Development of the IAFSS Agenda 2030 for a Fire Safe World

By: Brian Meacham

The world is facing enormous challenges in terms of increasing and diversifying population, climate change and associated impacts, and lack of natural, technological and financial resources. Concurrently, technology is rapidly advancing, cities are growing larger and denser, the population is aging and becoming more diverse, and risk control systems are not keeping pace. These challenges are recognized by countries around the world, across all levels of income, with varying capacity to address them.

To make matters worse, often missing in many discussions around such societal grand challenges – and how to address them – is the impact of unwanted fire on health, safety, climate, community resilience and the economy, and the benefits to be gained through fire mitigation. As the world has witnessed over the past few years with the increasing frequency and severity of wildland fire, expansive losses associated with informal or improper construction in low- and middle-income countries, and devastating consequences of inadequate fire safety features in high-rise buildings, fire cannot and should not be ignored.

As a means to raise the awareness about the relationship between fire and the grand societal challenges, to show that there are people who can help, and to provide a roadmap for addressing some of the key challenges, the International Association for Fire Safety Science (IAFSS) decided that the fire safety science and engineering community needed to become more proactive in communicating with policy makers about the challenges that exist and the opportunities to address them. The IAFSS (www.iafss.org) is an association of scientists, engineers and others, from some 40 countries, focused on advancing fire safety through research and education. For more than 30 years, the IAFSS has played a significant role in facilitating fire safety science research, education, dialogue and exchange between fire safety scientists, engineers, governments and the public worldwide.

To get the ball rolling around the topic of grand challenges and fire, in early 2018, IAFSS Committee members Margaret McNamee (Lund University, Sweden) and Brian Meacham (Meacham Associates, USA) began planning a workshop, IAFSS Agenda 2030 for a Fire Safe World, to be held in September 2018 in conjunction with the 3rd European Symposium on Fire Safety Science, Nancy, France. To seed thinking, a ‘white paper’ was drafted and circulated. A great deal of positive feedback was obtained, with Birgitte Messerschmidt (NFPA, USA) and Professor George Boustras (Centre for Risk and Decision Sciences, European University, Cyprus) joined the planning team, greatly assisting in the advancement of the paper,
development of the workshop, and communicating with members of the Joint Research Centre (JRC) of the European Commission and more.

Following a successful workshop in Nancy, the white paper was updated, and a similar socialization of the document and outreach for feedback and enhancement was conducted in association with the 11th Asia-Oceania Symposium on Fire Science and Technology (11th AOSFST) held in Taipei in October 2018. In addition, a request was made to IAFSS that they, along with ISO TC 92 (Fire Safety), and with the support of numerous sponsors, hold a Workshop to Define a Fire Safety Mission for Europe based on the IAFSS Agenda 2030 for a Fire Safe World. Hosted at the CEN/CENELEC facility in Brussels on 3 December 2018, this workshop drew some 100 attendees from across the sector, as well as representatives from the European Commission (DG GROW, DG Research), and resulted in enhancements to the IAFSS Agenda as well as to form material to support a proposal to the European Commission for a Fire Safety Mission for Europe.

Throughout the process, the full IAFSS membership was invited to comment on evolving versions of the paper, and to provide input to the interim versions of the document, in support of the development of a global view. As a result of the numerous workshops and global socialization of the paper, it was agreed that the societal grand challenges where fire safety science and engineering research can most significantly contribute in the near term are (1) climate change, resiliency and sustainability, and (2) population growth, urbanization and globalization. In addition, it was agreed that the ability to harness new technology, e.g. artificial intelligence and big data, and activities related to advancing, enhancing, and expanding higher education are cross-cutting areas that are essential to solve many of the activities associated with the two grand challenges.

In early 2019, the IAFSS Agenda 2030 for a Fire Safe World was completed and published in Fire Safety Journal, where it is freely available through open access for all to read and share (https://www.sciencedirect.com/science/article/pii/S0379711219303509). The paper discusses in more detail the grand societal challenges for which fire safety science and engineering can help, the fields of action within the disciplines where pertinent expertise can be found, and research topics that can be addressed. These are summarized in the table below.

