lengthy dead ends, single means of escape, lengthy travel distances, and reduction in fire resistance

[1] It is noted that following the term of the initial research, the Glasgow Caledonian University BEng (Hons) Fire Risk Engineering course was approved in July 2016 by the Engineering Council degree accreditation for IEng standard route and partial fulfilment of CEng standard route.

ratings, along with limited scenarios and design fire sizes, lack of consideration of firefighting operations, lack of sensitivity analysis, inconsistent use and justification of data sources, and inconsistent discussion of assumptions and limitations. In particular, concerns exist where 'trade-offs' are occurring between one type of fire protection measure and another and substantiation is lacking. There have also been concerns with the application of some modelling tools, where it appears default values are used when the reports discuss other influencing factors (e.g., fuel characteristics, occupant characteristics, etc.).

More guidance as to what FE analysis is required, and when, would be welcome. Just because an apparent deviation from the TH-Fire is small, it may have impacts on other fire safety features or functions. More holistic consideration is often needed.

It was observed that a range of FE capabilities exist within LAVs, and different authorities invite SFRS FEG participation at different levels. Some invite the SFRS FEG in early for consultation on warrants while others look to the SFRS FEG for detailed assessments. In some cases the SFRS FEG are not consulted at all, and they often do not know the extent to which, their feedback is incorporated into the final design. A fire safety design summary for all projects would be helpful. (Note: Jim McGonigal noted that the Fire Safety Design Summary form is included as part of the new electronic approvals system for non-domestic buildings.)

A consistent approach to when the SFRS FEG is engaged, and regarding their scope of involvement, would be welcome. It would be a better use of resource to be involved only in complex designs, if the LAVs had sufficient capacity to address the less complex issues.

It was noted that the SFRS is looking to expand their fire engineering team, as well as the training, education and capabilities of the team. The ideal is to have fire engineering degree for all members. This is helpful so as to stay abreast of fire engineering practice and technology. It was noted that in addition to training and education, appropriate technology is needed to facilitate adequate and timely reviews. In particular, with the growing use of computational fluid dynamics (CFD) modelling, significant computational capacity is needed to effectively assess models submitted as part of fire engineering designs. With old technology, each CFD model run can take as much as a week. If a firm conducts several CFD analyses as part of a design, it could take weeks to assess the models.

A requirement for a fire strategy to be developed early, and to obtain SFRS FEG input at that stage and get everyone in agreement, could address a significant number of concerns. Architects, developers and other such parties need to understand this and work to move the FE and SFRS FEG input earlier in the project work stream. It was observed that more FE education – and about FE – is needed across the sector.

It was noted that this session was helpful in identifying issues and opportunities. It was suggested that case studies with exemplar buildings could help illustrate the breadth and depth of items to be considered in a FE analysis and would be helpful to all. It was suggested that a small working group of SFRS FEG, FE, LAVs and BSD personnel could effectively work to address such issues.

Local Authority Verifier (LAV) Personnel

A two-hour meeting was held with seven local authority verifier (LAV) personnel at Denholm House in Livingston on 9 June. The attendees were invited by BSD. The attendees were welcomed by Jim McGonigal of BSD, who overviewed the purpose of the meeting, introduced Brian Meacham, and then left the meeting. The list of questions was distributed and discussion ensued. It was noted that the intent was not to address all questions in the session, but have them as guidance for the discussion. The key was to obtain perspectives from LAVs on the situation. Attendees were encouraged to send any additional feedback they might have by email after the meeting. Discussions were also held with an additional three LAVs who were unable to attend the 9 June meeting.

There was a bit of consternation about how fire engineers seemed to be approaching FE solutions from the perspective that fire engineers know the Regulations and the TH-Fire, and they know what the councils are looking for, so it is not clear why there are so many issues. This seems to be complicated by the fact that there is a significant increase in FE solutions for small deviations that architects used to address in the past, and fire engineers are providing volumes of material where is not seen as necessary.

When there are complicated issues, which warrant FE solutions, the approach seems to be that volumes of material are provided, but often includes insufficient justification of the analysis (including scenarios, design fires, data sources, models, input parameters used, reliability analysis, sensitivity analysis, etc.) and recommended outcomes (.e.g., single stairs, extended travel distance, reduced fire resistance ratings and the like). The perception is that fire engineers ‘cherry pick’ analytic approaches, data, models, criteria and the like to suit their target, as opposed to taking an holistic systems approach.

When LAVs question assumptions, analysis, etc., they sometimes get accused of being unqualified and/or problematic. It was noted, however, that LAVs do not go out of their way to make things difficult, and they have no intention to do so, but they do have a responsibility for public safety, and they take that responsibility seriously. This entails interrogating the designs and compliance with the regulations.

It was a generally held view that things work better when the LAV is notified early in the process about the potential, and the scope, for fire engineering designs. It was noted that while fire engineers often refer to BS 7974, which cites the need for a Qualitative Design Review (QDR) report at the start of the project to agree key factors, QDRs are often missing, and/or significant variations end up in the later reports, with inadequate communication in the interim. By BS 7974, a QDR is characterized by the following: “The scope and objectives of the fire safety design are defined, the performance criteria established and one or more potential design solutions proposed. Key information is also gathered to enable evaluation of the design solutions in the quantitative analysis.”

Furthermore it is stated “the following steps should be taken when conducting the QDR:

a. Review the architectural design of the building
b. Establish the fire safety objectives
c. Identify the hazards and possible consequences
d. Establish trial fire safety designs
e. Identify acceptance criteria and methods of analysis
f. Establish fire scenarios for analysis

All findings should be clearly documented as outlines in clause 5 so that the underlying philosophy and assumptions that underpin design can be clearly understood by a third party, e.g., an approvals body."

It was noted that there is no consistency in FE analysis – and in the review of FE designs (across LAVs). Some see this as a concern, while others note that if a design is unique, aspects of the analysis will be unique. It was noted that it would be helpful to have guidance for conducting, and for reviewing, FE designs. It was also noted that a collection of 'approved alternatives' could be very helpful for 'small' deviations.

There was discussion around the warrant process and the issue of staged warrants. Several, but not all, have issues with regards to staged warrants. The concern with FE designs is that the design can change throughout the project, so agreeing strategy is one thing, agreeing the final design another. This is problematic with the QDR, as well as with specific designs conducted under subcontract (e.g., a sprinkler design, for example, may not be done by the fire engineer, but by a sprinkler contractor who is engaged later in the project). Assuring installation as per the strategy (and design) is a concern as well. Much of this is a matter of confidence and trust. Some are accepting of the work that many of the fire engineers conduct, and of the peer reviews conducted by other fire engineers, but others want to approve everything, and not until final design.

In general, the benchmark councils use for assessing any fire design is the TH-Fire. Even though it is not required to comply with the TH-Fire – only the Building Standards – it was noted that some benchmark is needed, and the interpretation is that the TH-Fire is the route to compliance, with other designs as alternative. (Note: this is reinforced by text in the TH-Fire, which speaks to other design approaches as 'alternatives'. Technically, however, it is not clear what an alternative to an alternative means…) Furthermore, some councils require comparative analysis, following the guidance in BS 7974 (which is a Code of Practice, with guidelines, and is not a standard), to demonstrate safety is achieved in a comparative manner. Nonetheless, it is reported that there is wide variance in the application of BS 7974, and in selection of 'comparative' buildings, which in some cases are reported as not bearing reasonable representation of the target building (e.g., the 'comparative' building might be different use, size, etc.).

That being said, other councils do see – and approve – designs which are not as rigidly benchmarked against the TH-Fire, as long as they provide adequate technical justification. In some cases, especially for unique occupancies, overseas benchmarks have been found to be acceptable. Still, it has been noted that more consistency in quantified benchmarks (criteria, fires, etc.) would be helpful. Otherwise, discussions can get wrapped up in debate between experts, with it being difficult in some cases to determine what is a difference of opinion in approach, versus what might be a clear concern over implementation of approach and interpretation of outcome.

Qualifications of participants in the process, including designers and reviewers, was discussed. It was generally felt that fire engineers should have to demonstrate some level of competency and qualification, perhaps through chartered engineer status through the Engineering Council. Likewise, LAVs felt they should, and do, demonstrate competency and qualifications in their area: building control. The LAVs point out that they can review structural, energy and other designs without qualifications in those disciplines, and fire is no different, especially for compliance with the TH-Fire. Generally they have no concern even for small deviations from the TH-Fire. For more complex FE designs, LAVs recognise their limits. If they have persons on staff with FE qualifications, they are comfortable undertaking reviews. If not, they seek assistance through counterparts via LABSS or otherwise, sometimes via the SFRS, or by appointing an external 3rd party expert from industry, academia or other.

Discussion points are that it is difficult, in the current system, to identify ‘qualified’ or ‘competent’ fire engineers as there are no requirements around the title or to report qualifications as part of projects.

Subsequent to the meeting at Denholm House, discussions were held with representatives of an additional three LAVs by phone and in person. These discussions were held to broaden the input from LAVs around projects which went well, projects which experienced problems, and projects from a broader geographical distribution.

These discussions generally echoed the group discussion. Concerns were raised about the attitude of some fire engineers (e.g., I am the expert – just trust me, or you are not qualified to assess my work) and about challenges that arise when actors change (from architect to SFRS representative). In some cases the fire engineer was working from different documents than the LAV had, which made discussions difficult. In other cases the SFRS representative changed – after initial agreements – and the replacement did not honour previous agreements, which had a significant impact late in the project. Poor project documentation was also noted as a concern (although examples were identified of good documentation as well).

Likewise, the positive aspects were echoed that when all parties are engaged early, are respectful of each other, and communicate, things go well. Third party (peer) review was used in some cases, and generally worked well (although in some cases the SFRS and/or the BSD did not concur, which was extremely frustrating to the other parties). It was noted that more guidance on use of third party / peer review would be helpful, as well as clarifying the roles of the SFRS and BSD with respect to review and approvals.

With respect to the involvement of the SFRS, it is understood that they have a consulting role during the building warrant stage, and that Councils are not obliged to accept all suggestions or recommendations from SFRS. However, it is also understood that SFRS can step in after a building has been occupied and close it down under the Fire Service Act, and that good relations with SFRS are in everyone’s best interest (all parties are ultimately working toward safe buildings). While it is reported that things work just fine in many cases, it has also been reported that there are situations where the SFRS simply have a different view on a technology or approach and do not seem to accept any level of analysis or justification. In addition, the SFRS review time can be quite long. This places pressure on the project, the fire engineers and the Councils. The types of issues reported as being particularly of concern include reliability of automatic sprinklers, in particular when used as part of a single means of escape design; use of cross-laminated timber (CLT); and variations in exit capacity and length of travel from those described in the TH-Fire.

There was support for the concept of a ‘central review’ resource, with fire engineering expertise, to assist LAVs when requested.

Addressing the issue of having a qualifications system for fire engineers was seen as being extremely beneficial: both for design and review. It would help reduce uncertainty and build confidence.

As with the group meeting, participants in individual discussions found the opportunity to discuss the issues as beneficial.

University Personnel

Meetings were held with personnel from Glasgow Caledonian University (GCU) and the University of Edinburgh (UE) on 6 June and 9 June, respectively. Participants included faculty (lecturers) and administrators. Jim McGonigal and Bill Dodds from BSD participated in the meeting with GCU, with Jim joining the meeting with UE. Meetings were held in Glasgow and Edinburgh, respectively. The list of questions was provided. It was noted that the intent was not to address all questions in the session, but have them as guidance for the discussion. The key was to obtain perspectives from academics on the situation. Attendees were encouraged to send any additional feedback they might have by email after the meeting.

Discussions with the academic community supported observations by others that the number of fire engineers being educated in Scotland is lower than in previous years, and that demand remains high. It was observed that universities tend to do a poor job of marketing to students entering university about the fire engineering profession, and that the number of students entering engineering programs is down in Scotland in general, as compared with other disciplines.

Despite comments to the contrary voiced in the meeting with fire engineers, there are some undergraduate fire engineering programs in the UK, in addition to the program in Scotland at GCU. It could be observed that one reason few of the graduates from these programs are coming into Scotland is that job prospects are even better elsewhere. Nonetheless, this does not explain the lack of student numbers entering university programs in fire engineering.

Graduates form GCU hold a wide range of positions, including as consulting engineers, engineers for fire systems companies (e.g., detection and alarm, smoke control, sprinklers, etc.), engineers with the fire service and in government (local and national). The curriculum is generally consistent with the model curriculum for undergraduate programs in fire engineering as originally developed by the International Association for Fire Safety Science (IAFSS) and more recently updated and published by the Society of Fire Protection Engineers (SFPE) - https://c.ymcdn.com/sites/sfpe.site-ym.com/resource/collection/24609C80-7253-49A5-83AF-D0499353EAEA/SFPE_BS_Model_Curriculum.pdf (note: the SFPE also has published a recommended course content / topics for the MS programs in fire engineering - https://c.ymcdn.com/sites/sfpe.site-ym.com/resource/collection/24609C80-7253-49A5-83AF-D0499353EAEA/131027_MS_Program_in_FPE_-_Final.pdf

At UE, fire engineering is taught as part of the Civil Engineering program, and there is not a dedicated degree in fire engineering. It was recognized that this could be an issue with graduates with respect to any qualifications system for engineers which might require a university degree in fire engineering. Nonetheless, it is felt that a university degree needs to underpin the fire engineering qualification for Scotland[2].

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[2] It is noted that following the term of the initial research, the Glasgow Caledonian University BEng (Hons) Fire Risk Engineering course was approved in July 2016 by the Engineering Council degree accreditation for IEng standard route and partial fulfilment of CEng standard route.

There was discussion with academics about competency as associated with fire engineering qualification, including the fact that structural analysis for fire is a specific focus, and it is not expected that a fire engineer could undertake this. The structural fire analysis should be undertaken by persons with structural engineering (degree) knowledge. (Note: this is consistent with current thinking in New Zealand, where efforts are underway to clarify the roles and responsibilities of fire engineers and structural engineers with respect to structural fire engineering analysis.)

There was also quite a bit of discussion about engineering ethics. In other countries, part of gaining professional engineers recognition (licensing), as well as engineering education, are educational requirements for ethics and economics. The system in Scotland, where engineering is not protected, should somehow include training / education on ethics and a canon / code of ethics or similar (e.g., see http://www.sfpe.org/page/CodeofEthics, accessed 14 July 2016).

The qualifications, competency and ethics issues were discussed in part in the context of use of new technology / research and the need to apply it appropriately. Concerns around some of the newer technology, such as cross laminated timber (CLT), traveling fires, and the like, and whether sufficient knowledge exists to expand the use of these technologies, under what conditions, and the qualifications of persons necessary to undertake appropriate analyses, were raised.

Concerns were also raised regarding lack of national consistency in approach to undertaking and accepting engineered designs (e.g., acceptable by some local authorities but not others, different level of analyses required, etc.), potentially competing objectives in the regulations (e.g., push for sustainability, which might lead to more timber or other combustibles, versus safety given those materials), lack of 'joining up' building design with building operation, in particular lacking appropriate system for fire risk assessment (similar to fire engineer – title not protected, no requirements for expertise, wide range of analyses conducted, etc.).

Participants noted that it was beneficial to engage in discussions, as all parties learned more about issues and opportunities.

Architects

Telephone discussions were held with a limited sample of architects during the period 8 – 14 June to obtain a perspective from those who often engage fire engineers.

It was noted that 'fire engineering' was essentially unknown a few years ago, but has been increasing in recent years. The reasons for engaging fire engineers are to address fire and life safety issues that are outside of the TH-Fire and to develop rationalized fire safety strategies. In some cases there is a desire to reduce the cost of fire protection, and in other cases there are project constraints which make it difficult to achieve all requirements in the TH-Fire, but there is an overriding desire to 'do the right thing' with respect to fire and life safety. As noted by one architect, it is taken seriously, as it is literally a life or death issue.

While use of fire engineers in on the rise, knowledge about qualifications and competency is relatively low. Most information is obtained from web searches, selection of fire engineers is somewhat trial and error, and firms tend to stay with fire engineers who have proven helpful. The desire for more mechanisms to help make better informed decisions was voiced. The comparison was made to structural engineering, where there is a certification system, which includes audits, so a level of oversight is perceived as helping provide for suitable competency.

One concern with the use of fire engineering on a project is the variability in the submittal and review of fire engineered designs from one local authorities to another. In some cases there are clear processes while in others not. In some cases where processes exist they seem at odds with the Building Regulations.

One example given is that in Glasgow, there is a requirement to submit a ‘request for consideration of alternative means of compliance’ for any deviation from the Technical Handbooks (https://www.glasgow.gov.uk/index.aspx?articleid=17339). It is stated on the website that: “The Building Regulations are mandatory, but the choice of how to comply with them lies with the building owner. If the guidance in the Technical Handbooks is followed in full then this should indicate that the building regulations have been complied with. However, a designer may put forward other ways of meeting the regulations in the form of alternative means of compliance. The surveyor assessing the building warrant application will be able to advise an applicant whether or not they need to submit details of alternative means of compliance in writing.”

The point in question is the statements: “If the guidance in the Technical Handbooks is followed in full then this should indicate that the building regulations have been complied with. However, a designer may put forward other ways of meeting the regulations in the form of alternative means of compliance.” However, the Building Regulations do not require the Technical Handbooks to be followed, so technically any design can be submitted as so long as it demonstrates how the regulations are complied with, and as such are not in fact alternatives.

There were several observations related to the length of time required to gain regulatory approval. More than one project resulted in over a year from application for a warrant until approval (with some still pending). It is not understood why it has to take so long. Related to this are concerns over the processes for approval, and the fact the decisions can change over the course of the project. There seems to be no certainty that fire engineered solutions will be approved. Situations such as these can have a significant financial impact on the project and lead to asking the question ‘why involve fire engineers?’ and does not seem to fit the intention of a functional regulatory system.

A range of experiences were noted with the use of third party / peer reviewers and the role of SFRS. In some cases peer review went well, while in others there seemed to be no clear process for engaging reviewer and no clear lines of responsibility. In some cases the SFRS simply rejected the outcome of reviews intimated that they would take action under their legislation if the project went forward. Similar concerns were raised with BSD involvement, in one case effectively overturning approval by LAVs (and associated reviewers).

It was noted by one architect that the way the system currently works is that the only way to assure approvals will go smoothly is if the SFRS needs are met, since they seem to have the power to override any other decisions / approvals, to the point of influencing BSD views. This may not be what was intended by the regulatory system, but it is how it is functioning in practice.

Concerns were also voiced with respect to the relationship between procurement processes and the warrant process. Design-build approaches, used in many countries, are difficult within the Scottish system, since the ‘final design’ is required for the building warrant. This should be considered in any assessment of the regulatory system structure, as more design-build projects are likely.

Overall, the lack of national consistency in review and approval was a major concern, as was the roles of all involved in the regulatory process including third-party reviewers. Clear processes for review and approval would be welcome. National consistency would be welcome. A set of ‘approved alternatives’ would be welcome to help streamline the system. Architects would be more willing to undertake small deviations (without fire engineers) with ‘approved alternatives’ and clarity in the review and approval process.

Variation in expertise of fire engineers and interaction with others in the process was raised as a concern. It was noted in particular that sprinkler systems are often problematic, since there are multiple actors involved. A fire engineer might identify the need, and a mechanical engineer and/or sprinkler contractor may undertake design, and coordination is not always done well.

There was also concern that building fire safety systems are becoming too complex, and that owners / managers do not understand what is needed to maintain safety. The concept of the Operations and Maintenance Manual (OMM) was floated and was well received.

As with other actors, the architects noted that they appreciated the opportunity to raise concerns and help move to a more effective system.

Developers / Owners

To help obtain a broad set of input, a few building owners / developers were interviewed over the period 10-14 June. The range of experiences amongst them was in some ways quite similar, but in others quite diverse.

In all cases the experience was that by using fire engineers a significant amount of time was required. In one case the complexity of the building warranted it, and it would likely not have been possible without fire engineering. In another case, given the issues with review and approval, the use of fire engineers was simply an unnecessary cost, since fire engineering was essentially unaccepted, the final design had to be changed to meet SFRS desires, and the cost to do so was significant.

Generally there is a feeling that fire engineers can provide benefit. On complex buildings they are necessary to carry out analyses to demonstrate safety. However, the lack of a clear process for approval, wherein certainty can be assured if the process is followed, and significant costs are incurred, can result in simply moving away from fire engineered solutions, since it appears the Scottish building regulatory system is not really set up to accept them, or at least the lack of consistency / surety means the risk can be too high to go down a fire engineering route.

A key concern seems to be the timing and role of the SFRS. It is understood that from a legal perspective the SFRS have a consulting role during the building warrant stage, and Councils are not obliged to accept all suggestions or recommendations from SFRS. However, it is also understood that SFRS can step in after a building has been occupied and close it down under the Fire Service Act, and that good relations with SFRS are in everyone’s best interest (all parties are ultimately working toward safe buildings). While many times things work just fine, it has been reported that there are cases where the SFRS simply have a different view on a technology or approach and do not seem to accept any level of analysis or justification. The types of issues reported as being particularly of concern include reliability of automatic sprinklers, in particular when used as part of a single means of escape design; use of cross-laminated timber (CLT); and variations in exit capacity and length of travel from those described in the TH-Fire. It has also been reported that in some cases, BSD supports the SFRS over the LAVs and their review / approval decisions. There needs to be greater awareness by all involved in the process in terms of whether certain technologies / approaches are acceptable or not, who can make the decision, what is needed to support the decision, and under what conditions can 'veto' powers be exercised and by whom?

Overall, as heard from the architects (and others), the lack of national consistency in review and approval was a major concern, in particular the lack of clarity over the roles of LAVs, third-party reviewers, SFRS and the BSD. Clear processes for review and approval would be welcome. National consistency would be welcome. A set of 'approved alternatives' would be welcome to help streamline the system. The way the process works now, the amount of time required is high, the certainty of approval is low, so fire engineering can be a difficult sell for any but truly complex buildings.

Also, as heard from the architects, concerns were voiced with respect to the relationship between procurement processes and the warrant process. Design-build approaches, used in many countries, are difficult within the Scottish system, since the 'final design' is required for the building warrant. This should be considered in any assessment of the regulatory system structure, as more design-build projects are likely.

The owners / developers noted their appreciation at being included in this research, and welcome changes to the system to better facilitate fire engineered solutions in the future.

Insurers

Telephone discussions were held with representatives of the property insurance industry on 14 June.

The perception is that there are a large number of fire engineered projects, but few being large / complex projects as was expected for fire engineering (e.g., airport terminals and the like). The range of qualifications in the market – across engineers and reviewers – raises concerns that issues are not being addressed. A particular concern is that SFRS can only focus on life safety issues, and that LAVs are doing the same, even though some aspects of property protection (sustainable development) and economic welfare are in the Building (Scotland) Act.

