Meacham Associates Reference: 2022_08
Client Reference: CSV-2122-055
Client PO Number: 01049

Dr. Kate Nguyen
Chief Engineer
Cladding Safety Victoria
PO Box 23392
Docklands VIC 8012
Australia

9 May 2022

Subject: Peer Review of CSV draft Protocols for Managing Cladding Risk – Phase 1 Report

Dear Dr. Nguyen:

This letter report contains my Phase 1 peer review summary comments regarding the CSV draft Protocols for Managing Cladding Risk (PMCR). As directed in the Request for Quotation (RfQ) document, the focus of this Phase 1 review is on the material presented in the *Draft Technical Report for Review*. As suggested in your email of 2 May 2022, the *Overview* document was reviewed as well for context.

The RfQ summarized the scope of work as follows: *CSV seeks a peer review to confirm the document's methodology and reasoning, and to identify any key gaps or opportunities*. As outlined in my proposal to the RfQ, my approach is to provide comments within the documents of focus from the perspective of intended context for application, adequacy of the methodology to deliver on objectives given the context, and overall logic of the approach.

The comments and questions noted as part of this Phase 1 review are based on my expertise and experience, and no specific research was conducted in relation to any gaps that may need to be addressed or alternate approaches that might be considered. As needed, this may be necessary as part of the more in-depth Phase 2 review.

As such, based on the RfQ and your email dated 2 May 2022, I provide the following "high-level" comments related to material in the *Draft Technical Report for Review*, with a focus on the following questions:

1. Is the methodology of the protocols fit for purpose?
    a. This includes comment on section three (Scope and Principles, page 27-35).
    b. Additionally, do you agree with the tolerable level of risk presented on page 29?

2. Is the dynamic comparative criterion suitable? Specifically, please provide your opinion on the concept of "Comparable Prototype" building presented in 3.3.

3. Are there any other interventions that we should consider?
    a. Is the design of interventions based on the threat-barrier comprehensive?
    b. What is your overall comment on the interventions in section 4?

In the following discussion, unless otherwise noted, references are to the *Draft Technical Report*.

Comments on Methodology and Reasoning being 'Fit for Purpose'

The overall aims of this project are stated in the Introduction (p5).

"*A project has been initiated to develop a systematic and repeatable method for designing solutions to mitigate fire risk created by combustible cladding on Victorian residential multi-storey dwellings that have a relatively low cladding risk.*

Consistent with 'the as low as reasonably practicable' (ALARP) principles, the intent is to facilitate the identification of solutions that appropriately balance the resource requirements for a solution (time, cost and effort) with the risk posed by combustible cladding on these buildings.

The project has been initiated because current regulatory arrangements are not consistently yielding the proportionate risk mitigation solutions reflective of the ALARP principles.

The aim of this project is to develop and publish a set of evidence based rules that can be applied to remedy cladding risk on a set of Victorian buildings and allow cladding rectification obligations currently imposed on Victorian building owners to be removed."

Comment 1: The overall project aims as stated in the Introduction are clear and reasonable.

The context of the CSV draft Protocols for Managing Cladding Risk (PMCR) is presented in Section 1.2 (p6-7).

"I*n order to meaningfully provide an effective and manageable method for managing buildings with façades incorporating combustible cladding, Cladding Safety Victoria (CSV) has developed and applied the Cladding Risk Prioritisation Model (CRPM) [1]. The CRPM is central to the function of identifying and prioritising buildings presenting the highest levels of risk associated with combustible cladding. At the centre of CRPM lies the development of the Initial Fire Spread Cladding Assessment Number (IF-SCAN) [2]. The IF-SCAN is a qualitative measure that enables the high-level separation and prioritisation of buildings with a cladding specific fire hazard risk. The purpose of the IF-SCAN is to identify the level of this risk of buildings so that an appropriate and proportionate response can be developed.*

The CPRM process triaged buildings into risk groups of High, Elevated and Low (Table 1). Buildings which do not fall into the High Risk group for full removal are considered of Elevated Risk or Low Risk. In terms of IF-SCAN the upper threshold for Low Risk / Elevated Risk is defined as not more than two for buildings without fire suppression sprinkler systems and not more than three for buildings with fire suppression sprinkler systems. Among these groups, buildings with IFSCAN of not more than one are considered Low Risk, based on the limited fire spread foreseeable as a direct result of the façade cladding type, quantity and position.