<table>
<thead>
<tr>
<th>Societal Grand Challenge</th>
<th>Fire Science and Engineering Fields of Research and Action</th>
<th>Research Activities</th>
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<tbody>
<tr>
<td>Climate Change, Resilience and Sustainability</td>
<td>Wildland Fires and Wildland-Urban Interface</td>
<td>• Fundamentals of Wildland Fire Ignition and Spread, • Understanding and Management of Wildland-Urban Interface, • Wildfire Resilient Buildings, Human Behavior in Wildland Fire, • Wildfire Control, Suppression, • Wildfire Incident Management</td>
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<tr>
<td>Societal Resilience</td>
<td></td>
<td>• Resilience of buildings, communities and society • Incident Management • Risk for cascading/escalating incidents</td>
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<tr>
<td>Fire Safety and Sustainability</td>
<td></td>
<td>• Low Environmental Impact Fire Safe Materials • Fire Safe Energy Storage / Energy Saving Materials • Environmental Impact of Fire • Economic impact of fire including cost of fire protection, savings due to fire service and indirect losses from fires • Toxicity of Materials to Environment</td>
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The IAFSS understands that tackling these challenges requires a multi-disciplinary and global effort, and calls fire scientists and engineers around the world to open necessary dialogue in their regions and beyond to make regulators, funding agencies and fellow scientists and engineers aware of what needs to be done to move towards a fire safe world 2030 and beyond.

The IAFSS understands and appreciates that the fire safety research and engineering community cannot live on its own island – it must be integrated with other disciplines, and with society, to make the impact that is needed. We need the help of others to help us break out of our silos and embrace a much wider understanding of societal needs, and of the role of fire safety science and engineering on building and infrastructure design, construction, and management. It is also clear that fire safety challenges will change and develop over time. Thus, the IAFSS Agenda 2030 for a Fire Safe World represents a snapshot, highlighting important topics. Updated position papers should be developed in the future to keep abreast new emerging challenges. The IAFSS will continue to work to raise awareness, foster multidisciplinary collaboration, develop new models, methods, data and education in support of this vision. We invite all who are willing to partner with us to contact the Association (www.iafss.org) and support the IAFSS Agenda 2030 for a Fire Safe World.

Acknowledgements

Sincere appreciation is given to Margaret McNamee for leading the effort, to Birgitte Messerschmidt and Professor George Boustras for their valuable contributions associated with
early drafts and workshops, to the IAFSS Committee members for their input and support, and to the IAFSS members and others whose contributions through feedback on drafts, discussions during workshops, and related avenues resulted in a global perspective on the document.
Defining Performance-Based Design

By: Greg Baker, Fire Research Group Limited, New Zealand

1. Introduction

The following article is the first in a series of articles that summarise a presentation entitled *The Contribution of the RTM to the Global Advancement of Performance-Based Design*, given by the author at the recent SFPE 2020 Performance-Based Conference & Expo, which was held in Auckland, New Zealand from 11 to 13 March 2020.

While the conference presentation as a whole focused on the broader role of the SFPE’s *Standing Committee for Research, Tools and Methods* (the so-called ‘RTM’) in advancing the implementation of performance-based design (PBD) internationally, this summary article from the presentation specifically deals with the author’s views on what qualifies as being defined as PBD.

The context for this article is a new SFPE committee which has recently been formed to develop a new SFPE standard on PBD. One of the first activities for this new committee has been to form a collective view of how to define PBD.

For clarity it should be noted that the views expressed in this article (and the original conference presentation) are those of the author alone and do not represent the formal view of the above-mentioned committee, or the SFPE as a whole.

2. Definition of Performance-Based Design

Although current performance-based design (PBD) in the field of fire safety engineering has been in existence for more than two decades in some countries, there still appears to be a lack of clarity about what PBD actually is in different parts of the world.

It is possible to speculate that this is partly due to significant differences in the building regulatory environment in different jurisdictions, which in turn has a significant impact on what constitutes standard industry practice in a particular jurisdiction.

The following definition is one possible way of defining what PBD is, in the context of performance-based fire safety engineering, namely:
PBD methods are **alternative, risk-informed** methodologies used to demonstrate compliance with fire safety objectives.

The author acknowledges that this definition for PBD is consciously narrow and specific while different stakeholders will often have broader goals and objectives.

### 3. Alternative Design Methods

As noted in the definition above, emphasis is placed on two terms - ‘alternative’ and ‘risk-informed’.

