Fire Safety Verification Method – The Australia Research Experience

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ABSTRACT

A methodology described as a Verification Method (VM) has been proposed in Australia as one way of evaluating the level of fire safety of a building design. It has been based on a similar VM developed in New Zealand, and has been issued by the Australian Building Codes Board (ABCB) for public comment with the possibility of adoption into the National Construction Code (NCC) in 2019.

As part of the VM development, a consortium of fire safety engineers and academics were invited to undertake some detailed research into calibration of eight different buildings using the proposed VM. In addition the researchers were asked to evaluate the buildings using quantitative risk assessment to determine the building risk levels against some risk tolerance criteria established by ABCB.

The research showed that none of the 8 buildings met the VM requirements, despite all complying with the NCC prescriptive building code requirements. All buildings as designed also had risk levels in excess of the ABCB risk tolerance criteria.

A Summary Report compiled by the research consortium was issued by ABCB as part of the Public Comment consultation process, and it shows that there would be some considerable uncertainties in using such a VM at this time for regulation of fire safety of buildings in Australia, not only for more complex buildings but even simpler retail, aged care and residential buildings.

The Summary Report suggests that more fire science and engineering research is required before such a VM can be fully adopted across Australia, and that in the interim, more concentration should be given to updating fire engineering guidance and strong attention be given to professional competence, education and accreditation of fire safety engineers.

KEYWORDS
Performance based design, fire safety engineering, risk assessment, verification method, fire modeling, fire statistics, competence, education, accreditation, regulatory system
INTRODUCTION

The cladding fires at the Lacrosse Building in Melbourne in 2015 [1], the Grenfell Building in 2017 [2], and many other external wall fires in high rise buildings around the world had created a degree of momentum in the examination of good practice of fire safety engineering and building design across Australia.

These events have led to many government inquiries, such as the Hackitt Inquiry [3] in the UK, the Victorian Cladding Taskforce [4], and the Shergold-Weir Inquiry for the Building Ministers’ Forum (BMF) [5] in Australia. All are looking at the fire safety failures and questioning the whole building regulatory system as well as the competency, education and accreditation of fire safety engineers, and the adequacy of the science and engineering on which they base their designs. This situation is a major example of where research on regulatory policy, science and engineering need to come together to address some very significant community concerns.

Into the midst of this great state of flux, major issues are being raised about the ability of fire safety engineers to evaluate or quantify the level of fire safety afforded by a particular building design, and how such levels of safety can be verified to ensure community safety objectives are met. This applies not only to buildings designed using the prescriptive Deemed-To-Satisfy (DTS) provisions, but also those based on performance based design, typically using a combination of DTS provisions and so called “Performance Solutions” or “Alternative Solutions” in the Australian National Construction Code (NCC).[6]

The Australian Building Codes Board (ABCB), which is responsible for the development of the NCC at the national or Commonwealth Government level, has a long term goal of using quantitative risk assessment and risk based acceptance criteria based on individual and societal risk using F-N curves to regulate all 17 hazards in the NCC, including for fire safety. It is part of their strategy to “measure” or “quantify” levels of safety in buildings and at the same time provide the more design freedom and encouragement of greater use of performance based building design in Australia, including the use of innovative materials and systems.

VERIFICATION METHOD FOR FIRE SAFETY

In the short term, ABCB decided that a key part of the way to start to “quantify” fire safety, and improve performance based design and building safety, was to adopt a Verification Method for fire safety (VM) [7] in the NCC that could be incorporated into building regulations in each State and Territory.

For the whole fire safety and regulatory community in Australia, the key questions raised by the proposed VM have been:

• Will its adoption in Australia lead to buildings of adequate safety, or create unacceptable risks?
• Is the VM rigorous and robust in terms of the science and engineering of fire safety?
• Will its adoption lead to much greater use of the NCC and performance based building solutions, rather than prescriptive DTS solutions, which is the stated ABCB national policy for the construction industry?

The ABCB developed VM was in part based on the VM from NZ [8], (also known as C/VM2), but has been changed through input from an ABCB working party.

The VM for fire safety in Australia is essentially a prescriptive process or methodology for a fire safety engineer to follow in evaluating whether the fire safety of a particular building design meets the Performance Requirements of the NCC with the following characteristics:

• There are 12 design fire scenarios which are prescribed in technical detail, along with stated data for many other inputs, which require fire engineering analysis in order to establish ASET/RSET outputs for each design fire.
• Fixed tenability and other acceptance criteria are prescribed
• Some very limited guidance is provided on fire and egress modelling as well as structural fire analysis.
It is a process not unlike the International Fire Engineering Guidelines (IFEG) [9], but with many fixed input parameters or ranges of input data prescribed to be used in the VM.