The aim [of this project] is to develop a practical and proportionate approach to addressing the risk presented by the façade cladding on Elevated Risk buildings."

Comment 2: The focus of the CSV draft Protocols for Managing Cladding Risk (PMCR) is on buildings identified through the application of the Cladding Risk Prioritisation Model (CRPM) as being categorized as Elevated Risk. For the purpose of this review, neither the CRPM nor the boundaries around / definitions of the risk categories are considered. More specifically, the focus is on developing a "practical and proportionate approach to addressing the risk presented by the façade cladding" in these buildings. Given these constraints, it is reasonable and appropriate to (a) limit the development of the PMCR to the category of "Elevated Risk" buildings and (b) to focus on development of a "practical and proportionate" approach.

Section 2 of the *Draft Technical Report* provides a review of the literature deemed appropriate for the project. It includes standards and practices regarding assessment and rectification of combustible cladding, the ALARP principle, fire testing, software, and Cellular Automata and Bayesian Networks.

In the discussion around the ALARP principle, reference is made to the related principle, "So Far As Is Reasonably Practical" (SFAIRP). In discussing the SFS Practice Guide for Façade/External Wall Fire Safety Design (SFS Guide), it is noted that the SFS Guide discusses both ALARP and SFAIRP, "with the recommendation on the SFAIRP approach over issues relating to insurability and professional liability of the buildings and building practitioners" (p8). This distinction is not completely clear. As per the UK HSE (https://www.hse.gov.uk/managing/theory/alarpglance.htm):

> *"ALARP" is short for "as low as reasonably practicable". "SFAIRP" is short for "so far as is reasonably practicable". The two terms mean essentially the same thing and at their core is the concept of "reasonably practicable"; this involves weighing a risk against the trouble, time and money needed to control it. Thus, ALARP describes the level to which we expect to see workplace risks controlled.*

The UK HSE interpretation seems to be consistent with the Safe Work Australia interpretation (https://www.safeworkaustralia.gov.au/system/files/documents/1702/interpretive_guideline_-_reasonably_practicable.pdf), which focuses on 'reasonably practicable' as being the key issue. The literature review (p16) cites work by Ale et al. that suggests "the suitable approach to use ALARP as part of the regulatory system is to translate ALARP into industry standard rather than a guidance as a matter of opinion." This seems to be an issue primarily for lawyers to address, but I understand this work (PMCR) to be developing more of an 'industry standard' (being produced by an entity whose remit includes addressing the issue) than 'guidance as a matter of opinion' (which could be the interpretation of an engineer on a specific project).

In general, the discussion on benefits and detriments of fire testing and computational modeling for deterministic fire engineering analysis is reasonable. However, it is worth noting that it is suggested that the utilisation of FDS requires specialized expertise and that current models' capability to deal with complex architectural features, environmental conditions and material combinations is immature (p23). I do not disagree with this, but I would also note that fire safety engineers are often educated to use such tools, and that there are competent modelers (as cited in the Draft Technical Report).

The research then suggests that Bayesian Networks (BN) can be a more appropriate approach. It is noted that "the parameterisation/validation of a BN is a challenging task and requires assimilation of subject matter expertise, lab/field experimental data, modelling, and data assimilation" (p26). This mirrors the general challenge of proper application of complex deterministic models, such as FDS, but may be even greater in terms of paucity of data and near complete lack of practitioners with the required expertise. Care is urged in going down a path that will require data and expertise that does not currently exist, and which could take some time to develop.