**What is meant in the stated definition by ‘alternative’ design methods?**

The New Zealand building regulator currently provides two prescriptive, deemed-to-comply design documents which can be used by fire safety designers to demonstrate compliance of a building design with the protection from fire clauses of the New Zealand Building Code (NZBC). Such prescriptive compliance documents are called ‘acceptable solutions’ in New Zealand, with the major one being C/AS2 [1].

If a designer designs a building to comply with the provisions of this particular acceptable solution, C/AS2, then the design as a whole is deemed to comply with the fire safety clauses of the NZBC (the ‘protection from fire’ clauses C1 to C6).

**Under the stated definition, for a design method to qualify as being a performance-based design method, it must be an ‘alternative’ method to prescriptive methods such as C/AS2 in New Zealand.**

**In relation to prescriptive design methods**, an important reason for alternative methods being needed is that most prescriptive design methods have limitations in their scope of application, beyond which the document cannot be used.

A common example of a limitation in the scope of application of prescriptive design methods is the height of the building being designed.

**Figure 1 shows an extract from C/AS2, where paragraph 1.1.2.e) stipulates that “buildings more than 20 storeys high” are outside the scope of the acceptable solution.**

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1 The term ‘design method’ as used in this article is a consciously broad interpretation. It could be argued that a prescriptive design solution is not actually a ‘design method’ when the design process consists of verifying compliance with a prescriptive code/standard.
While the New Zealand prescriptive design method C/AS2 is an obvious example of a design method that does not fit the stated definition, perhaps not quite so obvious as to what is an alternative design method is the New Zealand verification method, C/VM2 [2].

Again, as with C/AS2, C/VM2 is also not a performance-based design method in relation to the stated definition because it is also not an ‘alternative’ method. C/VM2 is still a deemed-to-comply design method in terms of compliance with the NZBC clauses C1 to C6.

For clarity, ‘alternative’ in terms of the stated definition does not equate to a range of choices of design methods, rather it means an ‘alternative’ to those specific methods that are stipulated by the building regulator or authority having jurisdiction (AHJ) as being deemed-to-comply with the fire safety code.

As with C/AS2, C/VM2 in turn has its own limitations of scope of application. As shown in Figure 2, C/VM2 has the same (albeit worded slightly differently) building-height limitation to that in C/AS2, namely a threshold of 20-storey buildings.

**Figure 1. Extract from C/AS2 – Scope of application limitations [1].**

Outside the scope of this Acceptable Solution

1.1.2 Buildings with complex features are outside the scope of this Acceptable Solution. Complex features include:

- a) Atriums, and
- b) Intermediate floors, other than limited area Intermediate floors, and
- c) Operating theatres, intensive care units, hyperbaric chambers, delivery rooms, and recovery rooms (SI), and
- d) Recreation and event centres (with tiered seating for more than 2000 people) (CA), and
- e) Buildings more than 20 storeys high, and
- f) Prison buildings.

Buildings that have features for which solutions are not provided within this Acceptable Solution are also deemed to be complex.
In effect, the New Zealand prescriptive design method of C/AS2 and the fire engineering design methods of C/VM2 cannot be used to confirm the compliance of buildings of more than 20 storeys in height. Instead, what is called an ‘alternative solution’ in New Zealand, i.e., an ‘alternative’ design method, must be used to design the building in question, which now fits within the stated definition for PBD.

One of the implicit reasons that prescribed design methods (in the case of this example, C/AS2 and C/VM2) place limitations on their scope of application is related to risk.

Both the acceptable solution design method, C/AS2, and the verification method design framework, C/VM2, have an inherent level of fire safety risk that the New Zealand building regulator has deemed to be acceptable on behalf of New Zealand society as a whole.

Accepting the principle that the higher the building the higher the level of fire safety risk, if a designer were to apply the C/AS2 or C/VM2 design methods to the design of a building of more than 20-storeys, the designer would be exceeding the tolerable risk threshold implicit in both documents. Specifically, if a designer used C/VM2, for example, to design a 50-storey building, the design would most likely be exposing subsequent building occupants to a higher
level of risk and delivering a lower level of fire safety, relative to the risk/safety of using the
document to design a 20-storey building.

4. Risk-Informed Design Methods

What is meant in the stated definition by ‘risk-informed’ design methods?