With lack of focus on property, and diversity of expertise in the sector, there has been an increased trend of issues such as combustible void spaces, more use of timber (combustible) construction, combustible insulation and the like, perhaps without appropriate protection. The costs due to fire are increasing, and with a higher density of construction, higher losses could continue into the future.

Some fire engineers seem overly focused on cost savings versus fire safety, arguing for removal of sprinklers and other fire safety measures without consider of broader issues of life, property and economic protection. It can be difficult for building owners, who may have to come in after project approval and pay more for changes to get insured. Many fire engineers do not seem to help their clients understand the overall costs of fire and benefits of fire safety engineering. Reducing the cost of fire protection at construction can ultimately result in higher lifecycle costs and impacts on business and community.

The lack of minimum competency and qualifications for fire engineers is part of the problem. No requirements for understanding economics, business or public welfare. Some do not understand why regulations are in place, for example, believing historically listed doors require fire testing rather than protecting them, or not understanding that a small fire in an industrial facility with combustible insulation and no sprinklers could impact the business and the community. It was even reported that some fire engineers are modifying provisions of recognized standards, such as sprinkler standards, modifying flows, pressure and the like with inadequate justification. (Author's note: it would not be recommended to modify primary requirements of design standards without adequate justification, such as testing, to demonstrate that any such changes are acceptable.)

In many cases, it is the smaller fire engineered jobs which are the concern. Issues like extended travel distances, combustible construction, removal of sprinklers, etc. in nondomestic housing, offices, industry, education, healthcare and the like. Too much focus again on upfront cost savings and not appreciating long term loss potential.

It was noted that there should be some way to identify fire engineered buildings. As noted by others, there is a disconnect between allowing a fire engineered building as part of the warrant process, and knowing where fire engineered buildings are and what the potential impact is. Those undertaking fire risk assessments, and the SFRS, should know where these buildings are and how they differ from 'code compliant' buildings. The insurance industry bears the burden if the situation is unknown and loss occurs. Better documentation of fire engineered buildings is also needed. The documentation should go with the building, regardless of owner, as ownership can change hands often. The concept of an Operations and Maintenance Manual was well received.

Concern also with how guidance is being used, particularly BS 9999 and BS 7974. The issue of providing 'equivalent' level of safety is being ignored. Comparative or other analyses by fire engineers is not taking the full range of issues into consideration. There were also concerns that neither BS 9999 nor BS 7974 goes far enough in requiring a sufficiently broad spectrum of scenarios or fire to be considered.

Fire engineers and others should also be cognizant of resource limitations imposed by government, in particular on the SFRS. One should not assume same response today as in the past. This is big issue for past fire engineered buildings which may have assumed a specific fire service response time for manual suppression: if response is not there, is design valid?

More education in sector is needed. The insurance industry is willing to help. Inclusion of property and business protection will help the whole process.

The insurance representatives noted appreciated of being included in the research.

5 Situation in Other Countries

The challenges currently being faced in Scotland with respect to undertaking and verifying fire engineering designs are not indifferent to those being faced in other countries. The issues of minimum competency / qualifications of fire engineers, level of consistency in analysis and design being undertaken and delivered, capability and capacity of approvers and enforcers, process(es) for review and approval, appropriate role of the fire service in the process, and related issues have or are being explored in Australia, New Zealand, Sweden and other countries.

The purpose of this section is to present some of the challenges being faced, and the responses being explored, in a selection of other countries. The aim is to provide some ideas that might be considered in helping to address the related concerns in Scotland.

Building Act, Regulations and Supporting Documents

General

A fundamental starting point in review of how a system is working is the relationship and wording of the base documents in the system. In this case it is the Building (Scotland) Act, Building (Scotland) Regulations and Technical Handbooks, specifically Fire. While the scope of work did not focus on this in particular, and there has been little time to explore the issues in detail, it seems as if this could be an area for more in depth review in Scotland. In particular, the issue relates to if a functional system is desired, are the associated documents written in such as way so as to facilitate the functional approach, or are they written and structured in such as way so as to emphasise a prescriptive approach. This challenge has been identified in other countries as well.

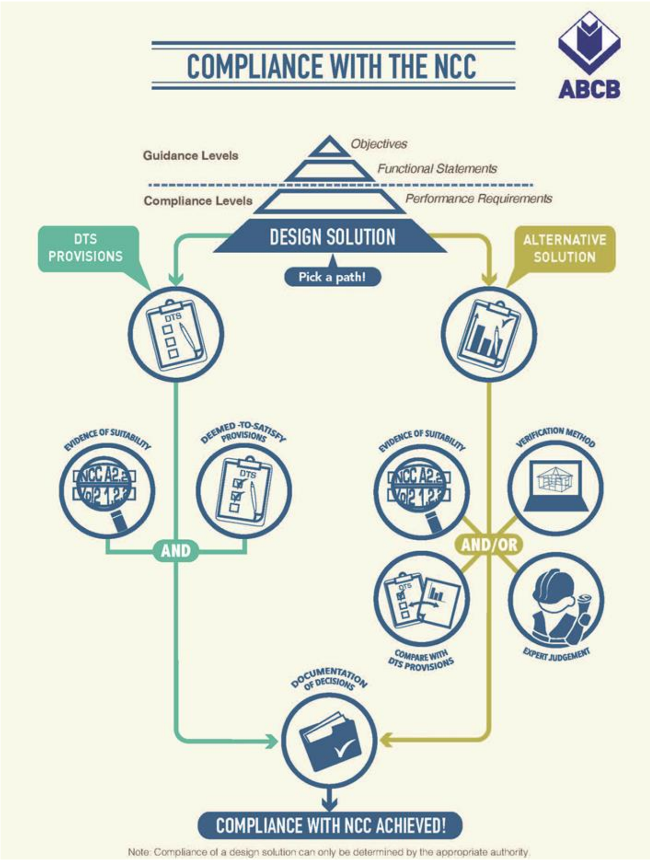
Australia

The National Construction Code (NCC) of Australia has been a performance-based code for 20 years offering a $1.1 billion of benefits per annum and an additional $1.1 billion of benefits per annum through reform (CIE, 2013). In 2013 NCC subscribers were surveyed to inform the strategy to increase the use of, and quantify, the performance requirements. Through this survey and other research, it was found that more uptake of performance would be beneficial, and quantifying performance would help in this regard.

To fulfil the needs identified by subscribers, it was determined that ABCB needed to do more to engender a performance mindset, help build capacity in the market, and move forward with quantification of performance (see the following for more information http://www.abcb.gov.au/Initiatives/All/Performance).

To help with fostering a performance mindset, the ABCB has separated the Performance Requirements from the Deemed-to-Satisfy (prescriptive) option, which previously had all been contained in the same document as appropriate to building types (e.g., residential buildings are in a different book than other building types). The consolidated set of Performance Requirements can be found here (http://www.abcb.gov.au/Resources/Publications/NCC/NCC-2016-Consolidated-Performance-Requirements).

Quantification is seen as being critical since the Performance Requirements in the NCC represent the tolerable levels of health and safety in new buildings and plumbing systems. Quantifying at this level means health and safety can be clearly represented in terms of individual and societal risk and allow ultimate flexibility in achieving these goals.



The Performance Requirements represent the tolerable levels of health and safety in new buildings and plumbing systems. Quantifying at this level means health and safety can be clearly represented in terms of individual and societal risk and allow ultimate flexibility in achieving these goals. Addressing both societal and individual risk allows building regulation to be proactive in its approach to multi-fatality events. Frequency (F), versus Number (N) of fatalities plots supports a quantitative risk assessment (QRA).

Fire Engineer Qualifications and Competencies

General

The mutual recognition of engineering qualifications across national borders has been a goal for many years, and there are a number of agreements in place to facilitate this. The International Engineering Alliance (IEA) (http://www.ieagreements.org/) has played a significant role in this arena. As detailed on their website, there are six international agreements governing mutual recognition of engineering qualifications and professional competence. In each of these agreements countries/economies who wish to participate may apply for membership, and if accepted become members or signatories to the agreement. The United Kingdom (UK) is a member through the Engineering Council (http://www.engc.org.uk/), as are Australia, New Zealand, Singapore, the United States and several other countries.

However, while basic competencies are addressed through such agreements, the issues of if, when, where, and how the competencies are applied in a country, and for what disciplines, are determined by countries or jurisdictions within a country (e.g., states and territories). In some countries (jurisdictions), there are no requirements to have any engineering qualifications to practice as an engineer: the control is market driven. In other jurisdictions, government registration is required, and practicing without a license is illegal. Likewise, fire engineering (fire safety engineering / fire protection engineering) can be either a ‘recognised’ (protected) discipline or not from one jurisdiction to another.

For consideration in the Scottish context is the combination of: should fire engineering be restricted / controlled such that only qualified practitioners can undertake / submit fire engineering designs; if so, what is the most appropriate control mechanism; what are the appropriate competencies; how are these competencies demonstrated; who makes the determination on competencies; and what are the implications of practicing without appropriate qualifications.

This section provides a brief overview of the systems and attributes related to professional recognition of fire engineering in Australia, New Zealand, and the United States. It is assumed that the readership is familiar with the Chartered Engineer approach through the Engineering Council in the United Kingdom, so details will not be provided. However, reference will be made for comparative purposes. Extended detail is provided for discussion about Australia. For other countries, less detail is provided, as many of the concepts / definitions are similar, and links are provided for more in depth information.

Australia

Whereas Australia is a federation of states and territories, control over the practice of engineering rests with the individual states and territories. This results in some variation across the country. However, it is generally expected that one becomes a Chartered Professional Engineer to practice engineering, the process for which is managed by Engineers Australia. Fire safety engineering is one of the practice areas recognised by Engineers Australia.

While not required in every state and territory, becoming a Chartered Professional Engineer, with a specialty in fire safety, provides the highest level of recognition and broadest ability to practice across the country. It also allows for mutual recognition in APEC countries (see, for example, https://www.engineersaustralia.org.au/national-engineering-register/apec-engineer-register and http://www.ieagreements.org/APEC/) and elsewhere (see, for example, http://www.ieagreements.org/).

Unless otherwise noted, the following information is excerpted from the Engineers Australia website (including https://www.engineersaustralia.org.au/professional-development/chartered-status and related pages).

Engineers Australia (EA) operates a National Professional Engineers Register (NPER). Most States and Territory governments in Australia have registration and/or licensing regimes for engineering practitioners in various areas of practice. NPER is used by many of these government bodies as the assessment framework for engineering qualifications and competence. For instance:

- Tasmania: designers and certifiers must be eligible to be registered on NPER.
- Victoria: engineers in the building and construction industry registered on NPER are able to be registered by the Building Practitioners Board without undergoing additional assessment.
- South Australia: geotechnical engineers must be registered on NPER.

- New South Wales: building certifiers must be registered on NPER.

- Queensland: All practicing engineers must be registered by the Board of Professional Engineers.

- Northern Territory: Engineers must be registered with a government board under the Building Practitioners Act in order to work in the building and construction industry.

- Western Australia: The government has announced a proposal to introduce a registration system for all engineers.

- Australian Capital Territory: The Land and Planning Authority utilises NPER for registration of building and plumbing certifiers.

The route to Professional Engineer recognition is through the Chartered membership process. Chartered membership is exclusive to Engineers Australia. The Stage 2 competency standards are used as the basis of assessment for Chartered membership of Engineers Australia (CPEng) and registration on the National Professional Engineers Register (NPER). The Stage 2 competency standards can be found here - http://www.engineersaustralia.org.au/sites/default/files/shado/Education/echartered/competency_standards_june.pdf

Chartered Status certifies that you practice in a competent, independent and ethical manner; and indicates you are a leader in your field. Chartered Status is open to those in the Member and Fellow grades of each occupational category:

- Professional Engineer – Chartered Professional Engineer (CPEng)

- Engineering Technologist – Chartered Engineering Technologist (CEngT)

- Engineering Associates – Chartered Engineering Associate (CEngA).

The role of the different engineering professionals is well-defined, and competencies are appropriate to the role (e.g., see https://www.engineersaustralia.org.au/national-engineering-register/role-engineering-professionals).

Professional Engineer

Within his/her own field of professional practice, a Professional Engineer will apply professional judgment to an engineering task and match and integrate technologies with client needs to create verifiable solutions for practical implementation. A Professional Engineer will ensue all aspects of a project are soundly based in theory and fundamental principle. The hallmark of a Professional Engineer is the capacity to break new ground in an informed and responsible way. The Professional Engineer is the approving authority for the integrated engineering solution. The Professional Engineer will typically hold a 4 years Bachelor of Engineering Degree.

Engineering Technologist

Within his/her own field of technical practice, an Engineering Technologist will apply technical judgment to an engineering task, and consider the specific technical issues that are critical to the task. The Engineering Technologist often approves and certifies technical operations and ensures compliance and design of components and sub systems that do not call for significant new development. The Engineering Technologist will have authority to approve designated aspects of the engineering solution. An Engineering Technologist will typically hold a 3 year Bachelor of Engineering Technology degree.

Engineering Associate

Within his/her own field of technical expertise, an Engineering Associate will apply technical expertise and skills in support of the engineering task, by creating technical information from design or engineering test work. The Engineering Associate may certify the quality of engineering work in defined circumstances, laid down in recognised Standards and Codes of Practice. The information created by an Engineering Associate will be assessed and approved by other authorised professionals in the engineering team. The Engineering Associate will typically hold a 2 year associate degree or Advanced Diploma in Engineering.

Registered Engineering Professional

A Registered Engineering Professional has the prescribed qualifications and experience to practice independently within his/her field of practice or expertise.

A Registered Engineering Professional commits to ethical conduct, continuing professional development and possession of professional indemnity insurance.

Registered Chartered Engineering Professional

A Chartered Engineering Professional is an experienced engineering professional with advanced skills and knowledge, whose competence is assessed against internationally benchmarked standards and by formal peer review.

A Chartered Engineering Professional has the capacity to provide professional leadership, including the ability to train, develop and supervise other engineering professionals within their field of practice or expertise.

A Chartered Engineering Professional is recognised as being globally competitive and able to operate internationally through Engineer Australia`s global alliances and mutual recognition agreements.

A Registered Chartered Engineering Professional commits to ethical conduct, continuing professional development and possession of professional indemnity insurance.

In Australia, the connection to the fire safety engineering community is through Engineers Australia's Technical Societies, which provide an important and integral link between the profession and specific areas of technical practice. Societies undertake many functions relating to the on-going establishment and maintenance of engineering qualifications relevant to their specific discipline. They provide a forum for the engineering team and industry practitioners to participate in professional technical development, networking opportunities with other professionals in the specific area of practice, and many other functions. Technical Societies that are operating units of Engineers Australia are bound by the Royal Charter and By-Laws, regulations and policies of Engineers Australia. The Technical Society for fire engineering is the Society of Fire Safety (https://www.engineersaustralia.org.au/societyfiresafety). If a search is conducted on a CPEng via the NPER, one can identify whether the person has indicated fire safety as an area of specialty (registration in more than one area is permitted).

New Zealand

In New Zealand there is no regulatory requirement to have an engineering qualification to practice as an engineer. Historically, however, for certain disciplines such as structural engineering, it has been expected that one have proper education in structural engineering and appropriate qualifications through registration as a Professional Engineer (PEng) through the Institution of Professional Engineers New Zealand (IPENZ). The path to PEng registration is much like as described for Australia in the previous section. Unless otherwise noted, the following is excerpted from the IPENZ website (https://www.ipenz.nz/home/development-registration/registration).

Becoming registered improves your professional standing as an engineer and comes with the following benefits:

- Establishes credibility through the use of registration title and post-nominals
- Provides peer validation
- Demonstrates your commitment to continuous improvement and excellence in our industry
- Instils public confidence in your competence
- Opens doors to work restricted by regulation
- Speeds up career advancement and increases your earning potential
- Improves your marketability and job prospects in New Zealand and overseas.

IPENZ look after four national Registers:

- Chartered Professional Engineer (CPEng)
- Engineering Technologist (ETPract)
- Certified Engineering Technician (CertETn)
- Professional Engineering Geologist (PEngGeol)

Chartered Professional Engineers and registered Engineering Technologists have access to equivalent international Registers, which are assessed against the same standards. You must meet some additional requirements to successfully register for these.

Chartered Professional Engineer (CPEng) and/or Professional Membership (MIPENZ)

- Engineering knowledge. You'll have a Washington Accord-accredited qualification (a four-year Bachelor of Engineering (Honours)) or equivalent knowledge.

- Engineering practice. You'll need to show you can deal with complex engineering problems and activities, requiring the application of specialist engineering knowledge and work from first principles.

Engineering Technology Practitioner (ETPract) and/or Technical Membership (TIPENZ)

- Engineering knowledge. You'll have a Sydney Accord-accredited qualification (a three-year Bachelor of Engineering Technology) or equivalent knowledge.

- Engineering practice. You'll need to show you can deal with broadly-defined engineering problems and activities requiring knowledge of principles and applied procedures.

Certified Engineering Technician (CertETn) and/or Associate Membership (AIPENZ)

- Engineering knowledge. You'll have a Dublin Accord-accredited qualification (a two-year New Zealand Diploma in Engineering) or equivalent knowledge.

- Engineering practice. You'll need to show you can deal with well-defined engineering problems and activities requiring knowledge and use of established analytical techniques and procedures.

With respect to fire engineering, one can become a Registered Professional Engineer with a specialty in fire. However, the designation given is simply PEng, and it is left to the ethics of the individual to practice in their area of competency. In New Zealand, the New Zealand Chapter of the Society of Fire Protection Engineers (SFPE) serves much the same role as the Society for Fire Safety (SFS) in Australia, providing engineers to serve on review boards for applicants and helping to define competency requirements.

It is currently possible for IPENZ to consider external qualifications, such as being a Chartered Engineer member of the Institution of Fire Engineers (CEng, IFireE), as meeting minimum competency requirements. However, it is required that the incoming engineer be able to demonstrate a working knowledge of the New Zealand building regulatory system before they can obtain the PEng. This typically requires some years of experience (the actual number of which can vary depending on the reviewer).

While there is at present no legal requirement to practice as an engineer, and there is no protection of the title of engineer, the Ministry of Business, Innovation and Employment (MBIE), under which Building Standards sits (responsible for the New Zealand Building Code) is reviewing this and is likewise engage in discussions with IPENZ to seek means to provide for better controls of the practice of engineering. This is in part a result of inquiries into the building failures resulting from the Canterbury earthquakes in 2010 and 2011, as well as concern from within the fire sector about the lack of clearly defined qualifications / competencies and/or enforceable controls around fire engineering.

There is a widespread view – across the sector, including engineers, Building Control authorities (BCAs) and the fire service – that allowing anyone to call themselves an 'engineer' and practice engineering is bad for everyone. Bad actors are negatively influencing the peer-review process. Bad actors are consuming significant time of the BCAs. Bad actors can be working for BCAs and other enforcers, as well as in practice. The current IPENZ approach of self-reporting, and BCA approach of engineers self-reporting via Producer Statements, does not seem to be working.

It has been suggested to MBIE that there needs to be a set of minimum competency criteria to define the practice of fire engineering (and for other engineering disciplines as well). Qualifications should be based on demonstration of competency, along with practical experience, obtained under the mentorship of a qualified engineer (a graduate engineer is not necessarily qualified to take full responsibility for a design, even though they might meet minimum competency requirements). It has been suggested that some type of 'T' shaped structure, where engineers must demonstrate minimum competency across the breadth of the discipline, as well as depth in one or more areas of expertise, might be something which could help.

United States of America (USA)

In the USA, to become a registered (licensed) engineer, one is generally required to have a university engineering education, to successfully complete the nationally administered Fundamentals of Engineering examination (http://ncees.org/exams/fe-exam/), to have some amount of professional experience working under the supervision of a licensed engineer (typically at least four years, but longer depending on university degree), successfully complete the nationally administered Principles of Engineering (sometimes called the Professional Engineering or PE) examination in a specific discipline, such as Fire Protection or Structural engineering (http://ncees.org/exams/pe-exam/). Engineers are registered by the state in which they intend to practice, and unique applications (and registration fees) have to be paid to each state.

The topics covered Principles of Engineering (PE) exam – and the questions used for the exam itself – are developed by the relevant professional society of the engineering discipline. With respect to fire engineering, the Society of Fire Protection Engineers (SFPE) determines the topic areas and competencies and writes the exam questions. The topic areas for the PE exam in Fire Protection can be viewed here https://cdn.ncees.org/wp-content/uploads/2012/11/PE-Fire-Oct-2012.pdf. The topic areas, and their weighting on the PE exam, are reviewed every three years.

In some states more than one license may be required, or additional tests may be required. For example, in many states, one can practice structural engineering if they have passed a PE exam in civil engineering. However, in California, for example, it is required that one passes an examination on Structural Engineering, and will actually gain a Structural Engineer (SE) designation (http://ncees.org/exams/se-exam/). This approach is particularly required where engineering analysis will be used / required, more so than compliance with design standards. The SE exam is required in California in part due to the performance-based approaches often used for earthquake engineering.

Fire Engineering Guidance

A number of fire engineering guidance documents have been published for several years and are used around the world. These include the International Fire Engineering

Guidelines (IFEG), the SFPE Engineering Guide to Performance-Based Fire Protection Design (SFPE Guide), ISO 23932: Fire safety engineering — General principles (replaced ISO 13387), and the BS 7974 and BS 9999 more commonly known and used in Scotland. While these documents provide a general process for qualified fire engineers to follow, and are generally consistent with each other (e.g., see Fergusson, 2006; Boutin and Meacham, 2013), they are largely process documents: they advise on what could or should be done, but do not state what must be done, and in most cases, how to do it (e.g., all state that fire scenarios should be considered, but none say which scenarios, how to construct them, how many to consider, etc.). They speak to the need to establish such components as fire safety goals and objectives, acceptance criteria, fire scenarios, design basis fires, occupant profiles and the like. However, for the most part they do not specify what should be used or when. They likewise speak to the need to develop trial designs, evaluate them against acceptance criteria, and consider such factors as sensitivity of output to input parameters, reliability of systems, and robustness of designs. However, for the most part they do not specify what should be used or when.

One impact of having ‘process’ documents and not ‘engineering’ documents is that there is wide variability in the interpretation and application of the guidance, which in turn makes it difficult for enforcement officials (verifiers) to understand whether the target criteria, scenarios and fires represent the societal expectations, whether sufficient analysis has been undertaken, and whether the resulting design is sufficiently robust (as compared with societal objectives). In some countries, such as New Zealand and Singapore, the variability in application prompted government to develop more specific fire engineering design guidance. The Australian Building Codes Board (ABCB) is developing a fire verification method as well, which is intended to be a possible route of compliance. The SFPE is addressing this concern as well, and has research underway to better quantify design fire scenarios, design fires and acceptance criteria. Another approach that has been taken in Japan and Sweden is to include specific scenarios, fires and criteria in the building code (and in the case of Japan, verification methods as well). NFPA, in their standards 101 (Life Safety Code) and 5000 (Building Code) define eight fire scenarios which must be considered.

