DOCUMENTATION FOR PERFORMANCE-BASED FIRE ENGINEERING DESIGN IN NEW ZEALAND

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ABSTRACT

This paper summarizes the introduction of performance-based codes in New Zealand, and describes some difficulties and inconsistencies caused by poor documentation. Other issues related to the design and review process are also described.

The paper describes the importance of good documentation for fire engineering design reports and for peer review reports. Performance-based fire engineering is a relatively new discipline, so fire engineering designs must be very well documented to ensure that the intended level of safety is achieved in a consistent way. Peer reviewing is an essential part of this process.

INTRODUCTION

Performance-based fire engineering design is being adopted around the world as a rational means of providing efficient and effective fire safety in buildings. Because this is a new discipline, there is uncertainty as to the best approach for a performance-based fire engineered design. In performance-based design it is essential for the objectives to be clearly established, and for a fire design report to contain certain minimum information. Guidelines for documentation should be provided to the fire engineer before embarking on the fire design and fire report.

It is also important that the 'Authorities Having Jurisdiction' (the Territorial Authority in New Zealand; City Council, Fire Marshal, Building Surveyor, Fire Service, etc) have systems in place to provide for consistent reviews of the submitted performance-based fire designs. The fire design report is usually unique to a particular building or application, and is often based on subjective engineering judgement, which requires excellent documentation if the design is to be reviewed on its merits. The review of the performance-based fire engineering design by qualified peer reviewers is essential to the success of performance-based design.

This paper provides guidelines for minimum criteria for documentation of a performance-based fire design report. It also provides guidelines on what should be required of the peer reviewer of such reports.

BACKGROUND

Performance-based design has been available in New Zealand as an option for building designers since the introduction of the Building Act in 1991 and The New Zealand Building Code in 1992. The New Zealand Building Code specifies the objectives, functional requirements and performance, which must be achieved in any design. The new system is summarized by Buchanan.[1] The performance requirements can be satisfied by two possible methods. The most common method is an "acceptable solution", using the prescriptive rules (Approved Documents) published by the Building Industry Authority.[2] The prescriptive rules are not mandatory, so it is also possible to offer an "alternative solution" based on specific fire engineering design. The fire design (acceptable solution or alternative solution) is submitted with the other building design documentation to support a Building Consent (building permit) application.

Alternative solutions are widely used in New Zealand, usually to justify departures from specific clauses of the prescriptive requirements.

The presentation and review process for fire engineered alternative solutions varies widely around the country. It was hoped that the implementation of a national Building Code would provide national consistency but there are many regional differences in interpretation, and differences in the reviewing procedure. Inconsistencies are largely due to the lack of guidelines such as proposed in this paper.

In New Zealand, the 'Authority Having Jurisdiction' is a 'Territorial Authority, TA,' usually a City Council. Most Territorial Authorities have no fire engineers on their staff, so they have difficulty assessing fire engineering designs. In some parts of the country, all alternative solutions are accepted without review if a professional engineer submits the design. That engineer may not be a fire engineer or even an engineer who has taken any fire related coursework, often a structural engineer. Some Territorial Authorities use the New Zealand Fire Service to perform the reviews for them. However, the Fire Service also does not have many staff with qualifications to review alternative fire engineered designs. The best option remaining to the Territorial Authorities is to use independent peer reviewers. The peer reviewers are usually other practicing fire engineers either from within or from outside the local area.

The proposals presented in this paper result from a one-day workshop at the University of Canterbury. The objective was to develop guidelines for documenting the performance-based fire engineering design process. The workshop identified problems and proposed tentative solutions for submittals of fire design reports and for peer review. Participants represented the University of Canterbury, the New Zealand Fire Service, the Christchurch City Council and private fire engineering consultants. In addition, this paper contains ongoing areas of improvement that have come to light since the original one-day workshop.

Design Submittal Concerns

The first issue addressed by the workshop was the quality of performance-based fire engineering design submittals. Problems with the current fire design submittal system were subdivided into categories which are discussed below. Guidelines for minimum submittal requirements are then provided.

Presentation

Several concerns relate to presentation of submittals. The fire design information is often difficult to find in Building Consent applications. Submittals are often poorly organized and poorly presented. Steps in the submitted fire safety evaluation process are often not clearly defined. Supporting fire calculations are not always included and even when included they are often not checked or there are mathematical errors. Other problems include missing computer input, or poorly presented computer output. Assumptions used to develop the fire report are not always clearly stated.