In essence, the term ‘risk-informed’ is referring to ‘probabilistic’ design methods.

It is important to differentiate between ‘deterministic’ (or ‘non-probabilistic’) and
‘probabilistic’ design methods, or more accurately, design methods that incorporate
‘deterministic’ or ‘probabilistic’ analysis methods.

The difference between ‘deterministic’ and ‘probabilistic’ analysis methods can be
represented by the mathematical relationships, shown as Eqn. 1 and Eqn. 2.

\[
\text{Deterministic Analysis} \quad f(A, B) = C \quad \text{Eqn. 1}
\]

\[
\text{Probabilistic Analysis} \quad f(p(A), p(B)) = p(C) \quad \text{Eqn. 2}
\]

In the context of a simplified engineering analysis depicted by Eqn. 1 and Eqn. 2,
‘deterministic’ analysis consists of a single value for the two exemplar input parameters, \( A \) and \( B \), resulting in a single value for the output parameter, \( C \), from the application of the
mathematical function, \( f \).

The ‘probabilistic’ analysis equivalent involves a probabilistic (or statistical) representation
for the two input parameters, \( A \) and \( B \), resulting in a probabilistic representation for the
output parameter, \( C \), from the application of the same mathematical function, \( f \).

5. Summary - Key Message

In providing a definition for PBD, and expanding on what is meant by the two definitional
criteria of ‘alternative’ and ‘risk-informed’ design methods, the key message in this article is
that detailed quantitative risk analysis (often termed ‘quantitative risk analysis’ or QRA) is at
the core of true PBD. In other words, for the design method to be regarded as a performance-
based design method, the analysis component of the design method must be probabilistic in
nature.

A widespread issue in the practice of PBD is that some form of qualitative or semi-
quantitative risk analysis is applied to the design in question, and it is either stated by the
designer or implied that the design is a performance-based design.

For example, so-called PBD where the designer as part of the analysis nominates a high
percentage reliability figure for a sprinkler system, and on that basis concludes that the design
complies with the requirement of the building code, is not actually PBD. To qualify against
the stated definition, a detailed QRA would need to be performed. The high percentage
sprinkler system reliability figure used by the designer, is typically an upper bound of what is
actually a probabilistic distribution of the reliability which in fact has a wide range of
possible values.
REFERENCES


A Survey on Evacuation Model Awareness, Usage and Users

By: Enrico Ronchi, Department of Fire Safety Engineering, Lund University, Sweden
Ruggiero Lovreglio, School of Built Environment, Massey University, Auckland, New Zealand
Michael Kinsey, Arup Shanghai, Shanghai, China

Evacuation models can be used in fire safety engineering as part of a performance-based design approach. To date, over 70 evacuation models are available, including a great variability in simulation approaches and features. A potential model user can find it difficult to know what are the most known and used models for fire safety engineering applications. Similarly, model developers may not be aware of the most important features which users value in evacuation models. To address these issues, an online survey was conducted to investigate evacuation modelling users’ experiences and needs. The survey consisted of 22 questions focusing on different aspects related to evacuation models and the community of their users. This survey was an expanded version of an earlier survey conducted by the Ronchi and Kinsey in 2011 [1], thus allowing a comparison between the current evacuation modelling market with the situation of approximately 10 years ago.

Who Are the Users of Evacuation Models and How Are They Used?

The survey was completed by 234 respondents from 41 countries. The respondents have a wide range of education and occupational backgrounds and use models for a variety of different purposes. Most of the sample is made of respondents with an engineering and fire engineering background. A quarter of the sample works in academia while the remainder works in industry or other fire safety-related areas. The most frequent uses of evacuation models include fire safety design for building and transportation infrastructure, research, emergency management and forensic investigations.