Comment 3: The literature review is largely adequate. However, the discussion on the ALARP principle is rather light on the one hand (background, development, applications), yet rather opaque as well (integration of cost optimization discussion). Specifically, a central theme of the ALARP principle (and the project) – the notion of tolerable risk – is not addressed by the review in any detail. The brief discussion on differences between ALARP and SFAIRP raises more questions than are answered. Given that the key legal core of each is the concept of 'reasonably practicable', and that ALARP lends itself to industry standards, it seems appropriate for use in the PMCR. Care is urged relative to equally presenting benefits and detriments of both computational fire modeling and Bayesian Networks, in complexity, data and practitioner expertise. It is suggested that a section on the 'Bowtie' approach be included, since that is central to the approach (as one finds in later sections[1]).

[1] It is suggested that a good source on the bowtie approach, including quantifying risk when using the approach, can be found in: Fiorentini, L. (2022) *Bow-tie Industrial Risk Management Across Sectors – A Barrier-Based Approach*, John Wiley & Sons Ltd., Chichester, UK.

Section 3 of the *Draft Technical Report* lays out the Scope and Principles for the project. It clarifies that the focus is on Elevated Risk (ER) buildings, where the risk is bounded by the IFSCAN risk rating of 2 (non-sprinkler-fitted buildings) or 3 (sprinkler-fitted buildings). It recognizes that ER buildings may have numerous clusters of IFSCAN 2 or 3, and if so, each cluster should be addressed individually, although mitigations can span multiple clusters. It acknowledges that any building possesses a certain residual risk even after all performance requirements are met and suggests that an acceptance criterion that reflects the comparative residual risk be used as a suitable safety level for general societal acceptance (tolerability). It for the first time clarifies that the 'risk' of concern with the cladding and its fire spread potential is focused 100% on life safety risks (injuries and fatalities). This discussion is clear and reasonable.

However, the selection of risk metrics and how they are to be used is less clear. It is suggested in Section 3.1 that, on the one hand, risk be expressed as an 'expected loss', which can be estimated through the use of a small set of potential fire events (scenarios) and with point-estimate probabilities and average outcomes assigned to each (although it is not defined for what variables these will be applied). However, it then references Meacham et al. (2021), which does not estimate risk in this way. The work by Meacham et al. (2021) shows how the use of fatality data (in general and by hazard type) and population numbers can be used to derive estimates of individual and societal risk that are largely tolerated (since they are based on current building stock and regulations). The work by Meacham et al. (2021) also suggest how risk changes based on age of building occupants. The draft report then intimates that if the societal level of fire risk for average-aged Australians is used as a tolerable risk value, it can be somehow connected to the 'expected loss' approach and used for reflecting 'tolerable risk'. This framing is not entirely clear. It is then suggested that a 'comparative risk' approach is appropriate, since it alleviates the need to select quantitative data (which seems contrary to the above discussion, which results in a quantitative representation of risk). It is argued that a 'comparative' approach enables risk measurement which is not fully and absolutely quantitative but rather may be categorical or ordinal (e.g., "better/worse than"), and/or quantitatively relative (e.g., "1.2 times the benchmark"). The discussion is further confused by the statement that follows later, i.e., a determination on tolerable risk is expected to stem from future consideration/ consultation by policymakers.

Comment 4: In general, the use of the notion of 'tolerable risk', using absolute or comparative approaches to estimate such, and working within an ALARP framework to mitigate risk to a tolerable level is reasonable and appropriate. However, in Section 3, the overall presentation of concepts of risk representation ('expected loss), how it is estimated, what 'tolerable risk' means in the context of this effort, and how it is estimated and used, is unclear. It is suggested clarity is needed on this component. Discussion on the mitigation of fire risk is clear and reasonable. Discussion in Section 3.2 on the requirements of decision protocols for Elevated Risk buildings is reasonable and mostly clear. There are some uses of 'acceptable' and 'tolerable' as applied to the risk that should be clarified.

Section 3.3 introduces the notions of a cladding risk premium and of a comparable prototype building that does not have combustible cladding but to which buildings retaining combustible cladding can be compared. Cladding risk premium is defined as the additional fire risk (of injury and fatality) of a building which is directly attributable to combustible cladding. It is reflective of the fact that combustible cladding can support a fire ignition, fuel a fire, and transport a fire. It has been described and utilised in past work undertaken by/for CSV.

Comment 5: It is deemed inappropriate to comment on the cladding risk premium' approach since it is embodied in the foundational methodology and classifications of building risk used by CSV that preceded this work.