Scientific Basis

It is essential for the scientific basis of each design to be well documented. This is often overlooked. Assumptions are often incorrect or not justified. Illogical reasoning is used on some occasions. There is a lack of agreement on acceptable references. Reference should only be made to literature that is widely accepted, such as the Society of Fire Protection Engineers Handbook.[3] Other suggested acceptable references are the Fire Engineering Design Guide[4] and the Building Industry Authority documents.[2] Software should only be used if it has international recognition and has been through beta testing by several users. Proprietary information and other non peer-reviewed documents are often inappropriately used as reference materials. Papers presented at non-peer-reviewed conferences should be considered inappropriate references.

Design Criteria

An essential part of performance-based design is the determination of design criteria, and documentation of that process. In many reports, it is not explained how the solution is obtained. For example, it is often not stated whether the design is an Acceptable Solution using the BIA documents, or an Alternative Solution using fire specific engineering design. Fire safety objectives are often not stated or they are unclear. There is sometimes no explanation of how objectives are met, basic design criteria are missing and fire scenarios are often not described or are insufficient in scope or variety.

Consistency

Concern exists as to how to maintain consistency in design submittals throughout the country. There is no standard framework for submittals. Territorial Authorities differ in what is an acceptable submittal. Designers are not consistent among themselves as to what is required. The level of knowledge and expertise among designers varies greatly. Interpretations of the Approved Documents also vary among designers and reviewers. The potential for differences between fire engineered alternative solutions is much greater than for acceptable solutions based on the prescriptive rules.

Responsibility

Last, but certainly not least, is the issue of responsibility. The designer responsible for fire safety is not always identified as part of the submittal. Very often the name of the individual who developed the fire report is not included on the documentation. It is generally unclear as to who is responsible for implementation of the fire requirements. Is the architect, the author of the fire report or the structural engineer responsible for the project? Very often, the fire report has been developed independently of the rest of the building design process. Consequently, the main contract documents, specifications and drawings sometimes do not include the fire safety measures required by the fire design.

There is sometimes no one person responsible to ensure co-ordination of fire requirements among different construction trades, and to take overall responsibility for the fire safety of the entire project. For structural engineering in New Zealand, it is accepted practice that the structural engineer would be involved in the site inspections, why not the same for fire engineering designers?

Minimum Design Submittal Requirements

In order to address the deficiencies identified above, essential documentation for fire design submittals is proposed.

Every design submittal should be a written report including:

1. The name and credentials of the person with overall responsibility for the fire safety design, including co-ordination between various trades.

2. The name and credentials of the person or persons doing the actual fire safety analysis.

3. A statement of design philosophy as specified in the Fire Engineering Design Guide,[4] to include:

   a) The performance requirements forming the basis of the design.
   b) The differences between those requirements and those of the Building Code.
   c) The overall strategy for meeting the performance requirements.
   d) An overview of the fire engineering analysis.
   e) A summary of the building design and fire protection features.

4. A clear description of the fire scenarios considered, and why they were used. Any assumptions must be justified.

5. Full details of any computer models used, including version number and date, input, and a summary of the output (actual data to be included in the Appendix). Software that has achieved international recognition and has been through beta testing by several users would certainly be acceptable for use.

6. A statement of any inspection procedures necessary on site.

7. A statement of the drawings and specification which form part of the fire design package, including applicable drawing numbers and dates.

The design submittal should be presented in three parts. They are the written report, drawings and specifications.

Written Report

- The information noted above should be included in a written report.

- All calculations should provide sufficient information for the entire procedure to be followed clearly and precisely.

- References should be given for all equations and assumptions.
- References should only be to literature that has been widely accepted.
- Computer input should be summarized with graphs or words rather than numerical printout.
- Computer printout should be included only as an Appendix, not in the main report.
- Copies of important technical literature may be included as an Appendix.
- There should be cross references to drawings and specifications as appropriate.

Adequate Drawings

- Contract drawings should be included which show the fire safety requirements. These may be separate fire engineering drawings or suitably marked architectural drawings.
- The drawings must be consistent with the written report and the specification.

Adequate Specification

- The specification must provide the words to support the requirements shown on the drawings.
- There should be a separate fire section of the specification to provide overall information, with references to the drawing as appropriate.
- The fire section of the specification should provide cross-references to all other sections which have fire-related material.
- Inspection procedures should be included.

Review System Concerns

The second part of the workshop addressed the system of review of fire engineering design submittals. The concerns related to the review of fire submittals were divided into the categories shown below which are discussed with guidelines for minimum documentation.

No Standard Procedures

The fact that there are no standard procedures for reviewers is a significant concern. There are no published guidelines on what basis or how a review should be performed. Currently, there is inconsistency nationally on how the reviews are performed and accepted. Should the review address only whether or not the final solution is adequate? Or should the review address the method and calculations used in achieving the solution?