The types of building/infrastructure and the context in which evacuation models are used by the respondents are presented in Figure 1. The most common building types for which evacuation models were adopted/used were train/metro stations, shopping malls, and arenas/stadia. This is unsurprising considering train/metro stations present a significant challenge for egress, possibly including the need for ascending evacuation [2]. Similarly, shopping malls and arenas/stadia may host large crowds which can be challenging to manage from an evacuation perspective. The results show that the main use of evacuation models relate to building compliance with codes/standards and aid in the design of new structures. Only 21% of respondents declared they use BIM in conjunction with evacuation models.
Regarding the years of experience with evacuation models, almost 60% of the sample has between zero to five years of experience with evacuation models, thus indicating that there is a significant portion of users with a limited experience in model use. This result is overall consistent with the 2011 survey. Respondents were also asked to report the frequency of usage of evacuation models. The results show that most people do not use them on a daily or weekly basis, but rather monthly or yearly. With such infrequent usage, this may cause evacuation modelling knowledge/skill atrophy which could result in increased time required to conduct modelling assessments and increased the likelihood of mistakes being made. Regarding the type of training, most users (72%) have been teaching themselves how to use an evacuation model rather than taking part in a formally taught course.

The respondents were asked the most important factors while selecting a pedestrian evacuation model. Those are namely 1) verification and validation, 2) documentation, and 3) data output of the model. This result is consistent with the 2011 survey and it indicates that users clearly value the reliability of the data obtained by an evacuation model as one of the primary reasons for selecting a model. It is evident that several pedestrian evacuation model developers consider these factors as very important as models are often accompanied by dedicated validation and verification documentation or papers presenting results of validation case studies.

What Are the Most Known and Used Evacuation Models?

A total of 72 evacuation models were known to the whole respondent sample. These results are based on a list of evacuation models which was provided to the respondent, along with the possibility to add models which were not mentioned in the list. Figure 2 shows the percentage of respondents who are aware of different models (the total sum of the percentage is higher than 100% as respondents had the chance to indicate they were aware of more than one model).
Regarding model usage, the survey results suggest that despite the large number of models available (over 70 models), a limited number of models appear to be the most used. The top three most used models were Pathfinder (35%), STEPS (9%), and MassMotion (9%). Amongst the survey respondents, 23% reported that they have changed the evacuation model they use in the past.

**Conclusion**

An online survey was conducted to investigate evacuation model awareness, usage, and users. The results indicate that despite the large number of models available (over 70 models), a limited number of models seems to be the most used only 12 models used by at least 1% of the sample. Based on the sample of the survey respondents, it appears evident that evacuation models seem to be mostly used by inexpert and non-regular users. The main usage of evacuation models relates to buildings and infrastructures which present challenges from an evacuation perspective (particularly in terms of the large crowds they may host). Participants of the survey ranked the most important factors for selecting a model as being the reliability of the results obtained and the documentation explaining the model.

This paper is a short version of a manuscript which has been published in the Fire Technology journal. Further information about the survey can be found in the full article associated with this work [3].

**References**


Comments on - On Some Issues with the Fire Resistance Testing

By: Ulf Wickström, FSFPE, Luleå University of Technology and TASEF Ltd, Sweden

In the Q3 2019 issue of SFPE Europe Magazine Węgrzyński, Turkowski and Roszkowski criticized the fire resistance furnace test standard and concludes that the ‘disregard of the energy balance in fire testing seems to be a design flaw of the method, originating from the limited knowledge related to heat transfer in the time of the first tests’. To be frank, I do not agree. The standard furnace test is one of the most ‘reliable’ we have in FSE. It is one of the very few methods where we can predict the test results by calculations based on physical material properties.

When analysing a test, we may consider accuracy, verification and validation.

By **accuracy** I mean how well can we generate test conditions. In this case I limit myself to thermal exposure conditions. The standard prescribes a furnace time-temperature curve as measured with plate thermometers. The standard requires that this curve must be followed within a few percent, except for the first few minutes. The fire laboratories have usually no problems doing that.

By **verification** I mean how relevant is the measured PT temperature for the temperature development in fire exposed structures. That issue was addressed when PT was introduced about 30 years ago by testing a very well-defined test specimen and measure its temperature when exposed to furnace conditions controlled by PT measurements. Thus, a so-called calibration element was designed and tested in several European furnaces. The conclusion that exercise was that if furnaces are run according to the standard and controlled by PT measurements, the calibration elements obtained the same temperatures. Shortly thereafter PTs were introduced in both the ISO and the corresponding CEN furnace test standards.