New Zealand C/VM2 and Singapore Fire Safety Engineering Guidelines are available for download online (see https://www.building.govt.nz/assets/Uploads/building-code-compliance/c-protection-from-fire/asvm/cvm2-protection-from-fire-amendment-4.pdf and https://www.scdf.gov.sg/sites/www.scdf.gov.sg/files/Singapore%20Fire%20Safety%20Engineering%20Guidelines%202015_0.pdf respectively).

There are pros and cons to implementing more detailed guidelines such as these. On the plus side, the scenarios, fires, criteria and modelling assumptions can become much better defined. On the minus side, some engineers see a reduction in design flexibility. If properly implemented, however, more surety can be gained without sacrificing flexibility. Various papers, presentations and webinars can be found that highlight different perspectives. A compilation and/or review of such material might be a helpful resource for Scotland, if a more detailed discussion around the pros and cons of such an approach is deemed necessary.

Review and Approval of Fire Engineering Designs

The review and approval responsibilities for fire engineering designs varies around the world, including private certification (e.g., Australia and England), local or regional government (e.g., Australia, Austria, Japan, Spain, Sweden, USA) and national (central) government (e.g., New Zealand, Singapore). For performance-based designs, review panels and/or appeals panels/boards may also be used (e.g., Australia, Japan, USA), and several countries utilise third-party (peer review) as well (e.g., Germany, New Zealand, USA). Several countries have a combination of approaches.

Generally speaking, government and private certification systems work well for 'simple' designs, such as those which follow 'deemed to comply' or prescriptive guidance, as no particular fire engineering expertise is needed. As the level of fire engineering increases, so too does the need for competency in fire engineering by the reviewing party. In many countries this is addressed through peer review, where reviewers are generally expected to have the same qualifications as the engineers. However, this concept falls down when there is no particular qualification for the engineers (and hence the reviewers), such as is the case in New Zealand. In countries with strong central governments, such as Singapore, Hong Kong and even Japan, there are requirements to send fire engineered designs to central review panel for consideration. Such panels are often comprised of academics, practitioners, building and fire control officials.

To assist reviewers in better understanding what to look for in fire engineered (performance-based) designs, some groups, such as the SFPE, have published guidelines for the review of performance-based design. Likewise, groups such as SFPE and BRANZ have published guidance on substantiating the use of fire models for a given application. Standards-making organizations, such as ASTM and ISO, also have published guidance of verification and validation of fire models, as do research organizations such as NIST. NFPA has a guide on review of fire risk assessments.

Ultimately, a country or jurisdiction selects an approach that best fits their social, cultural, economic and political situation. Not all approaches work as well as the jurisdiction would like. In New Zealand, for example, lack of fire engineers in the Building Consent Authorities (BCAs) prompts the use of peer review. However, the peer review system has challenges since (a) there is a lack of qualified fire engineers, (b) there is no protection for the title fire engineer, so there are unqualified engineers practicing, (c) the small number of engineers can result in too 'friendly' of a relationship between engineer and reviewer, since their role can flip-flop from one project to the next, and (d) when un- or inadequately-qualified reviewers are verifying work of un- or inadequately-qualified engineers, the outcomes can be quite concerning. By contrast, in Singapore, there are legislated requirements for qualifications of engineers and qualifications of peer reviewers – and the Civil Defence Force is involved as well. However, reviews for engineered designs can take 6-12 months – a length of time generally unacceptable in New Zealand.

New Zealand is currently considering changes to their fire engineering design review system, either implementing more requirements and guidance around peer review, and/or establishing some sort of centralized review body. More information on what is being considered may be shared by the relevant body in New Zealand, if requested, but cannot be shared in detail here. However, it can be stated that qualifications, processes and independence are central concepts under consideration.

Peer Review / Central Review in Select Countries

The manner in which peer reviews are addressed internationally vary widely, but in all cases of which the author is aware, a high level of qualifications is needed, and often some type of legislation is in place to help assure the system operates as intended.

Some countries, specifically Germany and Singapore, have dedicated reviewers. Germany uses the concept of 'Prufingenieur fur Bautechnik' (literally, test engineer, or review engineer), which is a dedicated professional who confirms calculations, specifically structural calculations. This is part of a system which requires calculation for risk-significant designs to be checked by a suitably qualified person. This is required by law, and there are requirements around the qualification of professionals. (More can be found here, in German http://www.bvpi.de/).

In Singapore, the building regulatory and control system utilises 'Accredited Checkers' (see https://www.bca.gov.sg/BuildingControlAct/building_control_ac_regulations.html), which like in Germany, serve the purpose of review calculations and designs. Started for structural engineering, the concept also applies to geotechnical engineering and now has a parallel in fire safety engineering, specifically for review of PBDs (http://www.scdf.gov.sg/sites/www.scdf.gov.sg/files/Singapore%20Fire%20Safety%20Engineering%20Guidelines%202015_0.pdf, Chs7 and 8). For structural in particular, there are significant requirements for education and experience, qualifications, and experience. For fire, a peer reviewer and a 'registered fire inspector' are required (http://www.scdf.gov.sg/content/scdf_internet/en/building-professionals/fire-safety-permit-and-certification/registered-inspector.html).

In the USA, there is also use of peer review, especially for performance-based design. This is required for alternative (performance-based) seismic design in the state of California (e.g., see Los Angeles requirements, http://www.ladbs.org/docs/default-source/publications/information-bulletins/building-code/alternative-design-procedure-for-seismic-analysis-and-design-of-tall-buildings-and-buildings-utilizing-complex-structural-systems-ib-p-bc2014-123.pdf), and in some jurisdictions, for performance-based fire engineering designs (e.g., see http://www.mass.gov/eopss/docs/dps/8th-edition/9-fire-protection-systems.pdf, Section 901.2, for requirements for 'alternative designs' for fire in Massachusetts), the key aspects of which are excerpted and presented below:

"2. Where alternative fire protection designs, which vary from any prescriptive requirements of this Chapter, are to be utilized, the owner shall engage an independent registered design professional, to review said alternative design. The scope of the review shall include, but not be limited to:

a. Design assumptions, methodologies, and resulting proposed system designs, to determine whether or not:

    i. the proposed fire protection systems and any other systems which are affected by the alternative design, are consistent with the general objectives and prescriptive provisions of this Chapter;

    ii. they all conform to accepted engineering practice.

b. Preparation of a written report to the building official as to the appropriateness of the proposed design specifically listing any variances from the prescriptive provisions of this Chapter and describing, in detail, the design provisions used to achieve compliance.

If the reviewing engineer concurs with the proposed design, the owner shall make application for a variance, to the State Building Code Appeals Board as provided in section 113.0. In addition to all supporting information and materials, the reviewing engineering's report required per this exception shall be included in the application for variance. A building permit shall not be issued until the variance, if required, has been granted, or unless the building permit is issued in part per section 107.3.3."

In Massachusetts, a registered design professional, is defined as "An individual who is licensed or otherwise authorized to practice their respective design profession as defined by the statutory requirements of the professional registration laws of Massachusetts." Similar definitions exist in other states. In Massachusetts, Fire Protection Engineering is one of the licensed disciplines (see list of disciplines on this page - http://www.mass.gov/ocabr/licensee/dpl-boards/en/ opening paragraph).

There are also guidance documents for independent review of structure, fire and other (e.g., see Connecticut, recommended guidelines for independent structural review - http://b3tg6t0eoc.site.aplus.net/wp-content/uploads/2014/08/SEC-CT-301-Structural-Peer-Review-Guidelines-2008.pdf).

Several countries use an approach where some sort of centralized review committee or panel is used to review designs, adjudicate appeals / variations from Code requirements, etc. This includes some states in Australia, Hong Kong, Japan, and some states in the USA. In Victoria, Australia, the Buildings Appeals Board (http://www.vba.vic.gov.au/disputes-and-resolutions/building-appeals-and-disputes) will consider alternative designs which seem to fall outside of the requirements of the National Construction Code (as adopted in Victoria). In Japan, there are nominally three routes to compliance: prescriptive code (Route A), prescribed-performance (Route B) and full performance (Route C). Full performance (Route C) requires review by a performance verification committee established by the Ministry of Land, Infrastructure Transport and Tourism (MLIT). An overview of the process can be found here (http://www.iafss.org/publications/fss/7/777/view/fss_7-777.pdf), as well as in IRCC documents (www.ircc.info). In the USA, several states require submittal of 'alternative designs' to some type of review board. This is the case for Massachusetts, discussed above, where in addition to having a peer review, the 'approved' design must still be submitted to the State Building Code Appeals Board for final regulatory approval. The make-up of these Boards vary by country, but often include representation from across the sector, including suitably qualified engineers and academics (academics play a large role in review panels in Hong Kong and Japan, for example).

Role of the Fire Service in the Design Review Process

Generally speaking, the primary responsibility of the fire service in most countries is emergency response (including ambulance and emergency medical services (EMS)) and operational firefighting. These are typically the areas in which most funding and attention is given. Secondary focal areas generally include fire prevention activities (from inspections of buildings to training and education), hazardous materials (HazMat) control (in buildings, but also response to HazMat events), and fire investigation.

However, the fire service also plays an important role in the fire safety design of buildings, primarily with respect to influencing regulations regarding facilities for firefighting operation in buildings, as well as in the review of fire protection designs, in particular engineered designs. When and where they become involved is often a function of legislation.

In many Asian countries, for example, the building code typically addresses issues such as structure, passive fire protection, means of egress and sometimes smoke control, but the fire code addresses active fire protection systems and facilities for firefighters (e.g., internal hydrants, firefight communications and the like). This is the case in Japan, Hong Kong, Singapore and Taiwan, for example. In these cases, the fire service has a central role in the review and approval of fire protection systems which fall under fire service legislation (i.e., the fire code). Independent reviews by building officials and fire officials is often conducted (e.g., by the Building Construction authority (BCA) and Civil Defence Force (CDF) in Singapore). The system usually works well, but issues can sometimes arise due to misalignment of regulatory systems (e.g., a performance-based building code and a prescriptive fire code), especially when performance-based design is proposed to be applied to the entire building.

In many other countries, however, all regulated systems and features that relate to a building are addressed by the building code, and the building control officer (building official, building consent authority, etc.) has primary approval responsibility. Having said this, there is generally still a fire code, but in this case it is more often focused on fire prevention issues (e.g., control of hazardous substances) and less about building construction and features. In these types of systems, while the fire service does not have primary approval authority, they are generally consulted on fire safety design issues. Examples include Australia, New Zealand and the USA (in general). Here again the system usually works well, but issues can sometimes arise due to misalignment of regulated responsibilities (e.g., building code focused on getting civilians out while fire code considers safety during firefighting operations). Issues often manifest when performance-based designs are proposed, in part because designs may look to 'trade-off' one type of fire protection system for another (e.g., reduce fire resistance rating if sprinklers are provided), and the 'trade-off' has implications for both the civilians and the firefighters.

While the fire service often have different fire safety objectives than building officials, in part due to legislated responsibilities, without exception whichever system is in place will work well when there is good, clear, transparent communication between building and fire officials, as well as with fire engineers, designers and other stakeholders. Likewise, when there is confusion, ambiguity, and lack of communication, the system does not work very well. This is the case in New Zealand, for example, where there is ambiguity with respect to the role of the NZFS in the building consent process, particularly whether they should be involved during the establishment of the fire engineering brief (like the QDR), at the detailed design stage, or both. Research is underway to clarify the situation, but there is a generally agreed sense that the primary involvement of the NZFS is best at the fire engineering brief stage when the fire safety strategy is being defined and agreements are being reached on design approaches.

Whatever approach is taken, success comes with clarity of roles and responsibilities, transparency in decisions, and good and frequent communication.

6 Observations and Discussion

Context

Based on more than twenty hours of discussion with various stakeholders impacted by fire engineering in Scotland – including fire engineers, local authority verifiers, Scottish Fire and Rescue services, architects, developers, insurers and the Buildings Standards Division – as well as review of the Building Regulations, Technical Handbook – Fire, and consideration of various guidance documents (e.g., BS 7974), it is my opinion that the situation in Scotland is not in dire straits, and is generally on par with other countries which have implemented functional -, objective - or performance-based building regulatory systems. This is largely because both functional (objective- or performance-based) building regulations and fire safety engineering – in particular performance - based fire safety engineering – are not yet mature, and the sector at times becomes frustrated as it seeks to find balance in a regulatory system which has gaps and a fire engineering discipline at an adolescent stage of development.

From a building regulatory perspective, the implementation of the functional standards was meant to allow flexibility in the system, as compared with rigid prescriptions of the previous system. However, the system lacks clear measures of the level(s) of safety / risk to be achieved by the Building Regulations, and associated quantified measures of performance, which can be used in engineering analysis. As discussed by the Inter-jurisdictional Regulatory Collaboration Committee (IRCC) and researchers of building regulatory policy (e.g., see IRCC, 1998, 2010; Lundin, 2005; May, 2003, 2007; Meacham et al., 2005; Meacham, 1999, 2004, 2009, 2010, 2010a, 2012, 2016), these elements are needed in order to help determine when societal objectives for building functions have been achieved and to help deliver regulatory consistency.

The need for considering risk / safety levels, and for better quantification of performance, can be seen in the comparison to the Nordic Building Code Committee (NKB) hierarchy of 1978 (NKB, 1978), which formed the basis of most functional (objective- and performance-based) building regulatory structures from the 1980s through the early 2000s, and the IRCC-Hierarchy, which expands on the NKB structure and includes risk/safety levels, performance groups and performance criteria (e.g., see Meacham, 2004; 2009; 2010). The NKB hierarchy is shown in Figure 1 to the right: the IRCC hierarchy in Figure 2 below.

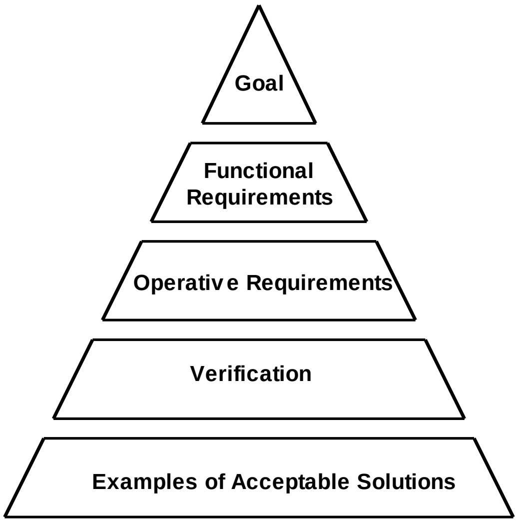


Fig. 1. NKB Hierarchy (NKB, 1978)

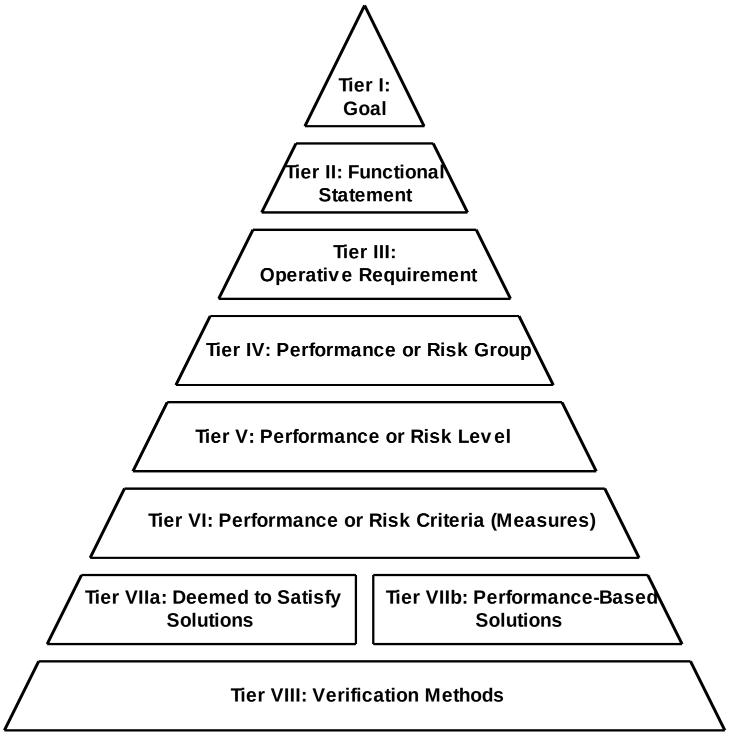


Fig. 2. IRCC Hierarchy (NKB, 1978)

At present, the current situation with functional (objective- and performance-based) building regulatory structures is under review in several countries, including Australia, Japan, New Zealand, Spain and Sweden, and investigation into next generation components and structuring is underway. In many respects, the state of play in 2016 can be viewed in terms of the Hype Diagram, which provides a perspective on the development of a technology. First a technology is introduced and entities jump on the bandwagon, often without fully understanding how to use it and the limitations associated with in, taking the market to the 'peak of inflated expectations.' Then, after some time working with the technology, and finding the gaps and problems that any new technology or system (or users) experience, one dives into the 'trough of disillusionment,' where frustrations emerge and efforts are needed to fix the gaps. Once one gets through this phase, and modified systems come into play, and users gain more experience, one proceeds up the 'slope of enlightenment' to ultimately reach the 'plateau of productivity' when gaps have been addressed, the experience of use has been gained, and a balance of sorts is achieved. The Hype Diagram is shown in Figure 3.

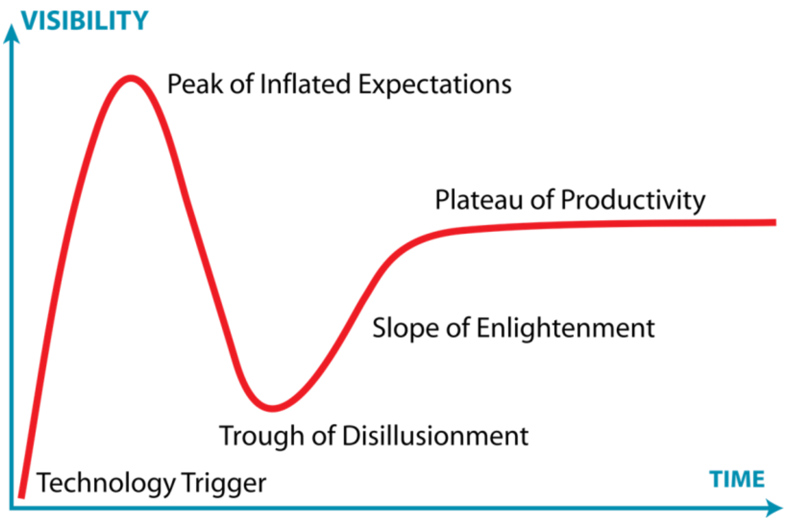


Fig. 3. Hype Diagram

With respect to how fire engineering might mature, an analogy often used is that of structural engineering, where there is a clear set of loads imposed on a structure (e.g., gravity loads, earthquake loads, wind loads, etc.), a clearly defined (and quantified) target of performance given these loads (e.g., resistance to the loads), and factors to apply that reflect the uncertainty in the actual loads and occurrences (on the load side) and the variability in material and system performance (on the resistance side). Such an approach is embodied in the Eurocodes for Structural Design, for example.

With respect to fire, however, there is not a design standard with well-defined and agreed loads to test the building (e.g., fire scenarios, design basis fires, etc.), criteria to assess ‘acceptable’ performance (e.g., tenability criteria, or evacuation time criteria, or structural stability in fire criteria), and specific factors to address uncertainty and variability in the loads and responses. There are guidelines, such as BS 7974, BS 9999, the International Fire Engineering Guidelines (IFEG) and the like, but these are couched in terms of ‘designs should consider X’ and not ‘analysis shall use Y loads and Z criteria, using A method of evaluation (e.g., ASET versus RSET) with a margin of safety of B’ (or other quantitative approaches to treating uncertainty, or requirements for sensitivity analysis of the design parameters, etc.). With no clear metrics in the Regulations, or requirements in Standards, each design is ‘one off’ with no means to assess the level of safety being delivered or whether it meets the Scottish objectives.

The fact that fire engineering is lagging structural engineering should come as no surprise. First, fire engineering has only existed as a discipline for about 30 years, whereas structural engineering arguably has existed for more than 100 years (from a scientific analysis perspective), with frameworks for integrating the underlying scientific principles being developed in the mid- to late-1900s. Second, fire engineering is significantly more difficult to quantify, undertake and assure than structural engineering, as structural engineering only has to deal with the artefact of the structure and its response to loads, and fire engineering has to take consideration of the people in the structure (building), who can influence the size of fire (e.g., changing contents) and its rate and magnitude of development and spread (e.g., based on contents, interior partitions, doors being open or closed, etc.), and who are influenced by the fire (with influence varying by occupant numbers, density, age, abilities, vulnerabilities, etc.).

In fact, if one looks at the development of an engineering discipline (Cornell, 1981) and how it applies to fire engineering (Meacham, 1999), this becomes apparent. The following is from Cornell (1981).

> In its earliest stages, a new area is characterized by rather uncoordinated relationships between practice and research, between needs and solutions, and between the profession as a whole and those dedicated to the development of the area itself. The problems that have been addressed by researchers tend to reflect personal tastes, ease of formulation or solution, and simple chance. Those applications in practice that do exist tend to be ‘local’, small parts of larger problems isolated and resolved without reference to a broader framework, because the framework has not been constructed. The major attention is often given to certain minor problems that have been popularized only by the internal dynamics of the small research community itself.
>
> In contrast, at a mature, stable level of development of an area of engineering one customarily finds a smooth interaction between research and practice. A vocabulary has evolved, a general framework exists, and the capabilities and limitations of the area are widely appreciated. Virtually all practitioners have received exposure to the subject and are accustomed to recognizing the kinds of situations in which the method is applicable and even to articulating their problems in the language of the area. Most research is being conducted in response to obvious needs of practice.
>
> Clearly in between these two stages of growth there is room for the uneven levels of development that characterize adolescence. Stimulated by larger numbers of contributors, growth is very fast and in some problem areas is indeed beginning to follow rather than anticipate the needs of practice. New practice-generated problems for research are being identified not only by growing numbers of

> experienced researchers but also by the engineers in practice who have begun to appreciate which of their old problems the new area can help. These initial reactions from practice are often poorly articulated and often, unfortunately, too optimistic. Nonetheless one can see the establishment of certain consensus positions that determine both a framework and a viable set of solutions for at least some rather broadly defined problem areas. But the development and internal coordination of the area are still largely incomplete at this stage: some topics are virtually untouched, limits of effectiveness of the parts or the whole are not well understood, some applications are rather naively formulated, and some practical applications have begun to address a larger framework but not yet with the confidence or the wisdom of experience.