It does not attempt to generate or quantify safety levels or quantitative risk numbers for the overall building design, but sets out a process to “quantify” individual fire scenarios.

AUSTRALIAN VERIFICATION METHOD RESEARCH

VM Analysis

The authors of this paper were part of a team led by the Fire Protection Association of Australia (FPAA) which undertook a calibration study for ABCB into the robustness and scientific credibility of the VM that ABCB were proposing for NCC adoption in 2019 through a formal Public Comment process [10]. The research team involved a number of practicing fire safety engineers from major Australia consulting firms as well as academics from the University of Queensland led by Professor Jose Torero.

The VM was applied to 8 buildings representative of the major types of buildings constructed across Australia. These included retail, residential, aged care and warehouse buildings, as well as a major hospital and an 80 storey residential/hotel and mixed use occupancy.

Under instructions from ABCB, the buildings were designed to meet the current prescriptive DTS provisions, which would make them acceptable as meeting the NCC Performance Requirements and therefore be in compliance with the existing Australian building regulations. This immediately raised a significant issue as the DTS provisions were never based on fundamental fire safety engineering analysis or quantitative risk assessment.

Each of the 8 buildings were subject to detailed fire engineering and risk analysis, including:

- Smoke and fire modelling using all 12 VM scenarios, in many cases in multiple locations, to determine smoke and heat spread from the room of origin to adjacent rooms, escape routes and other floors of the building to determine time to untenable conditions and ASET for each scenario
- This modelling required use of prescribed smoke leakage rates, conditions for failure of smoke walls, and modelling of smoke spread from floors of fire origin into stairs and floors above, which is quite complex even for the most competent practitioners
- The VM only required the modelling only to be applied in spaces or escape routes serving more than 50 occupants, although this appears an arbitrary number without justification
- Egress analysis, using prescribed pre-movement times and travels speeds, including for a substantial percentage of the population with disabilities, to determination time to RSET
- Structural analysis, to determine time to burnout and potential for collapse, including an Unexpected Catastrophic Collapse scenario, and potential to collapse during evacuation and fire-fighting, or collapse on adjacent property
- These scenarios as prescribed in the VM included fires that blocked exits, fires in concealed spaces, high challenge/worst credible fires, and robustness checks with individual systems considered to have failed
- For each scenario and each design fire location involving life safety analysis, ASET was required to exceed RSET, but no safety factors were set or required by the VM.
- Comprehensive modelling was utilized using contemporary tools such as SFPE Handbook equations, and zone and FDS modelling, and sometimes all three were used for the same scenario to enable an inter-comparison of results, but data specified for wall failure and window breakage was not scientifically sound and no methodological support for analysis was provided.
- Each building was subject to quantitative risk analysis and assessment against ABCB risk tolerance criteria using traditional event tree and modelling inputs. In many cases, overseas probabilities of system performance and other risk factors had to be used, given Australian risk statistics are lacking.
The analysis and reports listed all the assumptions and limitation of the analysis, and a sensitivity analysis was undertaken for specific buildings and particular scenarios.

**VM Summary Report Results**

The results of these detailed investigations are captured in eight Fire Engineering Reports (FERs) and an overall Summary Report [10] which has been published and circulated by ABCB with the draft VM which has been issued for Public Comment.

The Summary Report drew some conclusions which are not only of concern to the fire safety engineering profession but raise important fire science and technology questions for the fire research community. They are as follows:

- For these relatively simple buildings, which comply with the DtS provisions of the current national building code or NCC, they did not meet the requirements or acceptance criteria of the VM.
- The buildings generally failed to meet the VM requirements for a significant number of the 12 design scenarios.
- The buildings generally had fire safety risk levels (individual and societal) which exceeded the risk tolerance criteria set by ABCB, even though they complied with the ABCB own NCC requirements.
- Based on the analysis undertaken, the buildings would appear to require additional fire safety provisions, including in some cases additional measures in relation to structural fire protection, compartmentation, external fire rated construction and active systems in order the meet the VM requirements. For a first order tool this seems appropriate and conservative, but does not meet ABCB’s goal of “policy neutral”.
- While the VM is apparently conservative in its analysis, the research showed that some choices of inputs, assumptions or modelling approaches under the VM could produce less conservative and buildings potentially lacking adequate safety
- Therefore, the VM as assessed by this research study, was not considered to policy neutral ie, yield safety levels equal to the current DTS or prescriptive requirements of the NCC at no additional cost, which was the hoped for research objective of our client ABCB.