By **validation** I mean how relevant is the standard curve for real fires. Here we must rely on basic compartment fire theory. For details see e.g. ref. [1]. If we are considering structural fire resistance, we think about fully developed fires. Such fires are ventilation controlled, i.e. the heat released in the compartment is limited by the amount of air/oxygen entering the compartment. Additional fuel will not burn inside the compartment in will therefore not contribute to any temperature increase. The fire temperature will increase with time as the surrounding structures heat up and will eventually, if the fuel load is large enough, reach temperature in the order of
1300°C to 1400°C depending on burning efficiency. The rate of fire temperature increase depends on the ratio between the opening factor and the thermal inertia of the surrounding structures, cf. parametric fire curves in Eurocode EN 1991-1-2, Annex 1. For a certain value of this ratio (according to Eurocode a gamma factor equal unity) the theoretical fire temperature curve is almost identical to the standard fire curve. That implies that the standard curve has a good bases in theory but only for gamma equal unity. For other values it is possible to obtain other design fires according to Eurocode. Thus, according to the theory, the amount of fuel, i.e. the fuel load, does not influence the rate of temperature increase but only the fire duration. You may argue that a fully developed fire in a compartment lined with e.g. wood panels will be much hotter than a compartment lined with non-combustible concrete. Yes, that is true, but not because the wood burns but because the thermal inertia of wood is much lower than that of concrete. If we replace the wood with e.g. mineral wool, we might get an even considerably hotter fire although the mineral wool does not contribute to the combustion. In summary, for a given compartment additional fuel will not increase the fire temperature for fully developed fires. However, it will increase the fire duration and the risks of fire spread due to unburnt fuel being released by flames out through openings. In addition, the likelihood of a fully developed compartment fire to occur will increase if the surrounding structures are made of combustibles like wood panels rather than of non-combustibles like gypsum boards.

Of course, a single fire curve could not represent all fires. But in a similar way, no fire test method can represent all fire scenarios. The question is then can we improve the test and design conditions.

Yes, we can by considering the openings and properties of the compartment in question as suggested by the parametric fire curves of Eurocode or by applying methods as presented by Byström and Wickström and in ref. [1], or other more advanced methods like CFD calculations. But can we afford doing that more often, and do we have enough competence in the FSE community to make the analyses needed without depending of classifications based on the standard curve?

References

Algorithms and the Black Box Problem

By: Edmund Ang

“It’s all in the algorithm” - a common and popular phrase used when discussing technologies making key decisions. Many know an algorithm is deployed in software services such as search engines, intelligent assistants, and others. What is not obvious, is that increasingly an algorithm is deployed in safety critical equipment, e.g. an intruder detection system, multi-criteria smoke detectors and video fire detection system.

These smart technologies rely on algorithms to reduce false positive, e.g. spurious fire alarm due to dust, and false negative, i.e. not identifying a real incident. For example, most modern aspirating smoke detection system relies on an algorithm to process the signals from the LED and infrared sensors to determine a real or spurious alarm.

Whilst I am excited by the possibilities pairing algorithms with advanced hardware technologies; I am concerned these are becoming a black box to end-users, and their creators. My first concern is the increasing complexities. Using the aspirating detection system as an example, although the decision-making process to differentiate a true or false alarm appears straightforward, the reality is anything but. The system needs to be sufficiently robust to differentiate this in many environment under different scenarios. If machine learning based algorithm is used in the future, this will exponentially increase the complexities, and no one will fully understand the cause and effect of a scenario because of the evolving nature of machine learning. Case in point in another industry is the financial market’s flash crashes over the last few years attributed to the deployment of trading algorithms in high speed trading.

Secondly, there is no standardized testing method. Currently, each manufacturer maintains their own proprietary design, and there is no one standardized testing method for the robustness of the algorithm in dealing with various scenarios and edge cases. Therefore, there is no consistency in the expectation on the performance of such systems. Thirdly, the algorithms are mainly closed sourced. Acknowledging the need to maintain a company’s intellectual properties, most of the algorithms paired with the hardware technologies are proprietary or hidden. This means only the owners with access to the source code have a reasonable chance in understanding and stress testing the algorithm.

If the current situation is left unchecked, soon we will end up with the black box problem where no one fully understands the technology at hand; and we can only trust, albeit blindly with no verifiable assurance the system is sufficiently robust where a catastrophic failure like those seen in other industries will not occur.
That said, at this juncture, compared to other industries, the use of algorithm in fire safety critical technologies is still primitive. This is precisely the opportunity for the fire industry to set a strong foundation to ensure we have a full understanding and control over the algorithm we deploy today, and in the future.