As observed in 1999 (Meacham, 1999), it can be argued that fire engineering is a healthy adolescent. Research has begun better addressing the needs of practice, the essential elements of a framework and vocabulary have been developed, and many practitioners appreciate where and how the current methodologies can address their problems. However, the field remains largely uncoordinated, it lacks a comprehensive framework where the limits of effectiveness are well understood, and some applications are rather naively formulated.

While progress has been made in the 17 years since this assessment was published, fire engineering is still in the adolescent stage. A universal framework has not yet been developed and agreed. However, different levels of frameworks have emerged, such as the C/VM2 Verification Method for Fire in New Zealand (MBIE, 2014), and various frameworks have been suggested for risk- and reliability-based / informed fire engineering design.

In addition, there is not yet a universal set of competency criteria and minimum qualifications which ‘set the bar’ for the practice of fire engineering. As discussed in the body of this report, various efforts have been undertaken to establish mutual recognition for engineers, and to set competency criteria for fire engineers. However, not every country recognizes the criteria, enforces the agreements, or as is the case in Scotland, protects in any way the practice of engineering and specifically fire engineering. The result is that there can be a wide variation in qualifications, competency, and experience in the market, which can lead to project outcomes that lack completeness and quality, the potential for unethical behaviour, and general lack of confidence, which works against those whom are adequately qualified, ethical and professional. When these factors are lacking, functional (objective- and performance-based) regulatory systems can face problems (e.g., see May, 2003; Lundin, 2005; Meacham, 2010).

It is worth noting, however, that in the UK, the Engineering Council, through the Institution of Fire Engineers (IFE), charters fire engineers. There are various levels, including Chartered Engineer (CEng) and Incorporated Engineer (IEng), which reflect expected knowledge and capabilities, and which places boundaries of sorts around the areas in which engineers at the various levels can practice (largely self-regulated). In addition, the Society of Fire Protection Engineers (SFPE) has an international initiative to set globally agreed minimum competencies for fire engineers (fire safety engineers, fire protection engineers) and help identify minimum qualifications. Within the SFPE activity, a fundamental approach, which is based in part on the US approach to obtaining a Professional Engineer license, is to establish a clear hierarchy of knowledge and experience which underpins the profession. This is reflected in Figure 4.

At the base is the underlying science and engineering principles. This is embodied in research reports, peer-reviewed papers, and compilations of fundamental knowledge, such as found in the SFPE Handbook of Fire Protection Engineering.

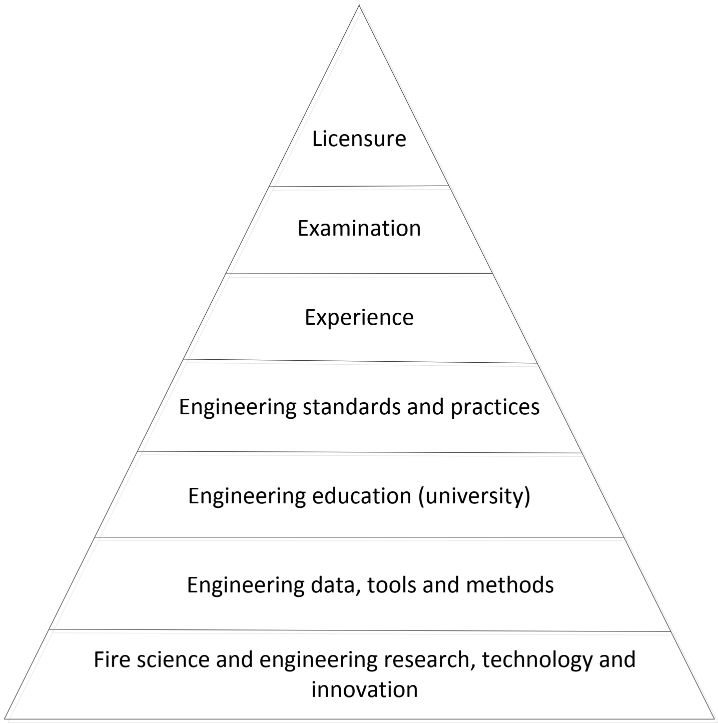


Fig. 4. Fire Engineering Knowledge Pyramid

From a solid base of knowledge, data is produced and archived, and engineering tools and methods are developed. These are embodied in the above types of formats, as well as in computational models, engineering frameworks, and related tools and methods.

This knowledge then serves as a basis for fire engineering education, at a university level (BS, MS and PhD), which serves not only to produce graduate engineers, but continues to feed the knowledge base, facilitates need data, tools and methods, etc.

To support the practice of fire engineering, the knowledge base and associated researchers and engineers have developed engineering standards and practices which are widely referenced and used. The BS 7974 series is an example of this, as too is the IFEG and other such guidelines. Specific design standards, as one might find in the British Standards, the International Organization for Standardization (ISO), the National Fire Protection Association (NFPA) and others, are other examples.

On the way to becoming a licensed professional engineer, or be otherwise recognized as qualified and competent in the field, engineers in many countries are required to practice under the mentorship of a licensed (Chartered or otherwise qualified engineer) before they are allowed to produce / sign projects on their own. Several countries require a minimum of four years, depending on qualification (e.g., specific engineering degree and experience). In some countries, such as the US, an examination in the specific discipline is then required (e.g., fire engineering) before one can become a licensed Professional Engineer. While not all countries license engineers, the intent of the qualifications process is to in some way similarly recognize minimum qualifications and experience (e.g., this might be through submittal of a package of information and interview, such as the Engineering Council division of IFE might undertake as part of the Chartered Engineer process). Regardless of specific form and type of recognition (e.g., license or Chartered status), the goal is the same: demonstration of knowledge and experience, based on education which is grounded in the discipline.

Current Situation in Scotland

Given the background context, the following observations about the current situation with fire engineering and the verification of fire engineering designs in Scotland are offered. Again, these are based on more than twenty hours of dedicated discussion, review of related regulations and guidelines, and perspectives obtained on a range of projects and project types. Even so, the extent of review within the project's three-week timeframe was necessarily limited, so arguably the input obtained is incomplete. Likewise, while efforts have been made to reflect as accurately as possible the input and feedback received, the observations are the interpretations of the author, and incomplete knowledge and misinterpretations could influence the findings.

It is also important to note that the scope of the problems, where identified, needs to be taken in context. While fire engineering is reported to be used on a large number of projects, it has also been reported that something like 80% of the projects could be effectively undertaken without 'significant' (or any) fire engineering, and that less than 10% of the projects require large, complex, fire engineered designs. The result is that projects which need complex fire engineering analysis represent a small percentage of all projects in Scotland. Almost all of these are exclusively in non-domestic buildings. However, given the noise around the issues with fire engineering that have arisen, the situation is significant enough to warrant attention.

The following reflects major issues and observations which arose out of the study. It should be noted that the following are not presented in any particular order of importance or priority and should not be interpreted as having such.

System works well with good communications and respect

A positive factor voiced by nearly all stakeholders is that the system works generally well when there is good communication amongst all parties, which starts early in the life of a project and continues until the end, and there is a high degree of respect for the expertise, capabilities and perspectives that the different stakeholders bring. Unfortunately, it was noted that this does not happen as often as anyone would like.

Indication of poor attitude by some actors

In some cases where communication, and projects, have not gone as well as they could, it was noted by some that poor attitude played a significant role. Examples of this were provided for each stakeholder group: examples include fire engineers who expected their work to be accepted simply because they were 'qualified fire engineers' and the other parties were not; local verifiers or fire service personnel who asked for much more than seems required by law and without clear justification (at least to the persons being asked for the additional work); clients asking for very specific bits of work to be done, without paying for a level of analysis appropriate to the problem and at a very late stage in the process. The simple observation is this type of behaviour and attitude does not help anyone. As noted above, good communication, and respect, goes a long way. So too do ethics. In some cases, engineers should consider not taking a project if the client is unwilling to pay for a proper analysis (as appropriate to the project). A 'race to the bottom' to do as little work as possible – just because a client is unwilling to pay for proper analysis – does not help confidence in the fire engineering fraternity.

Too much of a silo approach sometimes

In some cases it has been reported that different entities, which should be working together to solve a problem, facilitate a review, etc., are working too independently, and in the end the pieces do not work together as expected. This again impacts all stakeholder groups. The building regulations and guidance, in some areas, have the appearance of being developed in silos and not considering holistic building performance. It has been reported that developers, architects and the fire engineer are not always on the same page in meetings. The review of fire engineered designs sometimes occurs by different entities, with different perspectives, and a common and holistic set of review comments can be lacking. Working to address these problems makes for better projects and smoother reviews.

Lack of clarity in roles and responsibilities of actors

This relates primarily to the roles and responsibilities of local authority verifiers (LAV), the Scottish Fire and Rescue Services (SFRS), and the Building Standards Division (BSD). It has been reported that some local authority verifiers use the SFRS for review (and effective approval) and not just as a consultative body (and to be fair, it is unclear to the author what is meant by a consultative role). It has been reported that the view of the SFRS can effectively 'overturn' decisions made by a LAV under the potential that the SFRS might come in and close down a building, even if approved by the LAV, once it opens. It has been reported that the BSD has gotten involved when not needed and effectively 'overturned' LAV decisions (which, to be fair, is a role that BSD can take under their Ministerial View powers). It has also been reported that even if a LAV and an independent third party peer review 'approve' a design, the SFRS and/or BSD can overturn it.

While concerns exist, one cannot really say that any of the above situations are inappropriate: different actors have different responsibilities, and they are tasked with carrying those out as they see fit. The lack of clear performance metrics contributes to the problem, however, when different actors assess / determine 'appropriate' levels of performance / safety in different ways. Having a set of clear performance metrics, clearly defined decision-making making roles (when, for what, etc.), clearly defined qualifications of responsible persons within decision-making roles, and proactive and cooperative communication will greatly reduce the types of concerns highlighted above.

Fire engineering on too many 'small' deviations

While it is important to have a suitably qualified and competent fire engineer on projects for which fire engineering is required, not all projects require in depth fire engineering analysis, or volumes of fire engineering reports. It was reported that considerable time was being expended by reviewers (LAV, SFRS, third party) on 'minor' deviations, which many involved in the process see as inefficient use of limited resources. This type of issue can often be resolved with a combination of additional guidance and acceptance of decisions by qualified persons. In the Nordic countries, for example, several countries have a set of 'approved deviations' that are based on small deviations to prescriptive requirements which are generally approved, the idea being if they are always approved anyway, just make them acceptable. This could be done in the short term, and eventually can work into the Technical Handbook.

Concern of too much 'commercial' focus / projects which have engineer on board quite late

There were quite a few comments about the focus of fire engineers on saving client's money over fire safety, in particular when fire engineers are brought in late in a project and significant non-compliance issues are found to exist. While all actors understand

and appreciate that fire engineering is a business, like any other, which requires revenue to operate, there is also the sense that the business is focused on life safety, and that an appropriate balance is needed. This situation is not unique to Scotland, and in some countries, the situation has been characterized as involving some firms and individuals engaging in a ‘race to the bottom’ undertaken by ‘code lawyers’ who lack engineering qualifications and the professional ethics normally associated with the discipline. There is not the sense that Scotland is in the same situation. While the ‘commercial’ concern exists, most feedback reflected that most fire engineers try to do the right thing. However, client pressure can be high, and coupled with qualifications concerns and review pressures, undesired outcomes can result. Fire engineers can help address the situation, where practicable, by refusing to take jobs which have insufficient fees or scope to properly engineer a solution. Designers, developers, owners and the like (the fire engineers’ clients) can help by bringing fire engineers on earlier, with appropriate scope and fee, and engaging all stakeholders early so as to understand potential issues before they become significant issues. Designers can also help by better learning the Building Regulations and Technical Handbook and either carrying out ‘simple’ designs themselves or engaging fire engineers earlier in the project.

Resources lacking for ‘significant’ designs

While the number of ‘significant’ or complex fire engineering designs is relatively low, there seems to be a lack of resource at the review and approval stage to efficiently and effectively address such projects. It was noted in several cases that months, up to a year, were needed to gain final approval. In some cases the LAV lack fire engineering expertise, and find it difficult, and/or time consuming, to manage a third party (independent) review process. In some cases the LAV asks more from the SFRS than the SFRS is legislatively required to provide. The SFRS, while building a fire engineering team, does not yet have a fire engineer in all regions, and appears to lack computational technology to undertake reviews in a timely manner. To this point specifically, some of the current fire effects models, such as Fire Dynamics Simulator (FDS) or other computational fluid dynamics (CFD) models, can take weeks to run scenarios on desktop or laptop computers with insufficient processing power, memory and storage. In order to effectively and efficiently assess designs, which use such computational models, the SFRS – as well as LAVs and others engaged in review – need adequate computing power, training on the various software packages, knowledge of the underlying principles of the model, and sufficient time to assess the modelling output. It was also noted that some types of contracting processes are difficult to work with in the Scottish system, such as ‘design build,’ and resources are lacking for the constant design and review process – a~~s~~ system that is not effective in a regulatory structure that requires full and final design documentation for issuing a building warrant. Furthermore, when fire engineers only prepare ‘strategies’ and leave detailed systems design for subcontractors, the review process (and accountability assignment) becomes more difficult.

Lack of clarity in regulations and guidance

The fundamental purpose of the review was to assess the current situation with fire engineering in Scotland. This naturally involved discussions with stakeholders and actors within the system involved in fire engineering design, review and approval. It also needed to consider the tools used by fire engineers, reviewers and approvers (verifiers), which include the Building Act, the Building Regulations and the Technical

Guidance (Technical Handbooks and other). Consideration of these regulatory system components is essential in understanding the legislated goals, functional statements, and means of demonstrating compliance, as well as scope of the regulations (e.g., life safety only, or aspects of property protection, or…). Upon review, a number of issues and concerns were identified, which have a bearing on fire engineering practice, design and verification.

Regulatory scope – only life safety or more?

The question of whether property protection, in some form, should be considered for compliance with the objectives of the Building Regulations was raised by several stakeholders, including fire engineers, LAVs, SFRS and insurance industry representatives. In order to obtain a view on this, the Building Act (2003) was considered. The following is stated:

> (1) The Scottish Ministers may, for any of the purposes of
>
> > (a) securing the health, safety, welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings,
> >
> > (b) furthering the conservation of fuel and power, and
> >
> > (c) furthering the achievement of sustainable development,
>
> make regulations ("building regulations") with respect to the design, construction, demolition and conversion of buildings and the provision of services, fittings and equipment in or in connection with buildings.

In considering this clause, the objective of securing health and safety are (generally) clear. However, a fundamental question is: how are these factors measured? As will be discussed later in the report, the decision to date seems to have been by benchmarking to the Technical Handbooks, including the Technical Handbook – Fire (TH-Fire). However, the TH-Fire is guidance – it is not required to be used. This causes problems for fire engineers, reviewers and approvers in terms of what should be done if the TH-Fire is not used.

As for 'securing the welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings,' it is not clear what is meant by welfare or convenience, in particular with respect to 'others who may be affected by buildings or matters connected with buildings.' It could be argued that welfare has both social and economic components, and therefore people who derive a service from the activities in the building need to be afforded some protection, both directly and in-directly (e.g., loss of product or service due to fire in a building). The latter is often considered a business continuity / business interruption issue, dealt with by insurance. It is not clear of the application or intent here. Even if this is not the case, it could be argued that 'securing the welfare and convenience of persons in or about buildings' extends beyond safety to life in a fire (an acute event) and includes the structural stability after a fire, including the ability for the building to be rehabilitated after a fire rather than being allowed to burn down in a fire (a situation with both acute and chronic attributes). The latter situation could be considered a strong argument that the

Building Act requires property protection to be considered in the case of fire (and arguable other events, which were not considered in this research).

The argument that property protection is considered by the Building Act is further bolstered by the objective of ‘furthering the achievement of sustainable development,’ as it is difficult to envision how allowing buildings to burn down in a fire is sustainable, and/or how one could argue against the assertion that protecting a building from loss due to fire is sustainable. In either case, the requirement to further the achievement of sustainable development can be construed as a requirement to protect buildings from hazards which could cause premature and unnecessary loss of the building (e.g., fire).

<u>Requirements versus guidance</u>

In review of the Act, Regulations and Technical Handbook (Fire), and considering the feedback from the sector as to what is enforced (or is enforceable), it became clear that there are ‘mixed messages’ within the associated documents and how they are being applied and enforced in practice.

While the Building Act and in the Building Regulations have been crafted in such a way as to provide a ‘functional’ building regulatory system, where the only legal requirement is compliance with the Functional Standards, and there is no single legislated means of demonstrating compliance (i.e., no deemed-to-comply solution, no ‘approved document,’ no compliance document), it appears that the interpretation and implementation of the system has not been focused on the Functional Standards, but rather on the technical guidance, at least for fire safety.

Part of the problem may be that the Building Act does not positively state that any solution is possible (as long as it meets the Functional Standards), and that any valid solution must be accepted by local authorities (as long as it meets the Functional Standards) It can appear that, the focus seems to be on the fact that ‘guidance’ can be produced which can assist in the determination of compliance with the Functional Standards (“the Scottish Ministers may issue guidance documents for the purpose of providing practical guidance with respect to the requirements of any provision of building regulations and may issue revisions of the whole or any part of any guidance document”) and that “proof of compliance with such a document may be relied on in any proceedings (whether civil or criminal) as tending to negative liability for an alleged contravention of building regulations.”

This set of provisions seems to have been interpreted in such a way that once technical guidance was published (the TH-Fire), it has become the de facto regulatory benchmark and primary means of compliance for fire, to the point where demonstrating that the Functional Standards have been achieved by other means is not acceptable. It is not clear that this was the intent.

While the TH-Fire is not ‘enforceable’ in the sense that it must be complied with under law, in practice many LAVs appear to be ‘enforcing’ the provisions of the TH-Fire for three reasons: (1) basic liability avoidance, (2) lack of resources (to review and approve fire engineered designs), and (3) overall efficiency (time and resources). The ‘liability avoidance’ component can be understood, given that legislation states that: “proof of compliance with such a document may be relied on in any proceedings (whether civil or criminal) as tending to negative liability for an alleged contravention of building regulations.” An interpretation of this provision is that ‘as long as one follows the TH-Fire, one cannot be held liable for ‘noncompliance’ with the Building Regulations.’

This situation creates a difficult challenge. While it is not required to follow the TH-Fire, if one does so, one cannot be held liable for not complying with the Building Regulations, even though there is no guarantee that the TH-Fire (a) fully and completely addresses all fire safety issues of concern which are required to be met by the functional standards in the Building Regulation, and (b) while performance-based analysis and design should be readily accepted within the Scottish system, there are no performance metrics (benchmarks) other than as in the TH-Fire by which to assess designs, thus the TH-Fire is used as the de facto basis of performance (whether intended or not, or legally appropriate or not).

It is hypothesized that most actors in the sector – including fire engineers, LAVs and the SFRS – are concerned that by not following the TH-Fire, they open themselves to liability issues. While this may be the case under issues of negligence (which arguably is the case even for compliance with the TH-Fire), there is specific legal protection against liability for those which choose to demonstrate compliance with the functional standards by using means other than the TH-Fire: “Failure to comply with a guidance document does not render a person liable to civil or criminal proceedings.” While ultimately for the courts to decide, the presumption is that so long as a (performance-based / fire engineered) design has been accepted as complying with the functional statements in the Building Code, there is no liability if the resulting design is different than that which would have resulted from compliance with the TH-Fire, even if compliance with the TH-Fire would have resulted in a different outcome.

Regardless of the liability issue, and to a certain extent how the system has been interpreted to date, there is a need to clarify (a) what is required versus what is guidance, (b) how it is to be demonstrated that requirements have been met, (c) and how the system is to be enforced (including how designs are to be verified).

From a practical perspective, either the Technical Handbooks (THs) are required to be used, and engineered designs are deviations from the THs, or the THs are not required to be used. If required, what is the process for deviation? Is ‘benchmarking’ against the TH through comparative analysis the basis? If so, for fire, what design fires, scenarios, criteria, etc. were used in development of the TH-Fire (so as to provide a consistent baseline for comparison)? If these do not exist, how are comparisons to be made? If compliance with the THs is not required, what is the basis of demonstrating compliance with the Regulations (i.e., criteria / metrics) and how is compliance demonstrated (i.e., process).

While the above need to be considered in moving forward over the long run, a question of immediate concern is: if the TH-Fire is not required by national legislation to be used as a benchmark for comparing fire engineered design performance for compliance with the Building Regulations, do the LAVs have the authority to require that fire engineered solutions comply with the provisions of the TH-Fire? This question is raised because some LAVs reported using the TH-Fire as a benchmark for all fire engineered designs. If the TH-Fire is deemed not appropriate for this use, the issue as to whether the LAVs can continue to require such a benchmarking needs to be resolved.

Another short term issue is that the wording of TH-Fire itself appears to be working against the intent of having a functional system, wherein any viable solution is acceptable, and is fostering the use of the TH-Fire as the benchmark of performance. In particular, the TH-Fire is written is such a way that it is seen as the solution and everything else is an alternative. This does not match intent of the regulatory system and gives rise to LAVs (and others) interpreting the TH-Fire as the benchmark.

A longer term issue – which is a subset of the ‘required versus guidance’ issue – is whether Scotland desires a truly functional system, which equally allows prescriptive or performance solutions, or would prefer a prescriptive system as a base, and allow performance-based designs (fire engineered designs) by exception. In many respects they are similar, as they allow both performance and prescriptive solutions. The differences largely manifest themselves in terms of market expectations, regulatory baselines, and enforcement approaches.

In a functional system, the functional standards (objectives) are the only legally enforceable requirements, and any reasonable means of demonstrating compliance should be permitted, including prescriptive ‘deemed-to-comply’ or ‘approved documents’ as well as engineered solutions. However, such systems require clear performance metrics, widely available and agreed upon engineering data, tools and methods of analysis and verification, qualified practitioners, clear documentation, adequate education and training on how the system is to work, and sufficient resources across the sectors (especially for verification of designs). Gaps in any of these areas can lead to confusion, inefficiency and inconsistency. Generally, engineers like such systems, as they provide flexibility, but enforcers are often uncomfortable, as they often lack the same qualifications as the engineers, the tools for assessing designs, and therefore the comfort to determine compliance (e.g., has a reasonable level of safety in terms of ‘required safe egress time’ been achieved?).

In a prescriptive system, such as in the United States, the prescriptive code provides the legally enforceable requirements and engineered designs are by exception or as alternative to the code provisions. Such systems require less guidance in terms of how engineered alternatives are dealt with, as they are by exception and not the norm. Generally, enforcers like such systems, as the prescriptive code provides a clear set of requirements which can often be readily checked (e.g., maximum travel distance to an exit), and engineers have many concerns, as many buildings do not meet all prescriptive requirements (for a wide range of issues, from architectural design, owner needs, etc.), and much more effort is required to gain approval for engineered solutions.