A significant number of matters of interpretation and uncertainty associated with use of the VM arose in the application of the VM to analysis of these buildings. Study participants in this research, in attempting to carefully follow the proposed VM process as documented, found themselves in conflict about scenario application, analysis input, modelling approaches, tenability criteria, and other undefined process matters, despite having a high level of relevant expertise and experience. Another major issue was that depending on some of the inputs chosen or interpretations made, compliance with the VM requirements and the resulting risk levels could have been very different. This is because so many issues are left to the VM user and dependent on their competence, despite the VM trying to be a prescriptive process for “performance based design”. In that sense it is no different to the IFEG [9], except ABCB are trying to mandate a prescribed VM process with no flexibility to use the latest science.

**Public Comment Issues**

Some of these concerns and modelling issues have flowed through into more detailed concerns with the VM if it was implemented in the NCC in its current form, with potentially unsafe designs, including:

- High rise (unlimited height) residential buildings without sprinklers and with a single stair, provided that smoke seals were provided to apartments and each storey had less than 50 occupants
- Potential to not have to assess facades on existing buildings undergoing refurbishment, unless there was a change in classification (The Grenfell Building issue)
- Arbitrary occupant limits for design scenarios raises the potential for unsafe buildings
- Buildings of unlimited height may be permitted to collapse due to fire, so long as they do so inwards
Evacuation times which do not consider compartment layouts, travel distances, or actual time to prepare patients for evacuation in hospitals and aged care homes

CRITICAL ISSUES – FURTHER RESEARCH

Some of the critical scientific and engineering issues that emerged in the modelling and analysis of these 8 sample buildings and subsequent practitioner debate were:

- For any particular fire scenario, the VM approach to keep repeat modelling to determine the worst case location for maximum fire growth is impractical in a normal design/analysis engineering process.
- The fixed failure criteria of smoke walls set at 200°C and the values for leakage around doors appears to have no basis in the literature and there is no methodology to deal with window breakage at 300-500°C.
- There is no clear modelling guidance for smoke spread in long corridors, and between the fire floor, stairways and higher floors.
- Insufficient VM guidance on key assumptions and modeling methods led to differences between engineers in calculating evacuation times, detection times, and overall Required Safe Egress Time (RSET) values.
- Modelling of external fire spread up building facades incorporating combustible components.
- What to do about use of average tenability criteria when using FDS or other CFD models which generate different values based on location?
- A lack of guidance to fire safety engineers on how to select material data and also critical inputs to fire and smoke models where not provided in the VM.
- With no robust statistics in Australia for rate of fire starts, spread between the room of origin, etc, and reliance overseas data meant large uncertainties in the quantitative risk assessment results.
- No guidance on the limitations of the modelling or calculation methods and no requirements for sensitivity analysis.

This all suggests that much more fire research is required before a VM could be developed and promulgated into Australian regulations with the required level of certainty that, if a building met the VM requirements in full, it would have the required level of fire safety and be cost effective to construct and operate.

This level of uncertainty with the technology of verification methods is reflected in the significant changes to the application of the VM in New Zealand, where recently the VM has now been limited in its application to relatively simple buildings [11]. The idea that a high rise residential or commercial building could have only one stair and less than 15 minutes fire resistance, despite provision of sprinklers, has caused concern in Australia. The whole issue of robustness and resilience of design, and how those factors are evaluated in design and by approval authorities, is another area for rigorous fire research.

CONCLUSIONS

- A significant research study has been undertaken in Australia into a proposed Verification Method for fire safety evaluation of a building.
- The research showed some major issues with the VM which suggests it should not be adopted at this time.
- More research is required by the fire science and engineering communities to address the key issues holding back the applications of VMs into building codes and regulations.
- In the meantime, updating fire engineering guidelines with the latest research results and lifting engineering competencies should be the priority.
- The research suggested that if ABCB want to move at this time with the VM, that a trial be conducted on a simple set of buildings such as warehouses, and a comprehensive research program to follow up on these buildings, their design and there compliance with the VM be followed.
At the same time, there is a clear need in Australia and in other countries to lift the level of competence of fire safety engineers and other fire protection practitioners. This paper shows that policy reform of building and fire safety regulations cannot occur without the right engineering frameworks or without the backing of strong fire science and engineering research.

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