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Fire Engineering Reports and the Approval Process

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Introduction

In this presentation the purpose and contents of Fire Engineering Reports are discussed, and how as Building Surveyors you may begin to assess them for approval purposes. In New Zealand, we also have a performance based building code, and have been carrying out performance based alternate design fire safety engineering since the code's introduction in 1992.

Fire engineering design reports are commonly prepared to support a building development application where the design proposal does not fully comply with the deemed to satisfy (DTS) provisions. Usually such a report is only required when there is a significant departure from the DTS provisions. The Building Surveyor already has adequate training to review minor variations in the fire field, for example, slightly increased exit travel path lengths. However, the field of fire engineering is a very complex one, and one in which more expertise is required.

What is Fire Engineering?

Simply, fire engineering is an engineering consideration of fire and life safety rather than following the prescriptive provisions.

On a relative scale it can be considered an immature engineering discipline. Referring to Figure 1, placing "Structural Engineering" on a time line it is at the point where codes have been developed and these have evolved to standardise future designs. By comparison, present day "Fire Engineering" is placed at the point where fire design theories are emerging.

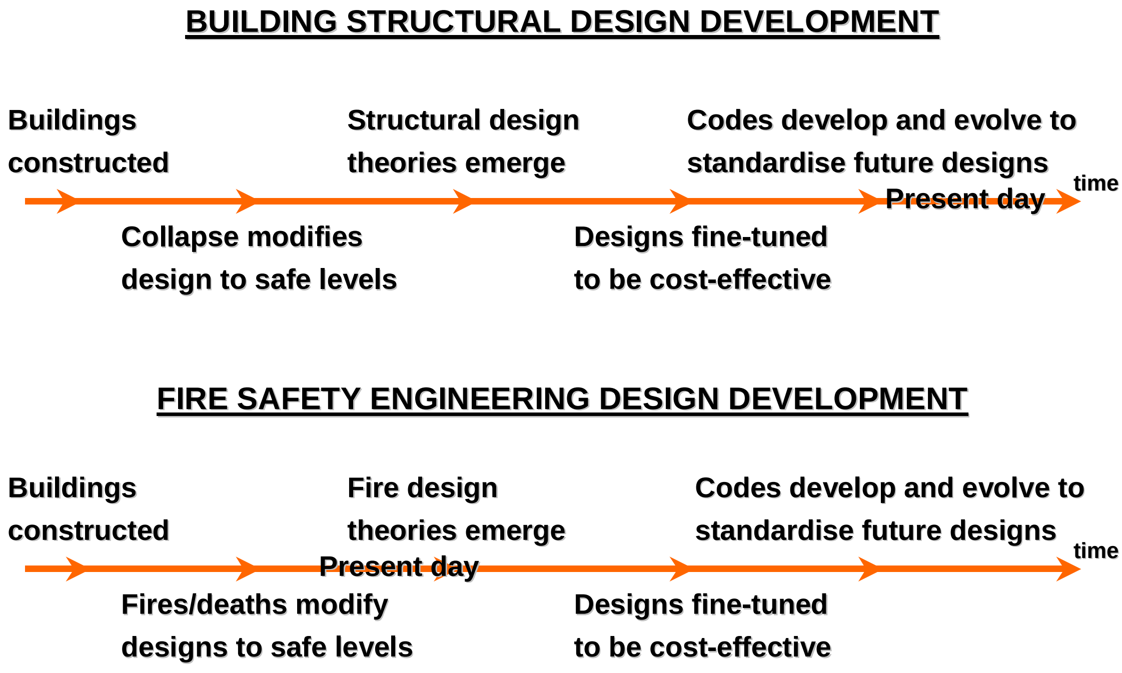

Figure 1 Code Development Timelines, comparing Fire Design to Structural Design
(Reproduced by kind permission of Stephen Kip, BCC)

Basically, the process of Fire Engineering illustrated in Figure 2, consists of identifying the input criteria, applying engineering design methods, calculations, modelling etc , to result in an output which may predict evacuation, fire detection and or suppression for example.