Regardless of whether Scotland decides to fully embrace a ‘functional’ system, or might consider a more ‘prescriptive’ system, it would be extremely helpful to agree some fundamental principles for fire safety performance. A key issue is whether there is some level of tolerable risk that can be agreed, and if so, what it is, how it is to be characterized, and how it would be implemented in regulation and design. This cuts across both prescriptive and performance issues.

For example, is a single means of escape acceptable in a building or not? If so, for what buildings and/or occupants, and under what conditions, is it acceptable? What is required to demonstrate that a building design provides appropriate safety to people during fire? Are first responders considered occupants? If not, what criteria are used to assess their safety? Are sprinklers reliable enough for ‘trade-offs’ in passive fire protection requirements (from the TH-Fire) in fire engineered designs? If so, under what conditions? What types of analyses are required? What about other ‘active’ fire safety systems? Is cross-laminated timber (CLT) suitable for tall buildings? If so, to what height, with what protection? At present, there seems to be no consistency in the responses to such questions, and therefore no consistency in design and verification, and in the building stock, across Scotland.

A first step might be to compile a dataset of how the above (and other design issues) have been resolved and implemented. This might help to gain insight as to the level of fire risk tolerable to Scottish society. In addition, it might lead to a set of simplified 'agreed alternatives' (to the TH-Fire), which can then be used across the country to increase the consistency in application while the bigger issue of 'functional' or 'prescriptive' system is being explored. If 'common deviations' are identified they can be agreed, documented, and used consistently. These might be in terms of travel distance, egress capacity, single means of escape, fire resistance rating, or the like. Such an approach would follow the tradition already established of modifying the TH-Fire when common variations are found to exist.

With respect to guidance, while the TH-Fire provides a rather clear path to follow for prescriptive compliance, there is a large variation in the sector on how fire engineering designs are conducted. This will be explored further below, but providing additional detail around what forms of guidance are acceptable, and what level of detail / analysis is required given the scope of a particular project, would be helpful (e.g., when might BS 7974 be required / desired over BS 9999, if BS 7974 is used, when is the QDR required, what level of detail is necessary to describe fire scenarios, quantify design fires, reflect tenability criteria, etc., what level of documentation is required, and so forth).

Wide range in review capability and capacity

Comments were received from nearly all stakeholders that there exists a wide variance in the capability and capacity for undertaking reviews of fire engineering designs. While some fire engineers questioned whether those conducting reviews / verifying designs had the 'right' qualifications, no evidence was found that reviewers lacked the qualification to undertake the type and level of review appropriate to their job function. However, it appears that there are concerns within some groups as to where to find personnel with appropriate fire engineering qualifications when review of technical details of fire engineered designs are needed, how to engage such persons in a manner that minimizes the potential for conflict of interest (and perception of conflict of interest), and how to secure resources necessary to undertake such reviews.

Local Authority Verifiers (LAVs)

Given the variation in local authorities around Scotland, from those in large urban centres to those small rural communities, it is not surprising that there exists a large variation in the fire engineering expertise on staff and in the approaches to undertaking reviews on fire engineered designs. However, as noted previously in this report, there is no evidence that LAV staff lack the qualifications or competence to undertake reviews within their scope of responsibilities. Across the sample of LAV personnel interviewed, there was clear indication of a high degree of knowledge and competency with the Building Regulations and Technical Handbooks across all areas, not just fire, significant experience with projects of all types and sizes, and a strong sense of trying hard to fulfil obligations of public safety while also being a flexible as practicable when faced with unique designs.

Specific to fire engineered design reviews, LAVs with fire engineers on staff voiced no particular concern with the ability to conduct reviews, but voiced some concern with the fact that some engineers / designers did not understand what information was to be provided at what point in the process, and that some fire engineers were not submitting complete sets of documents in accordance with the guidance that they claim to follow (e.g., they claim to follow BS 7974 yet do not provide a QDR, details on scenarios or fire, sensitivity analyses, etc.). Such issues significantly slow down the review process.

Those without fire engineering expertise on staff used third party reviewers when needed. In some cases, it was noted that it was difficult to identify appropriate persons, but that LABBS and other resources were helpful. It was noted that while the SFRS is to be consulted on fire engineered designs, the feedback from the SFRS can be used in many ways, including effectively being used as the detailed fire engineering review. While the SFRS are building a team to provide more expertise in this area, it is not clear that this should be their role. This issue of 'consultation' versus 'review' needs further discussion and clarification.

The wide variation in fire engineering knowledge on staff at LAVs, and wide variation in used of third party review (including SFRS), results in large variation in the review and approval processes. This makes for a challenging situation for owners, developers, designers and engineers, who have the expectation that since Scotland has a national building regulatory system, there should be little or no variation in the approvals system across the country, from the approval process itself to the types of designs (variances, trade-offs, etc.) permitted. This is an area which warrants further review and consideration. While there may be some local planning issues that should be considered, it is not clear why designs (design features, protection features) approved in one part of the country are not permitted in others (e.g., single means of escape). As noted above, this needs to be looked at from the fundamental perspective of the Building Regulations, including the societal tolerability of risk and quantification of performance expectations, but needs also be considered in the design verification / approval process. On the surface, it is not clear why there cannot be a nationally consistent review process (e.g., what is expected in a submittal, how will the review be conducted, what expertise / qualification is needed on the review team and when, how long will reviews take, when is third party review to be used, etc.).

It is understood that each LAV may not be able to support a fire engineer on staff, and that a range of mechanisms for conducting reviews may be needed (e.g., on staff to third party). To help with the resource and timing issues, it is suggested that a 'central' resource for peer-review of fire engineered designs could be helpful for some LAVs. This might be set up to include persons from LAVs, fire engineers, and perhaps SFRS (as appropriate), with the intent to be independent from the project and working to an agreed review process and set of criteria for review and approval.

The concept of a 'central' review body is being discussed in New Zealand for much the same reasons as above. The Building Consent Authorities (BCAs) lack resources, fire engineering expertise on staff, there is concern about qualifications of fire engineers, there are concerns with the peer review system, etc.. A suggestion under consideration is to have central review body, comprised of different actors in system, meeting monthly (or such) to review performance designs and advise BCAs. The concept is similar in nature to the Building Appeals Board in the Australian state of Victoria (http://www.vba.vic.gov.au/building-appeals-board), but specific for review of fire engineered designs.

Such a system is in place in other countries as well, including some jurisdictions in the USA. In the Commonwealth of Massachusetts, for example, any fire engineered alternative to the Building Code must undergo a peer review and must also be submitted to the Appeals Board for approval:

"Where alternative fire protection designs, which vary from any prescriptive requirements of this Chapter, are to be utilized, the owner shall engage an independent registered design professional, to review said alternative design. The scope of the review shall include, but not be limited to:

a. Design assumptions, methodologies, and resulting proposed system designs, to determine whether or not:

    i. the proposed fire protection systems and any other systems which are affected by the alternative design, are consistent with the general objectives and prescriptive provisions of this Chapter;

    ii. they all conform to accepted engineering practice.

b. Preparation of a written report to the building official as to the appropriateness of the proposed design specifically listing any variances from the prescriptive provisions of this Chapter and describing, in detail, the design provisions used to achieve compliance.

If the reviewing engineer concurs with the proposed design, the owner shall make application for a variance, to the State Building Code Appeals Board as provided in section 113.0. In addition to all supporting information and materials, the reviewing engineering's report required per this exception shall be included in the application for variance. A building permit shall not be issued until the variance, if required, has been granted, or unless the building permit is issued in part per section 107.3.3."

Scottish Fire & Rescue Services (SFRS)

Legislatively, the SFRS has a consultative role in the design review and verification process. It is understood that this is not meant to be an 'approval or denial' role. However, there is a wide variance in when the SFRS is engaged and the role they play.

In some cases, the SFRS essentially serves as de facto third party reviewers at the request of LAVs. In other cases, even though they do not have building regulatory decision authority, the SFRS can significantly influence the decision to approve a particular design by making reference to their authority under the Fire (Scotland) Act, which includes effectively shutting down the building for safety concerns. While it is not clear that the SFRS has ever taken steps to immediately shut down a building, for which a certificate of completion was issued under the Building (Scotland) Act, the concern that it may happen has reportedly influenced some fire engineered designs / approvals, requiring designs to be modified and ultimately comply with the TH-Fire (which is not required under the Building Act). It has also been reported that in the past, the SFRS person involved in the consultation on a fire engineered project could (and has) changed during the course of a project, with different personnel rendering different opinions (e.g., one SFRS officer agrees in concept to a design, while the next does not).

Although it appears that some of the above concerns are being addressed through the formation of the SFRS Fire Engineering Group (FEG), which aims to have dedicated fire engineers supporting various regions around Scotland (and not having personnel change annually), the issue of the specific role of the SFRS FEG needs to be clarified, agreed and uniformly implemented. The SFRS FEG officers themselves noted that they are sometimes asked to spend time on minor issues, which could be better addressed by LAVs, thus taking time away from more significant issues, in particular complex fire engineered designs. Clarifying what the SFRS role is, when then should be engaged, how their feedback is intended to be used, and requiring feedback be given to the SFRS on the final disposition of the project should be considered.

In addition to clarifying the role of the SFRS FEG in the fire engineering design review process, the stage(s) at which they become involved should also be clarified. It has been reported that sometimes the SFRS are consulted early, at the planning stage, but often quite late in the process – after the design is set and any changes could result in significant costs. For fire engineered designs – especially complex ones – it is suggested that the SFRS should be consulted at a very early stage, ideally at the qualitative design review (QDR) stage as outlined in BS 7974. This is where critical issues of building design, selection of fire scenarios and design fires, characterization of occupants, and initial identification of fire safety design measures are established. Having SFRS input at this stage – rather than at the design approval stage – should make for a better and more informed process for all involved. If this is done, there is also the need to have agreement by all that decisions at this stage should not be revisited (overruled, modified) at a later point in the project, unless the specifics of the project have significantly changed. (It is understood that 'significantly' is not well defined. However, it could be something like changing from two exit stairs in a high-rise building to one, or eliminating a previously agreed fire protection measure. Minor changes, such as extending a dead end from 10 m to 10.5 m would not typically be seen as warranting a significant change in design. At some point, good judgment is required.)

It is also important that the SFRS FEG be adequately resourced – just like the LAVs – so that they can efficiently and effectively carry out their duties. This includes an adequate number of qualified personnel, with access to appropriate training and education, but it also means having the technology required to undertake reviews of complex fire engineered designs. In particular, having the computational power and access to fire engineering software that is necessary to review and assess designs.

Recent advancements in fire engineering software (including fire effects models, such as computational fluid dynamics (CFD) models, and occupant evacuation models), and advancement in the speed and in the memory and storage space available on personal computers, has resulted in fire engineers applying advanced computational models to almost all complex fire engineered designs. While the ability to apply such technology is good for the fire engineers, those responsible for reviewing the adequacy to the designs – including LAVs and the SFRS FEG in their consultative role to LAVs – need access to the same technology. This is required in order for reviewers to be able to scrutinise model inputs, model outputs, and the sensitivity of model outputs (and therefore the design) to changes in inputs. This is necessary to check the appropriateness of the application of the model(s) to the fire engineered design. In short, the LAVs and those acting on their behalf, such as the SFRS, must fully commit to investing in current technology and the on-going development of staff to ensure currency, quality, efficiency and effectiveness in the verification role.

Lack of clear guidance / process(es) for review

In addition to the issues identified above, there is a concern that the approval authorities (LAVs and SFRS, as appropriate) lack a consistent process to follow for the review of such designs. Resourcing and other issues aside, there does not seem to be any compelling reason against having a common process to be used by all LAVs (and the SFRS, as appropriate) when conducting reviews and approvals.

Such a process should identify such factors as the steps to follow in the review process, the type and level of detail of information that should be requested from fire engineers, the level of scrutiny / assessment that should be undertaken on computational modelling, and so forth. Without a clear process, fire engineers do not know what is required, nor do the approval authorities.

Several documents exist which could provide some guidance. For example, the SFPE Code Official's Guide to the Review of Performance-Based Fire Protection Designs identifies information which should accompany a performance-based (engineered) design, questions which reviewers should ask of engineers, etc. The SFPE Engineering Guide on Substantiating a Fire Model for a Given Application provides information for engineers and reviewers on how to assess the applicability of a model to a specific issue or set of issues. The SFPE Engineering Guide on Predicting Room of Origin Fire Hazards provides matrices which help engineers and reviewers assess the appropriateness of engineering methods across different levels (e.g., simplified calculations to CFD models) to specific hazard assessments (e.g., smoke filling).

Ultimately, it may be prudent to develop a process and associated guidance which is tailored to the Scottish needs. Such a process and guidance document should follow closely the design guidance that is ultimately acceptable for use in Scotland (e.g., BS 7974, or perhaps a Scotland-specific fire engineering design guide, or…). To begin with, a simple flowchart which outlines key steps, information / data needs, etc., might be helpful.

It should also be noted that consistency in the review and approval (verification) process will also be helped if fire engineers have a more consistent approach to design and submittal of information (e.g., BS 7974, or perhaps a Scotland-specific fire engineering design guide, or…) and they are required to follow the guidance at a level of detail appropriate to the complexity of the fire engineering analysis (e.g., conduct / include QDR, scenario analysis, sensitivity analysis, …).

Lack of clear means to identify competent and qualified fire engineers

The issue of competency and qualification of fire engineers has been discussed within Scotland over the past year, in part facilitated by workshops organized by BSD. The lack of an agreed system or approach to accomplish this continues to result in concern by various actors across all stakeholder groups, including fire engineers themselves. It is not a simple issue to resolve, given that there could be clear financial implications for current actors if requirements are imposed with which they do not comply. However, engineering in general, and fire engineering specifically, deals with life safety, and in most countries there are high ethical standards around basic competencies and qualifications of engineers with the aim of assuring public safety.

The sector needs to sort this issue out. While the fire engineers themselves play a critical role, the government should consider their responsibility for public safety as well, and participate in the decision process, as appropriate, and be prepared to legislate requirements, as appropriate.

An illustration of the requirements leading to professional engineering recognition is provided in Figure 4, which was discussed in the Background section. A knowledge pyramid like this should underpin the Scottish system.

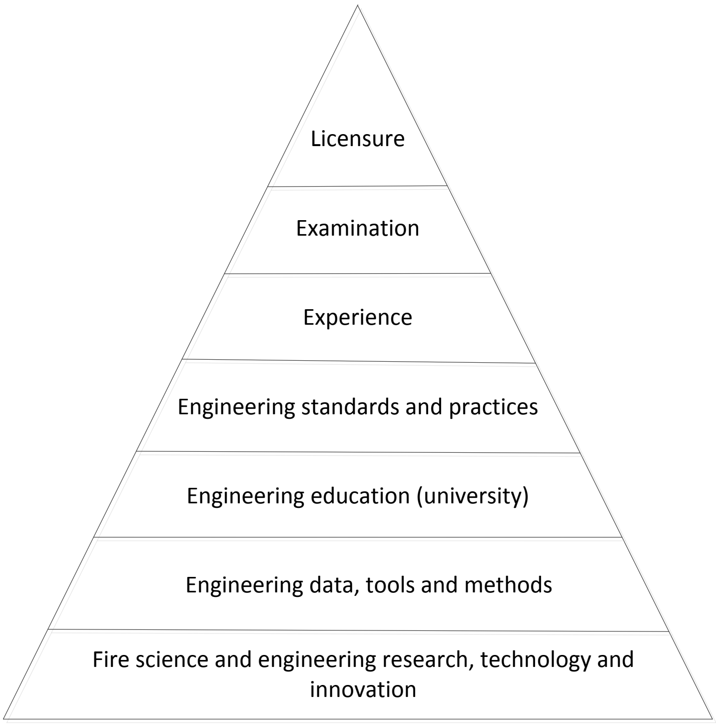


Fig. 4. Fire Engineering Knowledge Pyramid

In addition, issues which need to be addressed in the Scottish context include: what should be the qualification (CEng, PEng, PE), what are the minimum required areas of competency (e.g., fire dynamics, structural fire engineering, hydraulics, etc.), what is the minimum level of competency and how is this to be demonstrated, who determines competency criteria and measures, is a university degree needed as a fundamental basis and if so what degrees are acceptable, what is the minimum requirement for practical experience before becoming eligible for qualification, and is continuing professional development (CPD) required to maintain the qualification.

If help is needed sorting out minimum competency requirements, the Society of Fire Protection Engineers (SFPE), for example, has an initiative to try and define a set of internationally agreed competency criteria and means to demonstrate minimum competency. Connection with this effort could be helpful.

Opportunities to obtain professional qualification(s) for fire engineering exist now. One could become a Chartered Engineer (CEng) (or Incorporated Engineer, as appropriate) in fire engineering via the Institution of Fire Engineers (IFireE). Reciprocity agreements exist between professional engineering bodies in Europe, so some route through the EU might be feasible. One could also obtain Professional Engineer designation in another country (e.g., Australia, Canada, New Zealand, USA). However, before moving to any of these options, the sector needs to review the requirements and determine that the qualification, and minimum competencies needed to obtain the qualification, is right for Scotland.

The qualification does not have to be regulated, per se, as in the USA and other countries. However, it is recommended that Scotland consider their qualification as being more robust than CEng IFireE alone. This is not to say that the CEng IFireE qualification is not a good starting point; however, Scotland may decide that knowledge of the Scottish building regulatory system (and/or legal system) is also necessary, or the minimum years of experience working under the mentorship of a CEng (or other suitably qualified professional) should be set for Scotland, or other specific requirements may be desired. Also, it is recommended that the title ‘Fire Engineer’ should be protected, with its use limited to those with proper qualifications.

In addition, it is worth considering whether some sort of qualification is needed with respect to specific areas of competency, such as computational fire effects modelling (especially CFD), structural response modelling, evacuation modelling, and the like. This might be a certification of sorts (rather than qualification like CEng), an aspect of CPD, or other. It is important to consider this because qualification as a CEng (or other) does not mean one is competent to undertake CFD analysis (or similar), much like being competent to conduct CFD analysis does not mean one understands the breadth of fire engineering sufficiently to obtain a CEng in fire engineering.

Wide range of competency in fire engineering community

Given the lack of a qualification system, there is a wide range in competency and capability within the fire engineering community in Scotland, which makes it difficult for owners / developers / designers to identify and select competent persons, for LAVs to assess competency of engineers (and therefore to have confidence in their designs), and for LAVs to identify qualified persons to conduct independent reviews (not only on the overall fire engineering design, but on specific aspects, such as computational fire effects, structural response or evacuation modelling). The fact that anyone can call themselves a ‘fire engineer’ and not have to demonstrate qualifications or competency presents opportunity for abuse within the system – intentional or not.

Implementing a qualifications system for fire engineers, with clear minimum competency requirements, as discussed above, will help address this issue. Likewise, protecting the title ‘Fire Engineer,’ or at least implementing a register of qualified fire engineers, will help.

Lack of consistency and clarity in fire engineering approach(es)

There does not appear to be any consistency in development of fire engineered designs. This includes within organizations as well as between them, and by individual engineers from one project to the next. In addition, the level of clarity in presentation of scope, analysis and outcomes varies widely. It has been reported that in some cases too little information and justification is provided. Basic information such as applicable regulatory requirements and how they have been addressed are missing. Sources of data are missing. Models and modelling output is missing. In other cases it has been reported that excessive data and information is provided. Sometimes the level of analysis and associated documentation does not seem warranted given the scope of the effort. In other cases there is an appearance of confusing the issue by providing volumes of information without a ‘roadmap’ of how to navigate it.

In reports from past workshops in Scotland, the term ‘unconsistency’ has been used to reflect the view that there is “folly of trying to seek consistency in a profession that by its very nature adopts varying approaches to achieving solutions.” While it is agreed that each design is individual, the approach to undertaking the designs do not have to be individual, and in fact should be consistent. This is the reason that codes of practice and guidance documents such as BS 7974, BS 9999, the SFPE Engineering Guide to Performance-Based Fire Protection Design, the International Fire Engineering Guidelines, and ISO 23932 exist. The level of application and extent of data and information provided may vary, but it is unclear why the approach needs to vary.

The fire engineering community – including engineers, LAVs, SFRS and the government – need to identify and agree one (or more) approaches to fire engineering – and comply with the guidance. The latter point is critical. It has been reported that many fire engineers in Scotland generally follow the guidance provided in BS 7974 – but fail to provide specified details, such as the Qualitative Design Review (QDR) report with agreed objectives, criteria, scenarios, fires, methods of evaluation, trial designs, etc. Not all identify clearly what Functional Standards and/or TH-Fire provisions that they are complying with, or taking exception to and why. It has been reported that not enough fire engineers are providing adequate sensitivity analyses on modelling, reliability analyses on systems, and/or robustness checks / assessment of fire impact on firefighter operations. Also reported is inconsistent benchmarking for comparative analysis (including benchmarking against vastly dissimilar buildings and/or features), inconsistent use of acceptance criteria (e.g., sometimes BS 7974, sometimes other source, and sometimes mixed). It has also been observed that fire engineering reports vary widely in content and depth, and that almost no guidance on limits / bounding conditions of the design, or what is required if the building (or fire load, or occupants) changes significantly, is provided (more discussion on this provided below). The requirement for providing this type of information is found in the SFPE Guide, the IFEG, ISO guidance and other such guidelines – not just in BS 7974.

The benefits of an agreed process aside, there is also the issue of whether the guidance provides an appropriate level of detail to meet the Scottish fire engineering needs. For example, BS 7974 does not require more than one scenario, or more than one design fire to be used – it is simply guidance. However, many other countries have determined that single scenario analysis is insufficient. This includes New Zealand, which has developed a fire compliance / verification method (C/VM2), Sweden, which has various scenarios in their code, and the NFPA, which includes 8 fire scenarios in their *Life Safety Code©* (NFPA 101) and their model building code (NFPA 5000). In fact, the New Zealand C/VM2 goes so far as to include defined heat release rates for different building uses, guidance for fire effects modelling (e.g., species yields, ventilation conditions), occupant pre-evacuation times, and more. The rationale for this was to overcome the wide variation in application of fire engineering principles, which resulted in wide variation on the levels of fire safety being provided.

It is suggested that, at the moment, Scotland has a similar concern to New Zealand – it is unclear what the level of fire safety being delivered is – and the level of fire safety may be different from one local authority to another. Many of the reasons are discussed above, including lack of clear performance metrics and variance in review and approval approaches. In addition to addressing these issues, development of specific, detailed fire engineering design guidance (like the New Zealand C/VM2) may be helpful in Scotland for many of the buildings / building types currently being fire engineered.

Movement in this direction would potentially provide specified scenarios, fires, criteria, methods of evaluation, modelling parameters, pre-evacuation times, requirements for sensitivity, reliability and robustness analysis, and more. It would result in an approach that is clear to engineers and reviewers / verifiers. It would be much more detailed than current guidance, but would help to increase confidence in fire engineering analysis and designs.