Cladding risk premium makes use of the concept of the comparable prototype (CP) building, which is in effect defined as the subject building (SB) without combustible cladding. Arguably, this means it is inappropriate to comment on the use of a CP building, since it is embodied in the foundational methodology and classifications of building risk used by CSV that preceded this work. However, since it is requested to comment on this specifically, comment is provided below. (The remaining subparts of Section 3 are addressed by the two major comment areas below.)

Comments on Suitability of Dynamic Comparative Criterion / Comparable Prototype Building

As understood, the PMCR approach is generally to understand the subject building (SB), hypothesize a DtS-compliant comparable prototype (CP) building, assume possible mitigation measures, estimate risk reduction of mitigation, and aim to reach a 'near zero' level of 'cladding risk premium'. This assumes that there are ways in which the cladding risk premium can be reduced to an acceptably small value while retaining some or all of the combustible cladding that is originally present. This requires there to be sufficient risk reduction potential in the mitigation strategies (interventions). It also requires a reformulation of the CP for each specific SB. However, the actual risk associated with the SB will not be assessed beyond assuming DtS fire safety system compliance (p31).

The use of benchmark / comparative buildings has been used in risk assessments. However, questions can arise regarding the appropriateness of the comparative building. Given the approach that "CP achieve "Deemed to Satisfy" status with respect to fire safety measures," and that "in effect, the CP is the SB without combustible cladding," and that "the CP building is an embodiment of tolerable fire risk" (p31), it is unclear why previous discussion around 'tolerable' risk attempts to describe and quantify 'tolerable' risk in obtuse ways. If in fact the risk associated with a DtS building is 'tolerable', then that could simply be stated as the 'benchmark'.

However, this approach assumes that the level of risk delivered for each individual building by the DtS is 'tolerable'. This may not be the case. It may be that the risk is 'tolerable' only when taken across all buildings with their wide range of occupant. Since no risk assessment was undertaken in determining what level of safety the DtS should deliver for a specific building, there is the danger that for any specific building, with occupants of specific characteristics (including vulnerabilities), the fire risk may in fact be intolerable. (This is one of the challenges of assuming a risk level only benchmarked to 'average-aged Australians' in the analysis (p28).) If a comparison is to be made between the SB and the CP building as part of a risk-based approach, it would seem to be necessary to estimate the risk in the SB and related CP given the characteristics of the occupants, and perhaps other risk factors, and not simply by considering DtS compliant fire safety systems. It may well be that the DtS solutions incorporate all risk factors of concern (e.g., any apartment building is considered by the DtS to include vulnerable populations who are at higher risk that 'average-aged Australians', but that case is not made in this work.

Comment 6: Since the "the CP building is an embodiment of tolerable fire risk," and the aim is to reduce the fire risk of the SB to an equivalent level, and the 'loss estimation' approach is to define scenarios and assign probabilities, the question is asked: cannot this whole approach be simplified by applying the loss estimation approach to the CP building and introduce interventions into the SB until the SB fire risk is reduced to that near the CP building? It is not clear why anything more complicated is needed for defining 'tolerable' risk in an otherwise largely subjective approach. This could be done by developing estimates of the risk associated with the CP building for each SB. Inherent in this is a focus on the individual building risk profile, however, and not a societal risk approach, which does not consider the specificities of the individual SB. If it is intended to actually assess the comparative risk of the SB and the associated CP, then factors other than simply DtS fire safety system compliance (e.g., inclusion of occupant vulnerabilities and risk factors) should be considered.