There is no standard format for the reviewer's report. It is important that the reviewer identify how the review was performed. What was evaluated, what references were used? This is particularly pertinent if there is a conflict between the reviewer and the submitter. Other difficulties include the lack of "model" solutions for the reviewer to use as guidance and lack of quantifiable measures of calculating risk and safety to demonstrate that the performance requirements of the Building Code have been met. Another issue is the reviewer's participation in the construction, inspection and commissioning phases. Should they participate at all or should this be the responsibility of the original submitter of the fire report?

When is Review Required?

Whether the review is required is left totally to the discretion of the Territorial Authority, TA. Before accepting a design and issuing a building consent, the TA must be satisfied "on reasonable grounds" that the design meets the requirements of the Building Act. Depending on the level of fire engineering expertise within the TA, a second opinion may be sought from a peer reviewer. Some TAs have accepted all fire engineering submittals from registered engineers even if the engineer does not have any fire engineering qualifications. Other TAs have developed a list of fire engineers that they consider competent and "accepted". Design from "accepted" fire engineers will usually be approved without review, although the TA may require that the fire engineer provides a "Producer Statement" at the end of the project to ensure that the requirements of the fire report are actually implemented during construction. A Producer Statement is a docu-

ment permitted under the Building Act, in which the designer certifies that the design and/or construction are completed in accordance with the Building Code.

Who does the Review?

The majority of TAs do not have qualified personnel on staff to review fire submittals of full alternative designs, fire computer modeling or extensive calculations. If the submittal is only a BIA Acceptable Solution fire design the TA may feel it is within their competence to do the review themselves. If the TA has insufficient staff to review alternative designs, an independent fire engineering consultant is often engaged by the TA to do a peer review.

Who pays for the review?

The Building Act provides for the TA to pass along the cost of processing the Building Consent to the building owner through the submitter. Obviously, if the fees for review become excessive there will be complaints about the TA, which has its own effect upon the system.

What should the Review Actually Provide?

The reviewer's best judgement is used to determine if the submittal meets the NZ Building Code for alternative solutions, the BIA Acceptable Solutions may be used as a benchmark to determine the level of safety necessary.

The reviewer must be satisfied that the applicable computer models have been used appropriately. If the reviewer is not familiar or comfortable with the model used, it may be fastest and easiest to perform their own check using a different fire model to determine if the submitted design is OK. The review must be performed on the basis of technical merit, not comfort level. Fire engineering is still both science and art so it is not always black or white, there is often a lot of gray. The reviewer must ensure their personal bias and comfort level does not prejudice the technical review.

Liability

Most territorial authorities require that peer reviewers have professional indemnity insurance. According to the Building Act, the TA is responsible for acceptance of the submittal, but if there is another party involved, they will most likely be included in any litigation. There has been no discussion of who is actually liable for the design if the original designer changes the design due to the peer reviewer's comments. The peer review is usually carried out for the TA by an independent fire engineering consultant. In the event of a dispute between the designer and the TA, the Building Industry Authority may be asked to make a determination.

Who is Qualified to Provide Peer Review?

There is a concern regarding a lack of minimum qualifications for individuals performing fire engineering reviews. Different qualifications need to be defined for those reviewing acceptable solutions to the prescriptive fire requirements, and for those reviewing alternative solutions based on fire engineering design. A register of qualified individuals needs to be established. Currently, there is no training required to be a reviewer nor is there a "how to" manual for those performing review services. Additionally, there is the concern that the reviewers are not independent of the design system because most designers and reviewers come from the same small pool of qualified fire engineers. Impartiality may be affected if a reviewer is submitting designs to the Territorial Authority at the same time as performing reviews.

Suggested minimum qualifications are:

For prescriptive designs (acceptable solutions)—

- Two years relevant experience working with the prescriptive documents on a regular basis
- Future national certification program.

For prescriptive designs with limited deviations presented as fire engineered alternative solutions—

- Four years relevant experience with the prescriptive documents on a regular basis
- Future national certification plus experience.

For alternative solutions based on fire engineering principles—

- Full membership of the Society of Fire Protection Engineers, and

- Registered engineer with a degree in fire engineering

One credential provides minimum qualifications for fire engineering and the other qualification demonstrates knowledge of local New Zealand requirements.

Can the Peer Reviewer Be Truly Independent?

New Zealand is a small country. It is difficult to have any reviewer who does not know the submitter and the reviewer knows that they may be reviewed by the submitter in the future. The effect of this cannot actually be determined. One must trust in the ethics and honesty of the reviewers.

If the submitter and reviewer are from the same geographical area they may harbor the same inaccuracies about fire engineering. Many fire engineers in New Zealand are self taught, so misinformation applied by one fire engineer may be perpetuated by other engineers familiar with their work.