Wide range of quality of designs / documentation

As noted several times above, a wide range in the quality of designs and associated documentation has been reported. This is in part a result of lack of clarity in the regulations, lack of enforced design guidance, and lack of any required qualifications for fire engineers. It is also a function of engineers not adequately following the guidance which is available.

As noted above, not all projects will need extensive analysis or extensive documentation. The sector needs to sort out what constitutes 'simple' fire engineering analysis or 'minor' variations from the TH-Fire, and what constitutes 'complex' analysis (or projects) or 'significant' fire engineering efforts. Once the level of analysis is agreed, the level of documentation can be set appropriately.

Small (simple, minor) projects will likely need minimal documentation: what is the baseline requirement, what alternative is proposed, and how the proposed alternative is demonstrated to comply with the Functional Standard or does not significantly influence the target level of safety. An example might be adding 1 meter of travel distance in a single-story office building due to the specific architectural design. It seems unlikely that CFD analysis and computational evacuation analysis, and associated documentation, would be warranted.

However, large (complex, significant) projects need comprehensive and robust documentation, arguably including:

- QDR, with qualifications of engineers, scope of project, project objectives, basis of evaluation, criteria, scenarios, fires, methods of evaluation to be used, etc.

- Written agreement of all stakeholders on the contents of the QDR

- Full report with a summary of above (no need to restate agreed documents), scenario analysis (e.g., fire effects modelling, structural response modelling, evacuation modelling), data sources, sources and treatment of uncertainty, sensitivity, reliability, and robustness analysis, and so forth. References for all sources of data, methods of evaluation, etc. should be provided. Detailed drawings, equipment specifications, etc., as needed to demonstrate compliance with the design, should be provided. Statements of limiting / bounding conditions of the design should be provided.

- Operators and Maintenance Manual (OMM), which stays with the building, regardless of change of ownership or management.

It is suggested that the concept of an Operations and Maintenance Manual (OMM) should be required for all fire engineered buildings, since it becomes the de facto building code for the building, which will be used by LAVs, the SFRS, insurance personnel and others into the future to assess whether the building remains within the bounds of the fire engineering analysis and design. The OMM should summarize the scope of design, any bounding / limiting conditions (e.g., maximum fuel loads, occupant characteristics, etc.), fire protection system / feature testing requirements (e.g., sprinkler, smoke control, passive systems, etc.). It should also outline fire safety management requirements for the owners / managers (such as keeping exit pathways clear, keeping fire and/or smoke doors in operating condition, conducting fire /

evacuation drills, etc.). Unless addressed in a separate document, evacuation guidelines should be provided as well, especially for complex buildings which may have some type of phased or zoned evacuation, which requires training of staff and/or occupants, and requires the associated systems to operate appropriately (e.g., fire alarm signals, smoke control, lift operation, etc.).

7 Workshop Feedback

On 16 June 2016 a Stakeholder Workshop was hosted at the SFRS facilities in Cambuslang where the preliminary outcomes from this research were presented and feedback was solicited from the audience. There were about 80 participants in the workshop, including architects, developers, fire engineers, local authority verifiers (LAVs), Scottish Fire and Rescue Services (SFRS) personnel, and Scottish Government, Building Standards Division (BSD) personnel. The following briefly summarizes the questions and responses. Sincere appreciation is extended to John MacGregor from BSD for taking notes which helped shape the below summary.

- It was noted that architects may not be aware of the implications of design changes on the fire engineering strategy. In response, it is acknowledged that the understanding of all parties can shift over the course of the project. A key is to maintain good communication. Changes at the eleventh hour will ultimately cost the project and impact all involved.

- In response to the question posed by Professor Meacham that Scotland has to decide whether they want to have a functional system with prescriptive compliance paths, or a prescriptive system with performance (engineered) designs by exception, a fire engineer noted that they do not want to go back to prescription because the profession of fire engineering will be lost. In response, it was noted that either approach needs fire engineering, as they are two sides of a coin. Simple solutions can be prescribed. Complex solutions need fire engineering. The key is that for fire engineering to be successful, fire engineering needs to be a recognized profession with a clear qualification system, including a degree qualification. Without this, if anyone is allowed to undertake fire engineered designs, there is a lack of confidence that the designs will be appropriate. This is not ending fire engineering, it is enhancing it.

- A number of other questions were posed around the functional versus prescriptive approach and how the system might work. In response it was noted that society currently relies on fire engineers to reflect the correct level of safety, but that fire engineers lack guidance on that, and arguably they are not delivering it. For example, at present the same building could be approved in three different locations, but each with analysis involving different fire scenarios, design fires and acceptance criteria. The fire engineering and regulatory community needs to choose appropriate levels of safety and the performance criteria and assessment components necessary to reflect this.

- In response to the issue of variability in fire scenarios, design fires and acceptance criteria, a fire engineer noted that a good QDR structure could accomplish this, would benefit all, and would be easy to do. It was agreed this should be done, under the current system at the concept stage of the project, but a QDR alone will not address variability between firms and jurisdictions in selecting and using these parameters. This requires a regulatory change.

- Concern was raised about the role of the Scottish Fire and Rescue Service (SFRS), noting that it is hard to know at design stage what they want, and that they sometimes do not want to get involved if it might compromise their regulatory role. In response, it was noted that the roles and responsibilities need to be on the table at the start and the ground rules need to be set. In order to move forward the rules need to be clarified and agreed. This might take a regulatory change.

- A follow up question noted that it is necessary to involve all stakeholders, but that everyone must understand what each party brings to the discussion. It was suggested that education is necessary to promote the need and value of the fire engineer. It was questioned if more regulation is needed. What is the best way forward? In response it was noted that education is generally the best route and regulation the last resort. However, if there is ambiguity in the market, regulation may be necessary. Key issues seem to be that Scotland needs to define what a fire engineer is, what qualifications and responsibilities they have, and what processed do you want them to follow.

- A question was asked relative to how one moves away from prescription. The response was that more should be done to clarify the functional system, identifying what fits nicely under a prescriptive solution and when fire engineering is a real benefit. In the meantime, one can start by sorting out whether one has 'a Technical Handbook project' or 'Functional Standards' project. If a 'Functional Standards' project, guidance needs to be selected, such as BS 7974, and an assessment made of what is required. There is a cost / benefit component to whether one chooses the Technical Handbooks or an alternative approach. Either way, the process needs to be defined and followed.

- The question was asked as to whether the New Zealand system (with C/VM2) has been effective. The response was that the C/VM2 approach was not working initially for a variety of reasons, including lack of training and some incomplete concepts, but the fire engineering community and the BCAs got used to the C/VM2 and have generally grown to like it for many applications. It has solved some of the fire engineering design and review concerns, and has generally been viewed as having raised the bar.

- The issue of how one defines a fire engineer was raised. In response, it was noted that accrediting organisations world-wide typically require: a relevant university degree, some minimum experience working under a chartered / licensed engineer, and demonstrating of competency in the discipline. There are international agreements in place to recognize qualifications of engineers across borders which meet minimum agreed criteria. There was also the also the issue of educating the public and others as to what a fire engineer is. It was asked, for example, if anyone without a structural engineering degree be viewed as being qualified to design a high-rise building. Also, fire engineers have to know the limitations of their expertise and its relationship to other spheres of expertise – do not work outside of your area of competency. In some countries, knowledge of local codes and experience in the country is required. In New Zealand for example, CEng IFireE is recognized, but one cannot obtain a PEng designation without practice experience in New Zealand.

- It was observed by one participant that there is not one qualification in the UK that would fulfil Professor Meacham's requirements. It was also observed that much of the discussion was on new buildings, but that there are a lot of existing buildings with fire concerns. A department store refurbishment project was noted where the £36 million cost included £21 million for the fire safety system.

- The issue of operations and maintenance manuals (OMM) was raised, with the participant noting there is no interface between regulations and fire engineering requirements for maintenance. In response, it was questioned what is required under the Construction Design and Management Regulations (CDM) and other documents, but in general, an OMM should be provided. In New Zealand, building warrant of fitness / compliance schedule requirements require that critical building systems, identified at the design stage, are checked and reported on annually that they are fit for purpose, and that the NZFS audits the systems every three years.

- The issue of functional versus prescription was raised again at the end, where it was noted that Scotland might have a prescriptive regime for 80% of buildings and the other 20% might be better served by functional standards, and the question was whether Scotland could have both, where simple buildings are covered by prescription with functional parts applied to complex buildings. The response was yes – the system should have both components – and simple compliance documents will be beneficial for simple buildings, and more detailed guidance, along with clear performance metrics, beneficial for complex buildings.

- The question was posed as to whether fire engineering is needed to treat common variations from the prescriptive guidance. The response is that engineering should be used to determine needs, but simple prescriptions can often be used. One needs to understand the issue and select appropriate responses. One needs to know, for example, where the numbers in the Technical Handbook came from. One also needs to understand how significant ‘minor variations’ are to the level of safety.

- A question about benchmarking was raised with respect to the New Zealand C/VM2 and any such approach Scotland might take. In response it was noted that benchmarking is needed, and direct implementation of C/VM2 would probably not work (needs to be tied to the regulatory system). The New Zealand Department of Building and Housing (DBH) originally made C/VM2 part of the building code (regulation). Therefore you could only use C/VM2 and not (easily) undertake specific engineered designs using other methods. While this provided consistency, there are some cases where it is not appropriate. For example, the C/VM2 could theoretically allow the use of FRR structural elements of 20 minutes for a 50-story building. This is why benchmarking and assessment are needed. New Zealand is working to remedy the situation modifying the C/VM2 and again allowing other methods for fire engineered design of complex buildings.

8 Conclusions and Recommendations

Based on this research effort, it is concluded that while the building and fire regulatory, design and verification system in Scotland can be improved, the situation is not dire, and is generally on par with other countries which have implemented functional -, objective - or performance-based building regulatory systems. This is largely because both functional (objective - or performance-based) building regulations and fire safety engineering – in particular performance-based fire safety engineering – are not yet mature, and the sector at times becomes frustrated as it seeks to find balance in a regulatory system which has gaps and a fire engineering discipline at an adolescent stage of development.

There were four principal tasks for this effort:

- Establish a baseline of the current fire engineering position in Scotland.
- Identify areas of improvement for different 'actor' groups.
- Chair a workshop to discuss findings and explore possible improvements.
- Prepare a final report.

This document constitutes the final report. The workshop was held on 16 June 2016, in which preliminary findings were presented and the feedback summarized in Section 7 was obtained. A copy of the workshop slides are provided in Annex B.

Baseline of Current Fire Engineering Position

With respect to establishing a baseline of the current fire engineering position in Scotland, the situation is mixed. Some aspects are working well, but there is room for improvement in several areas. The issues are highlighted and discussed in Section 4 (feedback from stakeholders) and Section 6 (observations and discussion). The key aspects can be group and summarized as follows:

Functionality of the current system

There are challenges associated with the fact that there is no qualification system for fire engineers, including no benchmark in the market to help assess / determine competency, qualifications and experience. This leads to a range in quality in projects, uncertainty in terms of what level of reliance on expertise of fire engineers is appropriate, and how / at what levels reviews should be undertaken.

There is a lack of clarity in roles and responsibilities of actors – particularly around the review and approval process (verification) – and particularly with respect to the SFRS. This leads to uncertainty in the design and review process, and has led to significant costs on projects due to decisions which are made at the end of design / during construction.

There are indications that the community is operating too much in isolation at times (in silos). Such working in isolation means issues can be missed and problems not identified until late in a project.

Fire engineering principles are also employed on too many ‘small’ deviations from technical guidance, which does not seem to be the best use of scarce resources.

There is widespread concern that too many projects focused more on saving a client money than on delivering safe buildings. This seems to particularly occur when fire engineers are engaged late in a project to help resolve a problem that a designer was unaware of and a solution is needed to ‘save’ the project. This can place designers, fire engineers and verifiers in a difficult position.

The system works well with good communications and respect, but there is indication of poor attitude by some actors.

Fire engineers / engineers

Due to the lack of a qualifications system, there is a wide range of competency in fire engineering community. As noted above, this leads to a range in quality in projects, uncertainty in terms of what level of reliance on expertise of fire engineers is appropriate, and how / at what levels reviews should be undertaken. The lack of fire engineering degree programs contributes to this situation.

There is a lack of consistency and clarity in the application of fire engineering approach(es). While flexibility is a hallmark of a function-based regulatory system, it should be expected that appropriate means / methods of engineering be applied, and where a standard, guide or code of practice is used, it is followed in its entirety to a level appropriate to the project. There are numerous indications that this is not the case in Scotland.

There is a wide range in the quality of designs and associated documentation. This is in part a function of the lack of qualifications and consistent application of fire engineering guidance, but it is also an attribute of the building regulatory system, which could state more clearly the expectations of design reports and level of documentation required.

Verification of fire engineered designs

The building regulatory system, and how it is implemented in relation to fire safety, is viewed as not being consistent in terms of what is ‘required’ and what is ‘guidance.’ Although the system is nominally a function-based system – with the only requirements being to comply with the Functional Standards – in practice the guidance documents (e.g., Technical Handbooks) are serving as the de facto requirements by some local authorities. The guidance in the Technical Handbooks refers to what might be allowable as ‘alternatives,’ when in fact the guidance within the Technical Handbooks themselves are alternatives (i.e., not required).

Given the lack of clarity in the regulatory system, the interpretation by local authority verifiers (LAVs) varies significantly, from only allowing fire engineered designs if they are benchmarked comparatively to the Technical Handbook – Fire, to allowing any design if the LAV deems the fire engineering analysis, design and documentation appropriate. There is also the situation that a design which is accepted by one local authorities may not be acceptable in another, which is difficult to understand in a country with a national building regulatory system.

It appears that resources are lacking for the comprehensive review (verification) of 'significant' designs. There is a wide range of fire engineering capabilities within LAVs, there are a limited number of fire engineers in the market and therefore limited number available for independent third party / peer review, and the SFRS fire engineering resources are limited. These limitations, coupled with a large number of fire engineering efforts on 'simple' projects can result in significant review times and inconsistency in approvals.

There do not appear to be any agreed guidelines for review and approval of fire engineered designs, for the use of third party / peer reviewers, or for the use (consultation) of the SFRS in the process. Each of these issues contributes to uncertainty and inconsistency in the verification process.

Regulations / regulatory system

As noted above, the building regulatory system, and how it is implemented, is not achieving the vision that underpinned the changes to the system in 2005. This has led to inconsistency in terms of what is required and what is guidance. Although the system is nominally a function-based system – with the only requirements being to comply with the Functional Standards – in practice the guidance documents (e.g., Technical Handbooks) are currently being used as the de facto requirements by some local authorities. The guidance in the Technical Handbooks refers to what might be allowable as 'alternatives,' when in fact the guidance within the Technical Handbooks themselves are alternatives (i.e., not required). However, verifiers (and engineers) can find themselves in a difficult spot if they simply want to meet the Functional Standard as it is unclear what the target levels of safety / performance are, or how they should be measured and assessed. Moving forward, the issues of 'what is required versus what is guidance' and 'how is 'acceptable' performance measured' needs greater clarity.

The scope of the regulations – and therefore designs and the verification thereof – is not clear. The Building Act speaks to 'sustainable development' and 'securing the welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings' as well as health and safety of persons in and about buildings. It is hard to envision how one addresses 'sustainable development' without considering property protection (i.e., how is a building that is allowed to burn down and be replaced sustainable?) or how one can 'secure the welfare… of persons' without considering economic implications of fire (i.e., property protection and business continuity). However, the Technical Handbook does not clearly identify whether its focus is life safety or property protection.. This creates a conundrum for all actors in the system in terms of what should be included in a fire engineered design to comply with the regulations.

Suggested Areas of Improvement for Stakeholder Groups

BSD have made significant gains in bringing the relevant parties together over the past year. However, even better communication between BSD, LAVs, SFRS, fire engineers, architects, insurers, owners and developers is needed. This is not just during facilitated meeting and workshops, but as part on normal business. Having respectful, transparent, timely and relevant discussions on projects will help foster better relations, projects and outcomes.

As for suggested areas for specific groups the following is suggested.

Fire engineers

Sort out the qualifications issue. It is in the best interest of the discipline to establish professional credentials and push the market upward. Considerations should include minimum education, experience, areas of competency, ethics, economics and regulatory environment.

Develop a definition of ‘fire engineer’ and of ‘fire engineering’ for use in Scotland. It will be needed for the qualifications system and the regulatory system.

Think about what types of projects require ‘fire engineering’ – what is needed, why is it needed, what will it involve. This will help educate the market and inform regulatory decisions (e.g., what is in the Technical Handbook – Fire, what might become ‘accepted alternatives,’ what is needed for a comprehensive fire engineered design).

As a discipline, discuss and provide recommendations as to what types and levels of fire engineering guidance are appropriate for use in Scotland. If for example it is a variation of BS 9999, what would it contain, why, and how would it be used. If BS 7974, self-enforce the complete application of the guidance, and consider supplemental information on scenarios, fires and related factors. Require QDR. Consider development of a Scottish equivalent to the New Zealand C/VM2 for ‘simple’ fire engineered designs. Generally, be proactive and positively influence the development of the discipline.

Act as professionals and treat other professionals likewise. All actors in the system have different roles and responsibilities, and have expertise and experience suited to those positions. Different expertise is not somehow less expertise or lower value.

Local authority verifiers

Work with BSD to sort out what is ‘required’ and what is ‘guidance’ in terms of the regulations – and consistently apply the outcome / agreement nationally.

Develop procedures for review of fire engineered designs (ideally in concert with the fire engineers and the SFRS) – and consistently apply the approach nationally.

Develop procedures for use of third party / peer review of fire engineered designs (ideally in concert with the fire engineers and the SFRS) – and consistently apply the approach nationally. This might also involve establishment of a ‘central’ resource for peer review, or at least guidance on how to select peer reviewers (including qualifications, experience, conflict of interest issues, etc.).

Agree with the SFRS how consultation and advice should be used – when are SFRS involved, what feedback is requested, and what might be done with that feedback. Consistently apply the agreement nationally.

Seek resources for training and technology (e.g., computers and software) to support level of expertise and capability needed to undertake review of complex fire engineered designs (particularly those using advance computational models).

Act as professionals and treat other professionals likewise. All actors in the system have different roles and responsibilities, and have expertise and experience suited to those positions. Different expertise is not somehow less expertise or lower value.

Scottish Fire and Rescue Service

Work with BSD and other relevant entities to clarify the role of the fire service with regards the building regulations, and to minimize overlap / competing requirements between building and fire regulations.

Work with BSD, LAVs and fire engineers to obtain clear requirements / objectives relative to SFRS involvement in review process – when in process, scope of involvement, expectations for action on feedback, etc.. Consistently apply the outcome nationally.

Seek resources for training and technology (e.g., computers and software) to support level of expertise and capability needed to undertake review of complex fire engineered designs (particularly those using advance computational models).

Act as professionals and treat other professionals likewise. All actors in the system have different roles and responsibilities, and have expertise and experience suited to those positions. Different expertise is not somehow less expertise or lower value.

Building Standards Division

BSD needs to be clear on whether Scotland wants a Functional system with prescriptive alternatives, or a Prescriptive system with performance by exception, is desired. At present, the current mix is facilitating confusion and inconsistency in the implementation of the regulations and guidance.

In the short term, BSD need to clarify that the requirement is the Functional Standards not the guidance in the Technical Handbook, and how to benchmark expected performance (function) if the benchmark is not the Technical Handbook.

If furthering the Functional system is desired, consideration should be given to identifying target levels of performance (risk, safety) and development of quantified measures of performance (risk, safety) for use in regulation and for verification that designs comply with the regulations.

The scope of the standards should be clarified to identify whether property protection is included or not? How do the standards foster 'sustainable development' and 'securing the welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings' as associated with fire (and other hazards)? Clarification will help ease concerns throughout the implementation of the regulations.

A review of the Fire provisions in the Regulations, and the associated guidance in the Technical Handbook, is suggested in light of the above issues. The focus of the review will likely be influenced by the direction selected for the regulatory system.

Architects

Work to minimize the engagement of fire engineers at the last minute to 'save' a design – better understand the regulations, and where needed, engage a fire engineer early to help minimize impacts.

Work with competent and qualified fire engineers. Pay for value – do not drive to the bottom. Consider the long term issues and not just the short term costs.

Better communicate with LAVs any changes to projects in a timely manner. Start communication early. If major changes occur (design, materials, etc.) inform the LAV. Delivering a design that does not match up with conceptual agreements (e.g., QDR) will increase the review time and likelihood for problems.

Owners and developers

Work to minimize the engagement of fire engineers at the last minute to 'save' a design – better understand the regulations, and where needed, engage a fire engineer early to help minimize impacts.

Work with competent and qualified fire engineers. Pay for value – do not drive to the bottom. Consider the long term issues and not just the short term costs.

Involve insurers early, especially if there are property protection and/or business operation issues – important to the fire safety strategy – which are not addressed specifically in the building regulations. It is better to have all fire safety goals and objectives on the table and addressed rather than meet the code yet have to do more after construction to get insurance and/or otherwise manage risks.

Better communicate with LAVs any changes to projects in a timely manner. Start communication early. If major changes occur (design, materials, etc.) inform the LAV. Delivering a design that does not match up with conceptual agreements (e.g., QDR) will increase the review time and likelihood for problems.

Insurers

Communicate issues / concerns to owners, managers, fire engineers, SFRS and BSD. If parties understand issues then perhaps they can be addressed.

Provide data on issues of concern (e.g., competing objectives between sustainability and fire protection). Evidence is helpful in fostering change.

Help to educate the stakeholders in relevant areas, as based on fire loss history and other perspectives unique to the insurance sector.

Academics

It is not clear that any particular change is needed. However, it seems that more university programs in fire engineering may be needed to underpin a fire engineering qualifications system, and to provide more engineers into the market.

Overall resourcing needs

In order to work in a functional system, there is a high reliance on expertise to be able to assess engineered designs. This places a high burden on LAVs and the SFRS, which need to have personnel (or access to them) who are educated in fire engineering, trained on software and related technology used by fire engineers, and be adequately supported with technology (computers) on which software used by engineers can be run so as to assess and verify the appropriateness of designs based on such software.

With a lack of fire engineers in the market, and in particular employed by LAVs, it is prudent to consider formation of some sort of central review body for fire engineered designs, for the sole purpose of supporting LAVs with review and approval (verification) of complex fire engineered designs.

Concluding Remarks

The fire engineering situation in Scotland is at a crossroads. While not in dire straits, there are issues which warrant attention, and critical decisions need to be made relative to the future form and content of the regulatory system and supporting infrastructure. A variety of suggestions have been made. There is an opportunity here to craft changes to the regulatory system that will help to achieve the vision that underpinned the changes to the system in 2005. It is hoped that the research, observations and suggestions will help foster a more efficient building regulatory system and fire engineering environment into the future.