Comments on Threat-Barrier (Bowtie) Approach

Section 3.6 introduces the Threat-Barrier, or Bowtie approach. The ability of the Bowtie approach to immediately transmit complex information through its powerful (though simple) notation and graphic design has made it one of the most widely used an appreciated risk analysis methods worldwide, regardless of the type, size and complexity of the application.[2]

The application of the Bowtie approach to the cladding fire risk reduction focus of the PMCR is appropriate. The Bowtie approach has been shown to work well with the risk assessment approach known as layer of protection analysis (LOPA), where frequencies of occurrence and probabilities of barrier failure can be combined.[3] It seems as if this concept is proposed within the PMCR, but it is not so clearly defined. Nonetheless, there is recognition that the Bowtie approach of the PMCR can become more rigorously quantitative in the future as data are available, which is an aim of the PMCR,

Comment 7: The Bowtie approach is a reasonable and appropriate tool for the analysis of risk reduction efficacy of interventions proposed by the PMCR. As noted in previous comments, it is suggested that descriptions of how the risks are to be estimated in the PMCR need more attention as the project proceeds.

Comments on Comprehensiveness of Interventions in Section 4

Section 4 overviews a set of interventions, the aim of which is to combine to reduce the combustible cladding fire risks to which occupants of the building with combustible cladding are exposed to a tolerable level. There are 15 interventions, grouped into 4 areas: cladding removal; active fire safety system upgrades; passive fire safety upgrades and exit and egress protection. At a high level, this represents a comprehensive set of potentially beneficial interventions. The discussion and analysis approach for most seem reasonable and appropriate.

There are, however, a couple of issues / questions. The discussion on detection devices is not always clear, including benefits of each, limits on 'multicriteria' devices (i.e., just smoke and heat, or smoke and CO, or…?), and of how coupled (integrated) systems work. In addition, the analysis method of Alpert is questionable for analysis of smoke detector operation, as it was designed for sprinkler / heat detector activation modeling under well-defined conditions. More robust discussion is needed as to the efficacy of this approach in the PMCR context. Also, since cost-effectiveness (optimization) is an objective, it is not clear under what circumstances adding a fire resistive means of escape is more cost-effective than removing cladding. Of course, the exact conditions matter, but typically the addition of a stair (in particular) is extremely costly. Lastly, some text in Section 4.7 seems to be missing.

Comment 8: At a high level, the 15 interventions represent a comprehensive set of potentially beneficial risk reduction measures. The discussion and analysis approach for most seem reasonable and appropriate. Clarification around detection and cost-effectiveness of adding an exit is desirable.

Comments on Quantifying the Risk Equivalence of Alternative Mitigations

Section 5 is on quantifying the risk equivalence of alternative mitigations. While not a request for this Phase 1 review, I do offer some high-level observations.

[2] Fiorentini, L. (2022) *Bow-tie Industrial Risk Management Across Sectors – A Barrier-Based Approach*, John Wiley & Sons Ltd., Chichester, UK, p154.
[3] Fiorentini, L. (2022) *Bow-tie Industrial Risk Management Across Sectors – A Barrier-Based Approach*, John Wiley & Sons Ltd., Chichester, UK, p178-184.

Comment 9: It is noted that there seems to be some disconnects between framing of the risk in previous sections from this section. Also, the approach of using Bayesian Networks could benefit from more discussion, especially as to how it is a 'simple' approach and why the risk estimates should be broadly 'acceptable' given the variability and uncertainty associated with the SB and CP, especially where assessments are made by different people.

Summary Comments

Comment 10: Based on a 'high-level' review of the CSV draft Protocols for Managing Cladding Risk (PMCR) – Draft Technical Report, it would be my considered opinion that the proposed approach is reasonable, largely fit for purpose, and should be carried further into development and testing. While several observations have been made around issues of document clarity, consistent use of terminology, and risk estimation / characterization, the approach is sound and firmly rooted in risk and risk assessment and management theory and practice. The use of the Bowtie approach is particularly appropriate, as it helps to simply and clearly reflect options for mitigating hazards and risks. Further effort on benchmarking 'tolerable' risk is suggested. It is expected that open questions and issues will be adequately resolved as the project progresses.

Thank you for the opportunity to provide these Phase 1, high-level comments. If you have any questions regarding my comments in this letter report, or as presented in the associated *Overview* and *Draft Technical Report* documents, please do not hesitate to contact me.

Respectfully submitted,

Brian J. Meacham, PhD, PE, CEng, EUR ING, FIFireE, FSFPE
Managing Principal

Meacham Associates
Shrewsbury, Massachusetts
USA

Web: https://meachamassociates.com/