In most cases of peer review, the TA expects the submitter and reviewer to discuss the design with each other in order to reach agreement on the details of the design. The necessary revisions to drawings or fire report are submitted prior to acceptance by the TA.

Guidelines for the TA to Establish

The TA needs to establish some guidelines for what happens if the reviewer and submitter reach an impasse. The review could be returned to the TA for their acceptance or rejection or a third party could be engaged for another review. There are not any particularly easy solutions and most TAs do not have a procedure for this.

Another issue is confidentiality and exclusive references. The TA should have guidelines on how to handle a new fire design that the submitter would like to keep confidential. It may be the submitter can discuss the submittal with the TA to determine if it needs to go to peer review. If it does go to peer review, often the submitter can choose the peer reviewer from an accepted list. There is the real concern of providing new ideas and approaches to the competition.

If the report references a new report that the peer reviewer does not have, what should happen? Quite understandably, the submitter does not necessarily want to increase the peer reviewer's fire library at their expense. The TA may act as the intermediary and control the documents to provide assurance to the submitter that the peer reviewer does not copy the reference.

Minimum Review Requirements

In order to address the deficiencies identified above, essential documentation for fire review reports is proposed.

Every design review should be a written report including:

1. The name and credentials of the person carrying out the review.

2. The reviewer's association with the designer and any possible conflict of interest.

3. Confirmation of the design philosophy used by the designer.

4. A statement of the basis on which the design is accepted or rejected:
   - —The design is an "acceptable solution" that meets the prescriptive requirements of the Approved Documents, or
   - —The design is an "alternative solution" based on fire engineering principles, accepted on the basis of:
     - An opinion that the design meets the performance requirements of the Building Code, or
     - An opinion that the design provides an equivalent level of safety to an acceptable solution, or
     - Some other criteria.

5. A statement as to whether the whole design process has been checked, or just the design solution.

6. Expression of concerns about any of the steps in the design procedure, even if the design

solution appears to be acceptable. (For example, if computer modeling was inappropriately used, even if it had no effect on the final outcome).

7. Confirmation or modification to any inspection procedures necessary on site.

8. Confirmation of which dated drawings and specification form part of the fire design package that was reviewed.

Compliance Schedule

According to the Building Act, a Compliance Schedule is required for each building, provided by the designer as part of the documentation package. The compliance schedule details the required maintenance of specific systems in the building. There is a form that lists specific systems such as automatic sprinkler systems, fire doors, fire alarms systems, emergency lighting, escape route pressurization systems, risers mains for fire service, signs, means of escape from fire, hose reels and other required systems that are non-fire related. The designer is supposed to provide the maintenance requirements for all applicable systems. Typically, for the normal fire alarm systems and emergency lighting, the applicable installation standard provides the maintenance requirements.

If an installation standard from another country is used as the applicable standard, the maintenance details may differ. The designer should detail the required maintenance; in practice, this has been a bit slow in implementation. Normally the Territorial Authority identifies the applicable systems on the Compliance Schedule and their maintenance requirements.

Building Warrant of Fitness

The compliance schedule is valid for the first 12 months the building is occupied. After that time, the Building Warrant of Fitness applies. Any building with a system noted on the compliance schedule must have a certificate displayed, called the Building Warrant of Fitness. This is the responsibility of the owner, who hires an Independent Qualified Person (IQP) to perform the inspections. The qualifications of the IQP are set by each Territorial Authority. In the South Island of New Zealand, most of the TAs have prepared a joint list of qualified IQPs.

The process in New Zealand does not provide an easy mechanism to track criteria related to specific fire engineering alternative solutions. Very often an alternative fire engineered solution has limitations in order for the design to work. These limitations are vital to maintain if the alternative solution is to be successful during the life of the building. Examples of limitations include:

- Maximum storage height limitations
- Restriction on the type of furniture permitted
- Requirements for access through adjacent rooms to reach the exterior
- Natural draft ventilation louvers that must remain open at all times

These limitations on design could easily be modified during the life of the building so there should be a mechanism in the Building Warrant of Fitness maintenance program to track these limitations.

Conclusion

This paper proposes minimum documentation for submittals of fire engineering designs and for reviews of such designs. It is hoped that the information presented in this article can act as a catalyst for further discussion of documentation of fire design submittals and fire design reviews. These are significant issues for performance-based design that were not defined in New Zealand before the performance-based code was implemented. These inadequacies have the potential to permit inappropriate fire designs to go forward. Consistent national requirements would be beneficial to ensure life safety and property protection from fire, in compliance with the performance-based building code.

REFERENCES

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