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Annex A Questionnaire responses from fire engineers

1 Introduction

Arup were requested, by Brian Meacham, to respond to a series of questions relating to the state of fire safety engineering in Scotland.

The responses below outline Arup's view only. Arup have currently 18 fire engineers based in our Edinburgh and Glasgow offices with over 40 fire engineering active projects in Scotland.

There is potential for a variance in interpretation of some terms referred to in the questions. For clarity, the points below describe Arup's interpretation of key terms referred to:

Fire engineering – It is inferred in the questions that 'fire engineering' is a term used for approaches not following the standard prescriptive approach. Arup's view is that all fire safety design work (be it prescriptive or performance-based) is fire engineering on the basis that a competent fire engineer is needed to properly interpret prescriptive codes and performance-based codes, and judge whether or not they are appropriate for a particular application. For the purposes of these questions, it will be assumed that 'fire engineering' relates to non-prescriptive (or performance-based) solutions.

Peer review – It is assumed in our responses that the term 'peer review' relates to the reviewing of work by a 3rd party, independent of the consultant, who completed the work, and the regulatory authority, who is responsible for approving it.

2 Questions and Arup Responses

Q1)	**What is your general sense of the state of fire engineering in Scotland? What is working well? What is not working so well?**
A1)	We feel that there is a very focused and limited application of Fire Engineering in Scotland. Typically, Fire Engineering is more so used during the initial design stages of a project – implemented at design conception and carried through to Building Warrant application. Beyond practicing Fire Engineers there is a lack of understanding and encouragement, throughout the construction industry, that promotes the use/application of Fire Engineering. Overall we feel the practicing Fire Engineering community and the construction industry as a whole require a complete change in mind-set regarding the use of Fire Engineering/Engineers. This requires a move away from piecemeal, selective application which engenders a negative perception of fire safety engineering and more towards a holistic complete approach to developing Fire Safe buildings – inception, design, construction, implementation, handover, and management. The willingness of some local authorities and the Scottish Fire and Rescue Service, to meet at an early stage in a project, regardless of the degree of complexity faced, is an aspect that works well. It should be noted that this

	approach does not apply across the board, e.g. trying to meet other councils on projects is very difficult, and in this respect is something that also does not work well. We feel that the geographic variation in the procedural aspect of fire engineering verification throughout Scotland, the potential for prolonged approval processes, the project risk this creates and the difficulty in obtaining agreements with a phased warrant approach are active barriers to the use of fire engineering in building design.

Q2)	**On what types of projects is fire engineering used?**
A2)	We commonly find that a Fire Engineering (alternative/performance based) approach applies to projects, such as: • Education (schools; universities; colleges etc.) • Commercial (offices) • Arts and Culture (museums; galleries etc.) • Science, Industry and Energy (laboratories; energy from waste; distilleries) • Aviation (airports; hangers), and • Retail (shops; distribution centres/warehouses). • Existing buildings in all sectors – although not often referred to by verifiers as fire engineering these buildings where being modified can require significant engineering assessment to meet Building Regulations.

Q3)	**What are the main triggers for using fire engineering (e.g. make the design work at the 11th hour, remove FP features, address occupant vulnerabilities, address unique hazard…)?**
A3)	Some examples of “triggers” of when Fire Engineering is undertaken, include: • To optimise aspects of the design to return greater value and benefit to the scheme, e.g. evacuation strategy and exit provisions (defining number, width, and location); looking to increase the available lettable floor area (offices); optimising the structural fire protection design (influencing structural member sizing/connections, and determining required period of fire performance) • When the design has been completed and submitted for Building Warrant and the BCO identifies issues with compliance with the technical handbooks • A design developed with a lack of understanding, awareness, and application (by the project team) of Section 2 (Fire) of the Technical Handbooks

	• A difference of interpreting fire safety recommendations between the approving authority and the project team • Because the Building Control Officer/Fire Officer asked if the project had a Fire Engineer (due to a specific aspect of the design perceived to carry risk), and • Because the Building Control Officer/Fire Office asked for a Fire Strategy due to a specific non-compliance (i.e. the wider impact on the building). • A client specifically requested a fire engineer to be part of the design team in their ITT.

Q4)	**What percentage of projects would you estimate are variances from the Technical Handbook provisions, or conversely, from first principles?**
A4)	Almost all design projects we undertake include some aspect of variance from the Technical Handbooks as per Q4). In Scotland, fire engineers are typically only appointed where a variation is sought. For an understanding of the percentage of all developments, Local Authority Building Standards Scotland [LABSS] should be contacted. We would dispute the distinction of first principles requiring analysis from first principles from variations from the technical handbooks. For the majority of all variations we undertake an analysis or assessment from first principles in order to demonstrate compliance with the mandatory standards. However, it is our experience that the default position in Scotland is a fire strategy based on the technical handbooks with some variations. Therefore, this comprises 80-90% of our projects. A design that does not use the technical handbooks as its basis is rare but possible. This is likely to be a building or facility that does not, by its architectural design or use, fit the classifications of the technical standards.

Q5)	**What are the most common triggers for using one route or another?**
A5)	The default position in Scotland is to use the technical handbooks with variations from specific clauses where required or suitable. The need for analysis can be dependent upon the following technical reasons: • The level of risk the deviation is deemed to pose • The complexity of the problem • Potential mitigating measures (and supporting analysis)

	required/provided within the building Project considerations include the following, these may determine advice to a client on what design options to pursue: • Project costs/budget - fire engineering design costs are often balanced against value added to the project for example, increasing value of the final development or efficiency in material costs. • Timescale/project programme – fire engineering and in particular complex analysis will increase the time to obtain building warrant approval; no construction can take place without warrant. • The approving authority – have differing views and approaches to fire engineering verification which impact on the decision to pursue fire engineering or not (see response to Q12). Triggers for a first principles approach, i.e. not using the technical handbooks as a basis for the fire strategy, would include a specialist building or development which does not fit within the use classifications of the technical handbooks.

Q6)	**Do you think only qualified fire engineers are undertaking fire engineering designs?**
A6)	Within Arup our QA procedures require that all fire engineering work is checked and approved by professionally chartered fire engineers. We believe this is necessary to meet our legal obligations as designers and in fact the explicit recommendation with PD 7974 Part 0 Section 5. We have reason to believe that not all Fire Engineering designs being undertaken in Scotland are being carried out and supervised by qualified and competent Fire Engineers. This we have experienced via our peer review of other fire engineers work; having our work peer reviewed; and from discussion with regulatory authorities.

Q7)	**How would you define a “qualified” fire engineer?**
A7)	We consider that, in the UK, a qualified Fire Engineer is a Chartered Engineer (CEng), achieved through the Engineering Council, (EC) and registered with the Institution of Fire Engineers (IFE), with appropriate background and experience in the type of fire engineering he/she is undertaking. The Institution of Fire Engineers (IFE) and the Engineering Council (EC) both clearly define competence appropriate for operating as a Chartered Engineer (CEng). As an equivalent, we would also consider the term Professional Engineer (PE), as adopted by the Society of Fire Protection Engineers (SFPE); or, the National Professional Engineers Register, Australia (Fire Safety Engineering).

Q8)	**Do you think there are enough qualified fire engineers in Scotland – across all areas (design, review and approval, peer review, enforcement, etc.)?**
A8)	We do not believe that there enough qualified Fire Engineers in Scotland – across all areas as noted. We consider, from a private sector perspective, there to be far too few who are appropriately qualified to undertake design/peer review work in Scotland. We express some major concern regarding the depletion of knowledgeable and experienced persons from approval/enforcement, due to retirement. We are unaware of those in the public (regulatory) sector who are qualified Fire Engineers (Building Control authorities and Fire Service).

Q9)	**Do you think the existing mechanism(s) for professional qualification/certification are adequate?**
A9)	Yes. The process for professional registration as a Chartered Engineer (CEng) with the Institution of Fire Engineers (IFE) has been developed by the industry and is recognised by the Engineering Council (EC) as a sufficiently robust mechanism for demonstrating competency in fire engineering. This is the model we recognise and abide by.

Q10)	**If not, what would be your recommendation for qualification/certification/licensing?**
A10)	It is our view that all practising fire engineers should be either chartered, or are working towards Chartership, with the IFE. Additionally, all fire engineering designs should be supervised, checked and approved by a Chartered (CEng) Fire Engineer. We feel that the IFE is the most appropriate body for defining fire engineering competency, and that the introduction of additional qualifications/licenses/qualifications from bodies out with the IFE is not necessary.

Q11)	**Do you think specialist certification would be helpful, such as CFD or evacuation modelling competency?**

A11)	It is our view that a chartered engineer with appropriate training and experience in specialist tools is sufficiently competent to supervise and sign off work involving these specialist tools.

Q12)	**What are your views on the current approval process(es) for fire engineered designs?**
A12)	Generally, it is our view that the current approach to approvals for Fire Engineering designs is inconsistent across the different Regulatory Authorities in Scotland. Common challenges the fire engineering verification process present are: • The ability to meet with Regulatory Authorities to discuss in principle a project/approach • The politics we hear about from the Regulatory Authorities side to their structure and working practices • The prolonged time it takes for consultation and feedback, and • The changes in Regulatory Approvals personnel during the course of a project. • Preset 'acceptable solutions' to variations from the technical handbooks a consistent approach should not mean standard solutions. We specifically find the approvals process with authorities, who require individual view applications (or derogations) to each clause of the technical handbook to be submitted separately, is an active barrier to the undertaking of a holistic fire safety design for a building. We believe that it should be possible to adopt a consistent, co-ordinated approach for approvals across Scotland – to achieve the same response/applied approach, regardless of geographical location, and not need to unnecessarily involve other parties (only in special circumstances).

Q13)	**What percent of fire engineered designs are reviewed by qualified fire engineers?**
A13)	Within Arup, all fire engineered designs are reviewed and approved by qualified (i.e. CEng) fire engineers prior to being issued externally.

Q14)	**When peer review is used, how well do you think the approach is working?**

A14)	We do not believe that it is working well. In our experience it is not clear what criteria approving authorities use when selecting a 3rd party reviewer or what specific brief the 3rd party reviewer has been set. We recommend that a recognised and approved framework of 3rd party independent reviewers in Scotland should be developed that Building Authorities can consult directly with on designs. The framework should include academic institutions as well as practising Fire Engineers.

Q15)	**What are your views on the role of the fire service in the review process?**
A15)	The Fire Service are statutory consultees, and should therefore not be used as 3rd party/peer review verifiers, as this represents a clear conflict of interest. The role of the Fire Service in the approvals process is also not consistent with local authority areas. Some local authorities will rely on and actively engage with the Fire service to verify all Fire Engineering designs, whilst other local authorities do not encourage consultation with the Fire Service.

Q16)	**If you could change something in the review and approval process, what would it be?**
A16)	Define a consistent and clear approvals methodology for Fire Engineered designs across all local authorities, and centralise BCO Fire Engineering expertise to limit regional inconsistencies and deal with all large, or complex projects. Define a minimum competency criteria required for those submitting Fire Engineering solutions, and those verifying Fire Engineering solutions (both within approving authorities and peer reviewers). To ensure and formalise early engagement between approving authorities and designers a fire engineering brief which outlines the principles of design and the performance criteria which shall be adhered to would address some of the challenges outlined in A12). This is a common approach in other jurisdiction and informally undertaken for complex engineering assessments such as structural fire engineering analysis.

Q17)	**Do you think some sort of 'expert' review panel, comprised of members from inside or outside the Scottish fire engineering design community, could be helpful in any way?**
A17)	Yes, and this could potentially form part of a centralised BCO Fire Engineering department, which deals with all large and complex fire engineering projects, as well as a dispute resolution department for local authorities and designers

	to refer to. If consultants were to be included in this panel, their role would need to be clearly defined to avoid conflicts of interest.

Q18)	**Do you think more / different guidance for design / review is needed? If so, comprising what?**
A18)	The Technical Handbooks could be better developed to account for Fire Engineering. For example, illustrated Technical Handbooks, including more elaborate commentary (similar to NFPA 101 Handbook, and International Building Code Handbook). It would be useful to have a clear statement of the status of BS 9999 and BS 9991 in Scotland to enable consistent approaches by all verifiers. For minor deviations an engineering based design guide (effectively the role BS 9999 plays in England and Wales) could be defined. This is currently absent in Scotland.

Q19)	**What are your views on the current formulation of the Building Regulations with respect to fire?**
A19)	The requirements of the Building Regulations with respect to fire (i.e. mandatory standards) are concise and clear. It is our understanding that there is no regulatory requirement with respect to the provision of information to the ultimate building owner with regard to the fire safety design of the building. The modern contractual arrangements of construction are complex involving multiple designers and constructors. We have concerns that the absence of a regulatory interface between the Building (Scotland) regulations and the Fire Safety (Scotland) Regulations will impair the ability of responsible persons to meet their obligations under the Fire Safety (Scotland) Regulations. This is based on substantial experience in the existing building and fire risk assessment market. However, further consideration and guidance should be provided beyond life safety – considering our responsibilities and duties to society and the environment with regards to fire safety design impact. It should be acknowledged that Technical Handbook guidance cannot account for all design eventualities, and with such limitation in the field of application this does not mean that a safe solution cannot be achieved – to get there we must be open and up for the challenge. Construction techniques and materials are rapidly evolving; building energy performance and acceptable design criteria are increasing – to keep pace with such influencing demands the approach to achieving Fire Safe buildings must be adaptable. This represents a change in our culture, which will not happen quickly, but the

	principles and aspirations must be set out from the top.

Q20)	**Any other thoughts, issues, benefits, concerns, enhancements, etc. related to the Building Code or fire engineering within the building regulatory system that you would like to share.**
A20)	There needs to be a consistent process for ensuring that projects are constructed in accordance with the design, and in order to ensure the agreed and approved design is implemented – this ultimately reducing the risk of corner cutting and poor construction. For example, a version of the Australian/New Zealand principle of inspection and sign-off by the project Fire Engineer could be developed. Alternatively, increasing the competency and responsibility of Regulatory Authorities for inspection and sign-off of a building Fire Strategy, and creating a statutory requirement for implementation for specific building types, i.e. healthcare, education/schools etc.

3 Anonymised Questions and Responses

Q1)	What is your general sense of the state of fire engineering in Scotland? What is working well? What is not working so well?
A1)	There are several areas for improvement. • Architects and Contractors need to engage with Fire Engineers sooner, (although this is happening more regularly year on year, fire engineers are still called in late in the design to justify an issue at the last minute). • Building Control in different areas have different opinions, this is not an issue and leads to good design through a qualitative design review style of process. However, some local authorities are harder to please than others, this appears to be due to a lack of understanding regarding relatively simple fire engineering issues. • The Fire Service are often used as a battering ram by authorises especially where their own knowledge is lacking, however, this is not the roll of the Fire Service, they are a Statutory Consultee not an approving authority. Some Brigades want to get actively involved in the design where as others do not want to comment until the last minutes at which point it can be late in the design process and the foundations may have already been poured. • Fire Engineers. There is a reluctance for design teams to appoint fire engineers this can be due to cost saving (which is the most common reason, the fire engineering design gets pushed on to the architect) or because clients have had a bad experience. Although it is appreciated

	that some jobs go sides was, there are Fire Engineering firms that are not suitably qualified and, therefore, produce a solution which is not appropriate or wrong. This is wholly unacceptable as it drags the whole industry down. • Builders. A well-established argument from local authorities and the Fire Service is that the design will not be that way when it is on site. This is an argument fire engineers hear a lot. However, this issue is not the fire engineers, the building trade need to be suitably monitored. When the local authority signs of the building they should be happy with the Standard of work (as should the client).

Q2)	On that types of projects is fire engineering most used?
A2)	Fire engineering is used on all types of project to justify minor deviations. However, there are other projects where the design requires a far greater level of fire engineering (e.g. airports).

Q3)	What are the main triggers for using fire engineering (e.g. make the design work at 11th hour, remove FP features, address occupant vulnerabilities, address unique hazards…)?
A3)	The answer is client specific. Mostly there will be a deviation from the code which requires justification and risk averse clients will appoint a fire engineer early on to ensure the issue is properly considered. However, some clients will have an issue raised late in the design and seek advice from fire engineers to remedy the situation, this leads to fire engineers getting a bad name from all stakeholders. Other clients use us as a cost saving or value added design team member, this also leads to fire engineers getting a bad name.

Q4)	What percentage of projects would you estimate variances from the Technical Handbook provisions, or conversely form first principles?
A4)	Around 99% of our work uses fire engineering based arguments, sometimes these arguments are based on 1st principles. The remaining 1% are totally fire engineered designs (e.g. airports which do not have a code of practice). For the most part fire engineers will work to a code of practice (similar to the approaches demonstrated at the SFPE conference in Poland) and then justify non compliances either through a comparative or deterministic analysis.

Q5)	What are the most common triggers for one route or the other?
A5)	Risk and creativity. To reduce risk, if a design area is code compliant the approval risk is lower. Not using a code and doing the full design from first principles is governed by a lack of guidance for unusual buildings. As stated above, there is no guidance for airports in the UK and, as such, the design of such buildings is based on the principles set out in BS 7974.

Q6)	Do you think only qualified fire engineers are undertaking fire engineering design?
A6)	R6. A degree in fire engineering is not considered to be relevant, however, it helps people pick up the general principles quicker. That being said, there needs to be some way of distinguishing what makes a good fire engineer such that the cowboys are driven out. How this can be achieved is unknown.

Q7)	How would you define a ‘qualified’ fire engineer?
A7)	Difficult to answer, generally I would consider someone who is a chartered fire engineer to be qualified, however, at present there is no definition of a fire engineer and especially a chartered fire engineer (e.g. a fire alarm designer could be a charted fire engineer). The role of a fire engineer need clarification and status.

Q8)	Do you think there are enough qualified fire engineers in Scotland – across all areas (design, review and approval, peer review, enforcement, etc.)?
A8)	No, there are an insufficient number of fire engineers in local authorities (more specifically local authorities with knowledge to assess a fire engineering assessment).

Q9)	Do you think the existing mechanism(s) for professional qualification/certification are adequate?
A9)	Yes, however, no one really goes for Incorporated engineer (i.e. the half way to being chartered status) because there is no benefit (e.g. cost saving or time saving etc.) when you go for full chartership. If there was a reason to apply at

	an atrium stage I think people would be more accepting of it.

Q10)	If not, what would be your recommendation for qualification/certification/licensing?
A10)	No response

Q11)	Do you think specialist certification would be helpful, such as CFD or evacuation modelling competency?
A11)	No. Different people are good at different things. Some firms want everyone to know about everything some want people to be specific (e.g. CFD modellers).

Q12)	What are your views on the current approval process(es) for fire engineered designs?
A12)	Slow and inconsistent.

Q13)	What percent of fire engineered designs are reviewed by qualified fire engineers?
A13)	For this answer I am considering qualified to mean chartered. Within our firm all strategies are reviewed by chartered engineers.
Q14)	What peer review is used, how well do you think the approach is working?
A14)	No response

Q15)	What are your views on the role of the Fire Service in the review process?
A15)	See response to Q1.

Q16)	If you could change something in the review and approval process, what would it be?

A16)	Earlier discussions with all interested parties to agree the general principles.

Q17)	Do you think some sort of ‘expert’ review panel, comprised of members from inside or outside of the Scottish fire engineering design community, could be helpful in any way?
A17)	Yes, definitely.

Q18)	Do you think more/different guidance for design/review is needed? If so, comprising what?
A18)	No. The current guidance is adequate, however, the Technical Handbook is long and wordy, some sections could be summarised in a diagram to make the documents more user friendly. Authorities would like to see a prescriptive fire engineering design. This can cause many issues that would potentially suffocate the creativity of architects and result in fire engineers becoming code consultants. This also has the risk of designs being over or under engineered based on prescriptive design fires detailed in a guide to fire engineering code of practise.

Q19)	What are your views on the current formulation of the Building Regulations with respect to fire?
A19)	The Technical Handbook does not reference the most recent British Standards, this is principally due to the Building Standards Division (BSD) not having time to read the updated standard and, therefore, incorporate the changes where appropriate. Unfortunately this comes down to money, BSD need to have a pot of money available to properly revise the Technical Handbook, specifically Section 2. There are a lot of updated British Standards which are not covered in the updated Technical Handbooks. This can lead to issues with the design where engineers may be working to the most current standards because the engineer believes these are more appropriate but the approving authorises knock back the design because the Technical Handbook does not recognise the updated standard. This happens most notably with BS 9999. Although it is agreed that there are a lot of issues with BS 9999 there are good bit and principles which can be adopted. For this and other British Standards BSD could release a national annex similar to the national annexes released for the Eurocodes. This would allow all engineers to work to up to date guidance, and know the extent of applicability in Scotland. Note also the response to Q18.

Q20)	Any other thoughts, issues, benefits, concerns, enhancements, etc. related to the Building Code or fire engineering within the building regulatory system that you would like to share.
A20)	Nothing that has not already been raised.