I have two humble suggestions. Firstly, we need to adopt an open source mindset. Acknowledging the necessity to protect intellectual properties, this mindset can still be instilled when products are developed. At this point of development, it is still possible to open the algorithm deployed in safety critical technologies in sufficient details to ensure the wider engineering and research community can help examine and stress test these algorithms. Whilst a manufacturer can test the general cases, it is impossible to identify all the edge cases for these algorithms. Secondly, we need to develop an industry agreed testing and algorithm disclosure method to provide a level playing field to the manufacturers. The fire industry, in collaboration with the testing laboratories and standards setting body need to develop a testing method for safety critical technologies where an algorithm is a crucial part in ensuring the functionality of the system. This is to ensure there is consistency in the expectation on the performance of such systems. Further, the industry must collectively agree on a standardized algorithm disclosure method to ensure professionals utilising such systems can understand the decision-making process of the algorithms.

I appreciate the effort required to implement the suggestions above are enormous. Nonetheless, I fully believe if we all come together, the collective intelligence of the fire industry will prevail.

Edmund Ang  
Fire & Risk Engineer, and PhD Researcher at Hazelab Imperial College London

By: Daniel Brandon, RISE

This article summarizes the work on engineering methods for structural assessment of Cross Laminated Timber (CLT) members with design fires. These methods involve the prevention of phenomena leading to sudden exposure of protected timber material to the fire, such as gypsum failure and delamination of CLT. For full report see [1]. This work is part of a larger project with the goal to quantify the contribution of Cross Laminated Timber (CLT) building elements (wall and/or floor-ceiling assemblies) in compartment fires. [2]

A previous gap analysis [3] identified the need to evaluate the contribution of mass timber elements to room/compartment fires with the types of structural systems that are expected to be found in tall buildings (e.g. CLT, etc.). Subsequent research has shown that timber elements contribute to the fuel load in buildings, can increase the initial fire growth rate and possibly lead to sustained fires that do not burn out, because of failure of the base layer of gypsum boards, delamination of CLT lamellas or due to an excess of unprotected timber.

If it cannot be assumed that the fire brigade or sprinkler activation will suppress a fire, it may be necessary to design for burn-out without successful fire suppression. For this, engineering methods to limit the impact of gypsum failure, delamination and an excess of exposed timber are needed. Additionally, a method for structural design for CLT structures considering natural fires is needed to avoid collapse during the full duration of a fire. Engineering methods for predicting the structural damage and assessing gypsum board fall-off are presented in the full report [1]. Both methods were based on parametric fires, which were modified to take the contribution of timber to the fire into account. The use of parametric fires is only suitable if the compartment dimensions are limited (with floor areas up to 500m² according to EN1991-1-2, 2002) and if delamination of CLT and failure of the gypsum protection is avoided. A possible method to prevent delamination involves the use of non-delaminating adhesives, which can be identified with furnace fire tests according to [4].

As can be seen from Figure 1 the method results in conservative predictions of the char depth if delamination and gypsum fall-off are avoided.
The method proposed to predict gypsum fall-off successfully predicted the fall-off of the exposed layer of gypsum from the ceiling of all compartments of the analysis as shown in Figure 2. It should be noted that this was only validated with tests in which more than one layer of fire protective gypsum board was applied. Concerning prediction of fall-off of the second layer, the method correctly predicted gypsum board fall-off for compartments with medium to high opening factors. Predictions of fall-off for compartments with opening factors equal to or lower than 0.04m$^{1/2}$ were more conservative.

A method to avoid heat delamination of CLT involves the use of non-delaminating adhesives. Some of these adhesives were identified by Janssens [5] and Brandon and Dagenais [4].

It should be noted that delamination and fall-off of the base layer of gypsum boards do not necessarily lead to a secondary flashover in the late stages of a fire. However, the model presented in this work is not equipped to consider the effects of delamination or fall-off of the base layer. The approach taken is conservative as it does not allow delamination and fall-off of the base layer during the whole fire, but may be extended to consider the effects of delamination or fall-off of the base layer at a late stage of the fire in future studies.
Figure 2. Time from flashover to gypsum fall-off (only fall-off in the fully developed phase is considered)

References