4 Summary Findings from Stakeholder Meetings and Preliminary Assessment

Areas of Concern	**SUMMARY OF FINDINGS**
Preliminary Findings	• ‘Complex’ fire engineering on too many ‘small’ deviations • Concern of too much ‘commercial’ focus • Resources lacking for ‘significant’ designs • Lack of clarity in regulations and guidance • Lack of clear guidance / process(es) for review • Lack of clarity in fire engineering approach(es) • Lack of clear means to identify competent and qualified fire engineers • Lack of clarity in roles and responsibilities of actors • Works well with good communications and respect
General Concerns	• Wide range of competency in fire engineering community • Wide range of quality of designs / documentation • High degree of coming in late on a project – choice by engineers to accept work and at what cost • Indication of poor attitude – overall quite competent actors – no need to label some unqualified or incompetent because they have different expertise – this applies across all groups • Too much of a ‘silo’ approach sometimes

Regulations (Act, Building Standards, Guidance)	• While the system is functional in word (law), it is prescriptive in practice • It is not clear that the Regulations and associated Guidance are written appropriately for the intent (i.e., functional system) • There is a need to clarify the **requirements** under the Building Act and Regulations versus the **guidance** • If a truly **functional system** is desired, the wording of Technical Handbook (at least Fire) may be working against the intent • Regardless of 'functional' or 'prescriptive', need to agree basic principles • If remain 'prescriptive', a set of simplified 'agreed alternatives' might be helpful • If embrace 'functional' approach, a set clear performance metrics, methods and guidance will be helpful
Fire Engineering – Competency and Qualifications	• Why no expectation of minimum competency and qualifications? • Competency and qualifications need sorted out – CEng through Engineering Council / IFireE probably a good start, but more may be helpful (like PEng in Australia, NZ, Singapore, USA…) • If not addressed within sector, government intervention should be considered (e.g., licencing / registration)
Fire Engineering - Process	• Fire engineers inconsistent with designs – it is recognized that each design is individual, but process is not • Many follow generally BS 7974 – but fail to come through with specified details, such as QDR, agreed objectives, criteria, scenarios, fires, methods of evaluation, etc. • Not enough sensitivity analyses / robustness checks or assessment of impact on firefighter operations • Inconsistent benchmarking for comparative analysis • Inconsistent use of acceptance criteria • Reports vary widely in content and depth • Operations and Maintenance Manual (OMM) should be required for fire engineered buildings – scope of design, bounding conditions, limitations, testing requirements, … • An overall key to success is more and better communication – early and often • Once sort out what level of 'variation' needs 'fire engineering' design, establish guidance appropriately • Specific, detailed design guidance may be helpful (like New Zealand C/VM2) for 'typical' engineered designs
Review of Fire Engineered Designs –	• Large variation in levels of fire engineering expertise on staff

Local Authority Verifiers (LAVs)	• Large variation in review processes • Large variation in approach to fire engineered designs • Wide variation in how Scottish Fire and Rescue Service (SFRS) is used / consulted • Wide variation in peer review • No indication that LAVs are not competent in their areas of expertise, and generally very well aware of limitations (when exist) in fire engineering and when peer-review helpful • National consistency in review process would be helpful • A 'central' resource for peer-review of fire engineered designs could be helpful for some • More consistent approach by engineers will help • It is not clear why national consistency in review is not possible • Suggest use of QDR, and getting agreement from all, early in a project, helps facilitate good projects
Role of Scottish Fire and Rescue Service (SFRS)	• Concern voiced that the role and responsibility of SFRS needs to be clarified and addressed • By Act and Regulation, SFRS have 'consultative' role in building approval – what does this mean? • What is the appropriate time(s) for SFRS input? (I would argue early, at the QDR stage, to get all stakeholder issues on the table.) • Recent structure with fire engineering group helpful in gaining consistency • What are implications of not having SFRS concurrence?
B Meacham - Choices to be made	• Prescriptive or Functional? Address Act, Regulations and Guidance accordingly • If Prescriptive, sets of simplified guidance for small / common variations will be helpful, along with more guidance for complex FSE designs, and more detailed and consistent guidance for reviews • If Functional, need clear set of performance metrics (criteria), need to determine how 'acceptable' safety is to be achieved (e.g., what are target safety / risk / performance levels), need clearer and perhaps more detailed engineering processes, and need support for review complex designs, including perhaps some type of peer review panel • Sort out roles and responsibilities of actors • More communication, transparency, ethics, respect

Annex B Slides Presented at 16 June Workshop

WPI

Research in Support of Improvement in Verification of Fire Engineered Solutions: Initial Findings & Discussion

Professor Brian Meacham, BSc, MSc, PhD, PE, FSFPE, CEng, FIFireE
Fire Protection Engineering & Architectural Engineering
Worcester Polytechnic Institute, Worcester, MA, USA

SFRS Facilities, Cambuslang, Scotland
16 June 2016

Overview

- Terms of reference, process and approach
- Situation in other countries
- Preliminary observations / findings
- Discussion

https://www.dundeewaterfront.com/zones/central/VandA

http://www.clydewaterfront.com/projects/pacific-quay--secc/leisure/secc_arena

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Outcomes of Previous Efforts

- Survey and Workshop in 2015
  - Who can practice as a fire engineer / what is required competency level
  - Level of education and ongoing training required
  - How best to foster the exchange of ideas across fire engineers, regulators and academics
  - How to highlight "Best Current Practice" – International guidance & approaches

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Outcomes of Previous Efforts

- April 2016 Workshop
  - A lack of awareness of the services provided by Local Authority Building Standard Scotland (LABSS)
  - Limited understanding by the fire engineering community of the Building (Scotland) Act and supporting legislation
  - A limited awareness (and lack of consistency) of the information LAVs look for when determining if the functional standards have been satisfied
  - A lack of awareness of the services provided by Local Authority

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Outcomes of Previous Efforts

- April 2016 Workshop
  - The FE community is highly fragmented and does not speak with one voice
  - In practice, fire engineers generally check compliance against the guidance contained in TH-F. This allows them to establish where deviation(s) from the Handbook exists and identify potential approvals risk for their client
  - There can be significant delays in processing of fire engineering solutions by the LAV
  - Those that carry out the verification on behalf of local authorities need to have appropriate skills, knowledge and experience

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Scope of Work

- Establish a baseline of the current fire engineering position in Scotland.
- Identify areas of improvement for different 'actor' groups.
- Chair a workshop to discuss findings and explore possible improvements.
- Prepare a final report.

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Process

- Hold meetings and discussions with representatives of stakeholder groups
  - About 20 hours of meetings with FEs, LAVs, SFRS, architects, developers, insurance, BSD
- Summarize what I have heard in terms of what is working and what is not working so well
- Provide perspective based on work with other countries on similar topic(s)
- Provide report with findings and suggestions / options for consideration

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Sneak Peek at Preliminary Findings

- Importantly, the fire engineering and verification situation in Scotland is in pretty good shape – there are concerns and opportunities, but things are working generally well
- The types of issues are not unique – part of the growing pains of a 'new' discipline (FE) and a new regulatory approach (functional / P-B)
- The breadth and depth of change, if any, will be dependent upon what type of system Scotland wants to have going into the future
- Types of potential changes include restructuring regulations, additional guidance, qualifications requirements, peer review resources

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Situation in Other Countries

- IRCC
- Australia
- New Zealand
- Singapore

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IRCC

http://www.ircc.info/index.html

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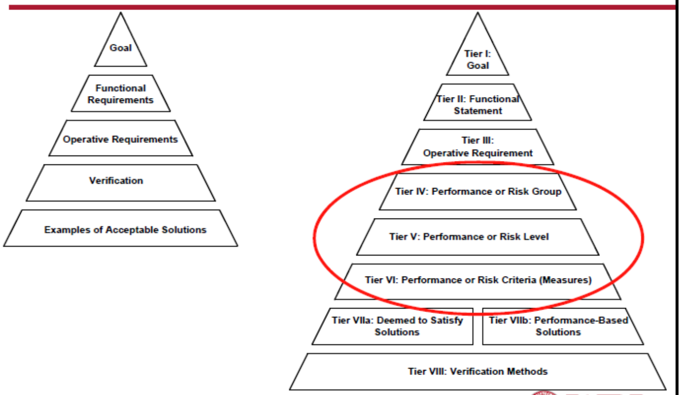
IRCC Hierarchy



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Updated Content - IRCC Hierarchy

- Recognition that quantification of performance is needed (how else determine compliance?)
- Recognition that risk might be a suitable basis for performance metrics (e.g., risk to life can include fire, structural, IAQ, etc.)
- Recognition that grouping buildings by risk or performance levels (targets) can be helpful
- Recognition to clarity in defining impacts, and expected responses (loads and resistance), and incorporating measures, is important

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Australia

- Quantification of performance
- Risk as a basis of performance
- Re-emphasizing performance
- Qualifications of engineers and reviewers
- Issues in Victoria identified with Docklands fire
- Issues arising around private certification

New Zealand

- Leaky buildings
- Response by government / quantification of performance
- Fire verification method and quantified criteria in code
- Qualification of engineers (or lack thereof)
- Canterbury earthquakes and FE concerns putting pressure on qualifications of engineers
- Increased guidance, while re-emphasizing performance

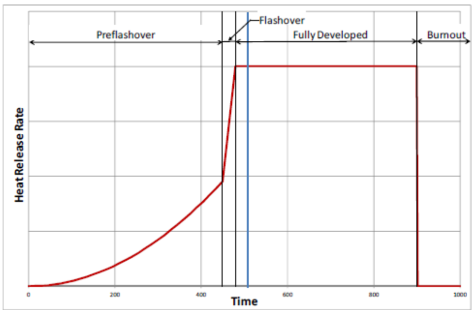
New Zealand – FSE Guidance

- New Zealand – C/VM2 Fire Compliance / Verification Method
- For use by design professional with specific fire engineering expertise, such as a Chartered Professional Engineer
- Based on Risk Groups
- 10 standard design scenarios
- Design fires specified
- Parameters affecting the movement of people specified:
  - Detector response, movement times, speed of movement

http://www.dbh.govt.nz/compliance-documents#C

New Zealand – FSE Guidance

- Design Fires



New Zealand – FSE Guidance

- Design Fires – specified parameters

Table 2.1 Pre-flashover design fire characteristics

Building use	Fire growth rate (kW)	Species	Radiative fraction	Peak rate of heat release
All buildings including storage with a stack height of less than 3m	$0.0469t^2$	$Y_{soot} = 0.07$ $Y_{CO} = 0.04$ $Y_{H_2O} = 1.0$ $Y_{CO_2} = 1.5$ $\Delta H_C = 20MJ/kg$	0.35	20MW
Carparks	$0.0117t^2$		0.35	
Storage with a stack height of between 3m and 5m above the floor	$0.188t^2$		0.35	50MW
Storage with a stack height of more than 5m above the floor	$0.00068t^3$ H		0.35	

NOTE: t = time (s) H = height of storage (m) Y = yield (kg/kg)

New Zealand – FSE Guidance

Fire Performance Criteria – **in Building Code**

Evaluated @ 2m above floor

FED (Thermal) = 0.3
FED (CO) = 0.3
Visibility = 10m
} Unsprinklered & or Occupant Load >1000p

FED (CO) = 0.3 } Sprinklered ≤1000p

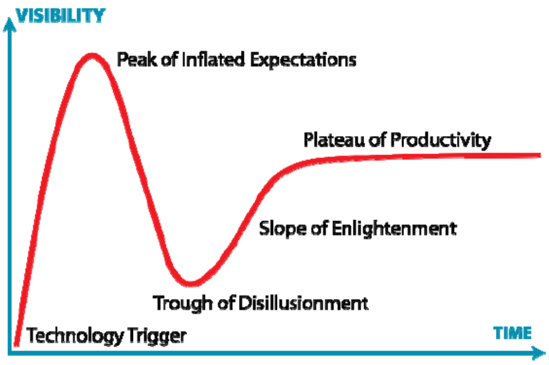
Singapore

- Singapore Fire Engineering Guidelines (SFEG)
- Part 1 – Fundamentals and general requirements
  - Fire scenarios
  - Available safe egress time
  - Acceptance criteria
  - Required safe egress time
- Marked-up drawings –Show essential fire safety provisions
- Operations and Maintenance Manual
- Peer Reviewer – Roles and responsibilities
- Registered Inspector – Roles and responsibilities

General Observations

- The situation in Scotland is generally on par with other countries, largely because both performance-based (functional) regulations, and performance-based (engineered) fire safety designs, are still developing
- We lack clear loads to test the building and criteria to assess 'acceptable' performance
- More difficult than structural engineering – people are involved, and people influence, and are influenced by, fire

The Hype Cycle



Engineering Discipline Development

- Infancy
  - Uncoordinated relationships between practice & research; needs & solutions
  - Developments reflect personal tastes, ease of solution and simple chance
  - Applications tend to be small parts of larger problems isolated and resolved without reference to a broader framework, as no framework exists

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Engineering Discipline Development

- Maturity
  - A framework exists and the capabilities and limitations are widely appreciated
  - Most practitioners have received education in the area, recognize situations in which the approach is applicable, and speak the language of the area
  - Smooth interaction between research and practice, with most research being conducted in response to obvious needs of practice

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Engineering Discipline Development

- Adolescence
  - Foundations for a framework and a viable set of solutions for some areas exists
  - Development is still largely incomplete: some topics are virtually untouched, limits of effectiveness of the parts or the whole are not well understood, some applications are rather naively formulated
  - Applications exist, but often without confidence or the wisdom of experience

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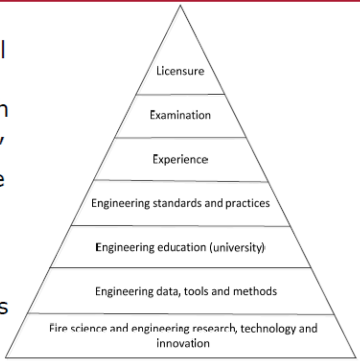
Professional Recognition

- A key objective of discipline is professional recognition
- This is achieved through education & experience, and sometimes by examination & licensure
- This is underpinned by the intellectual knowledge of the profession – research, data, tools and methods



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Situation in Scotland

- Preliminary findings
  - Fire engineering on too many 'small' deviations
  - Concern of too much 'commercial' focus
  - Resources lacking for 'significant' designs
  - Lack of clarity in regulations and guidance
  - Lack of clear guidance / process(es) for review
  - Lack of clarity in fire engineering approach(es)
  - Lack of clear means to identify competent and qualified fire engineers
  - Lack of clarity in roles and responsibilities of actors
  - Works well with good communications and respect

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Situation in Scotland

- General concerns
  - Wide range of competency in fire engineering community
  - Wide range of quality of designs / documentation
  - High degree of coming in late – choice by engineers to accept work and at what cost
  - Indication of poor attitude – overall quite competent actors – no need to label some unqualified or incompetent because they have different expertise – across all groups
  - Too much of a silo approach sometimes

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Situation in Scotland

- Regulations (**Act**, Building Standards, Guidance)

  (1) The Scottish Ministers may, for any of the purposes of

  (a) securing the health, safety, welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings,

  (b) furthering the conservation of fuel and power, and

  (c) furthering the achievement of sustainable development,

  make regulations ("building regulations") with respect to the design, construction, demolition and conversion of buildings and the provision of services, fittings and equipment in or in connection with buildings.

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Situation in Scotland

- Regulations (**Act**, Building Standards, Guidance)
  - Health and safety are (generally) clear objectives
    - Except, how are these factors measured?
  - What is meant by *welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings*?
    - Protection property for economic welfare of community?
  - What is meant by *furthering the achievement of sustainable development*?
    - It would be difficult to construe buildings which burn down and need to be replaced as sustainable development – does this mean property protection in a functional requirement?

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Situation in Scotland

- Regulations (**Act, Building Standards**, Guidance)
  - Schedule 5, Section 2, Escape 2.9: Every building must be designed and constructed in such a way that in the event of an outbreak of fire within the building, *the occupants, once alerted to the outbreak of the fire,* ***are provided with the opportunity*** *to escape from the building, before being affected by fire or smoke.*
    - Does not say everyone must escape safely
    - Does not say anything about the how many means of escape are required
    - Does not say anything about the time required for escape in the event of a fire
    - What is the performance measure (metric)?

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Situation in Scotland

- Regulations (Act, **Building Standards, Guidance**)
  - While the system is functional in word (law), it is prescriptive in practice
    - Many Local Authority Verifiers (LAVs) are using the Technical Handbook – Fire (TH-F) as the base document (guidance), and not the standards in the regulation (legally enforceable)
    - Likewise, many fire engineers are doing the same – it is not clear if this is mostly by choice, or as a reaction in order to gain approvals

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Situation in Scotland

- Regulations (Act, **Building Standards, Guidance**)
  - It is not clear that the Regulations and associated Guidance are written appropriately for the intent (i.e., functional system).
    - Not clearly stated in the Regulations that ***any solution***, which can be shown to deliver the stated functional standards, is acceptable.
      - Clearly says Technical Guidance may be written to help with practical solutions.
      - Clearly says not following Technical Guidance cannot be used against one in legal proceedings (civil or criminal).
      - *Does not **positively** say any solution is possible, and that **any valid solution must be accepted** by local authorities.*

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Situation in Scotland

- Regulations (Act, **Building Standards, Guidance**)
  - There is a need to clarify the ***requirements*** under the Building Act and Regulations versus the ***guidance***.
    - Either Technical Handbooks are required to be used, and engineered designs are deviations from the THs, or the THs are not required to be used.
      - If required, what is the process for deviation.
      - If not required, what authority do LAVs have for requiring demonstration of compliance with the provisions of the TH?
      - If not required, what is the basis of demonstrating compliance with the Regulations (i.e., criteria / metrics), and how is compliance demonstrated (i.e., process)?

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Situation in Scotland

- Regulations (Act, **Building Standards, Guidance**)
  - If a truly ***functional system*** is desired, the wording of Technical Handbook (at least Fire) may be working against the intent.
    - The TH-Fire is written is such a way that the Handbook is the solution and everything else is an alternative. This does not seem to match intent of the regulatory system, and gives rise to Local Authority Verifiers (and industry in general) interpreting the Technical Handbook as the benchmark against which everything else is compared.
    - If this is not the way the system is intended to work, this approach needs to be changed.

Situation in Scotland

- Regulations (Act, **Building Standards, Guidance**)
  - Regardless of 'functional' or 'prescriptive', need to agree basic principles
    - Is some level of risk tolerable?
    - Do you agree with single means of escape or not? If so, under what conditions? What is required to demonstrate safety of people during fire?
    - Are sprinklers reliable enough for trade-offs in design? If so, under what conditions? What types of analyses are required?
    - How will you define / measure 'acceptable' performance

Situation in Scotland

- Regulations (Act, **Building Standards, Guidance**)
- If remain 'prescriptive', a set of simplified 'agreed alternatives' might be helpful
  - If common deviations, agree and document – use consistently
  - Travel distance, egress capacity, single means of escape…
  - Follows tradition already established

Situation in Scotland

- Regulations (Act, **Building Standards, Guidance**)
- If embrace 'functional' approach, a set clear performance metrics, methods and guidance will be helpful
  - Clear set of performance metrics (tenability, structural fire performance, firefighter safety, …)
  - Clear fire engineering *process* for Scotland (BS 7974, BS 9999, IFEG, SFPE, own approach, …?)
  - Clear documentation requirements
  - Clear review process and requirements

Situation in Scotland

- Fire Engineering – Competency and Qualifications
  - Why no expectation of minimum competency and qualifications?
    - Competency and qualifications need sorted out – CEng through Engineering Council / IFireE probably a good start, but more may be helpful (like PEng in Australia, NZ, Singapore, USA…).
    - Society of Fire Protection Engineers (SFPE) looking at international competency / qualifications issue
    - Does not have to be regulated, per se, but should consider being more robust than CEng alone

Situation in Scotland

- Fire Engineering – Competency and Qualifications
  - If not addressed within sector, government intervention should be considered (e.g., licencing / registration)
  - Big issues include:
    - level of competency expected,
    - what this includes,
    - who determines,
    - are university degrees needed as basis,
    - is CPD required,
    - who 'vets' competency

Situation in Scotland

- Fire Engineering – Process
  - Fire engineers inconsistent with designs – it is recognized that each design is individual, but process is not
  - Many follow generally BS 7974 – but fail to come through with specified details, such as QDR, agreed objectives, criteria, scenarios, fires, methods of evaluation, etc.
  - Not enough sensitivity analyses / robustness checks or assessment of impact on firefighter operations

Situation in Scotland

- Fire Engineering – Process
  - Inconsistent benchmarking for comparative analysis
  - Inconsistent use of acceptance criteria
  - Reports vary widely in content and depth
  - Operations and Maintenance Manual (OMM) should be required for fire engineered buildings – scope of design, bounding conditions, limitations, testing requirements, …

Situation in Scotland

- Fire Engineering – Process
  - An overall key to success is more and better communication – early and often
    - QDR at concept stage – get all involved and do what is required
    - Agree – and keep to agreements (design and review)
    - Share information – work together – outcome better with all inputs
    - Be transparent with data, assumptions, limitations, …

Situation in Scotland

- Fire Engineering – Process
  - Once sort out what level of 'variation' needs 'fire engineering' design, establish guidance appropriately
    - Small projects likely need minimal documentation
    - Significant projects need robust documentation
      - QDR: qualifications of engineers, scope of project, project objectives, basis of evaluation, criteria, scenarios, fires, methods of evaluation to be used, etc.
      - Agreement of all actors on QDR
      - Full report: summary of above (no need to restate agreed documents), analysis, data, references, drawings, etc., as needed to demonstrate compliance
      - Operators and Maintenance Manual

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Situation in Scotland

- Fire Engineering – Process
  - Specific, detailed design guidance may be helpful (like New Zealand C/VM2) for 'typical' engineered designs
    - Specify scenarios, fires, criteria, methods of evaluation, modelling parameters, pre-evacuation time, etc.
    - Clear approach for engineers and reviewers
    - May be much more detail than currently provided, but aims to increase confidence in analysis

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Situation in Scotland

- Review of Fire Engineered Designs – LAVs
  - Large variation in levels of fire engineering expertise on staff
  - Large variation in review processes
  - Large variation in approach to fire engineered designs (e.g., benchmark against TH to accept engineering from first principles)
  - Wide variation in how Scottish Fire and Rescue Service (SFRS) is used / consulted (when, for what, how often, how feedback used)
  - Wide variation in peer review (use, personnel)

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Situation in Scotland

- Review of Fire Engineered Designs – LAVs
  - No indication that LAVs are not competent in their areas of expertise, and generally very well aware of limitations (when exist) in fire engineering and when peer-review helpful
  - National consistency in review process would be helpful (what is expected, how review conducted, who will be involved, …)
  - A 'central' resource for peer-review of fire engineered designs could be helpful for some (independent of project)
  - More consistent approach by engineers will help

Situation in Scotland

- Review of Fire Engineered Designs – LAVs
  - It is not clear why national consistency is not possible. A key issue to helping get consistency is whether the Technical Handbook is the basis for review, or not, and if so, how used, and if not, how addressed
  - Another key issue is role of SFRS – when involved, for what, how feedback used
  - I suggest use of QDR, and getting agreement early on by all, helps facilitate good projects

Situation in Scotland

- Review of Fire Engineered Designs – LAVs
  - Perhaps something like *SFPE Code Official's Guide to the Review of Performance-Based Fire Protection Designs* or similar would be helpful.
  - Can start with simple flow chart… does not have to be in-depth document (is a process)
  - Having it uniform across all LAVs is desirable
  - Can help foster consistency of approach and methodology by fire engineers (if they all know what is sought, approaches become more consistent)

Situation in Scotland

- Role of Scottish Fire and Rescue Service
  - Concern voiced that the role and responsibility of SFRS needs to be clarified and addressed
  - By Act and Regulation, SFRS have consultative role in building approval – what does this mean?
  - What is the appropriate time(s) for SFRS input? (I would argue early, at the QDR stage, to get all stakeholder issues on the table.)
  - Recent structure with fire engineering group helpful in gaining consistency
  - What are implications of not having SFRS concurrence?

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Summary

- Situation not dire, but choices to be made
  - Prescriptive or Functional? Address Act, Regulations and Guidance accordingly
  - If Prescriptive, sets of simplified guidance for small / common variation, more guidance on design, more guidance on review
  - If functional, clear set of performance metric, determine how safety determined, clearer engineering processes, support for review including peer review panel
  - Sort out roles and responsibilities of actors
  - More communication, transparency, ethics, respect

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Thank you for your participation in meetings over the past 2 weeks and for your participation today.

Questions? Comments? Discussion

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