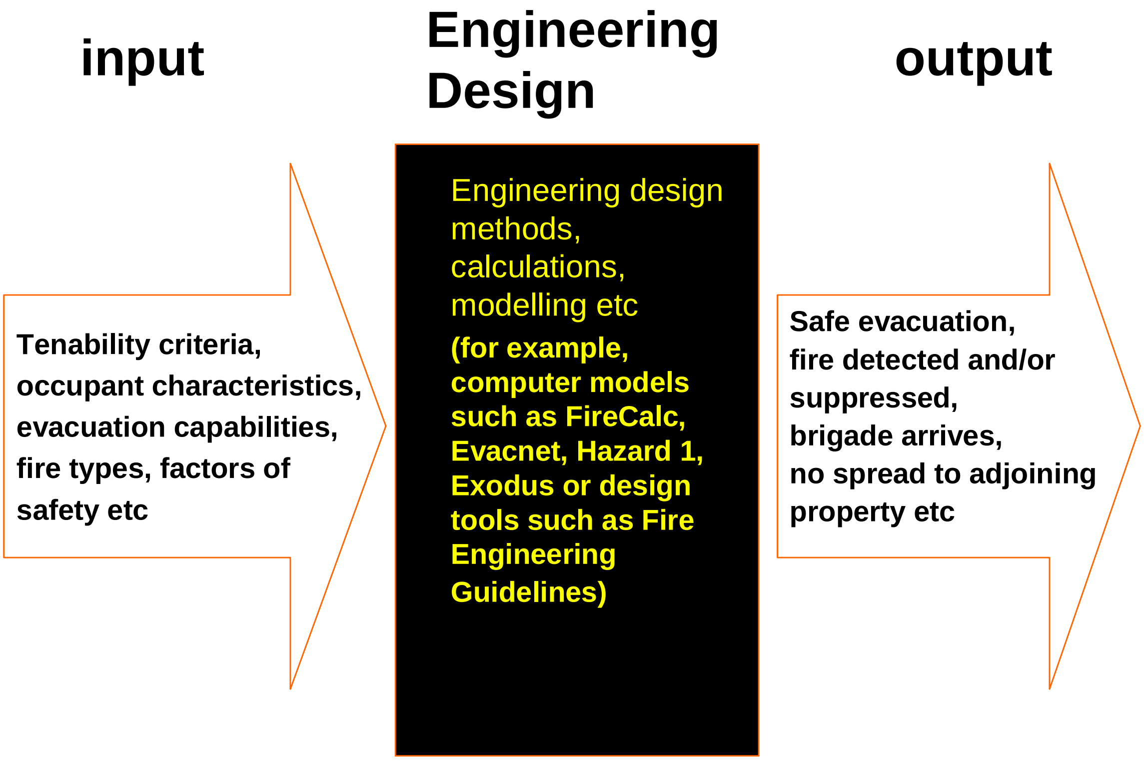

Figure 2 Fire Engineering Process
(Reproduced by kind permission of Stephen Kip, BCC)

The Fire Engineering Guidelines

To assist with this process, the Fire Code Reform Centre (FCRC) has published the Fire Engineering Guidelines (FEG). It provides useful information against which Fire Engineering Reports can be measured.

The scope of the FEG deems its purpose to be to identify a methodology for the design and assessment of fire safety in buildings. It identifies an engineering approach to building fire safety and gives guidance on the application of scientific and engineering principles to the protection of people and property from unwanted fire. Additionally it outlines a structured approach to assessment of building fire safety system effectiveness and to the achievement of pre-identified design objectives.

The Building Code of Australia (BCA) does not specifically recommend the use of the FEG, and it is clearly open to designers to adopt the evaluation methods that best meet their purposes. However for simplicity today, I will refer to the methodology presented in the Guidelines.

The guidelines are not intended to provide a fixed format for all fire engineering design reports, however they recommend that typically reports should contain the following information.

a) Objectives of the study

b) Description of the building and its type of occupancy

c) Results of the Fire Engineering Design Brief (FEDB):

- membership of the FEDB team
- fire safety objectives
- results of hazard identification
- basis for selecting fire scenarios for analysis
- acceptance criteria
- trial concept designs
- redundancies between and within sub-systems
- influence of fire safety management

d) Analysis of results:

- Assumptions
- engineering judgements
- calculation procedures
- validation of methodologies
- sensitivity analysis
- evaluation of results of analysis against acceptance criteria

e) Identification of final concept design:

- fire protection measures to be provided
- ’management in use’ issues integral to the design

f) References:

- Drawings
- design documentation
- technical literature

The Fire Engineering Design Brief (FEDB).

The FEDB is best described in a process diagram, refer Figure 3.

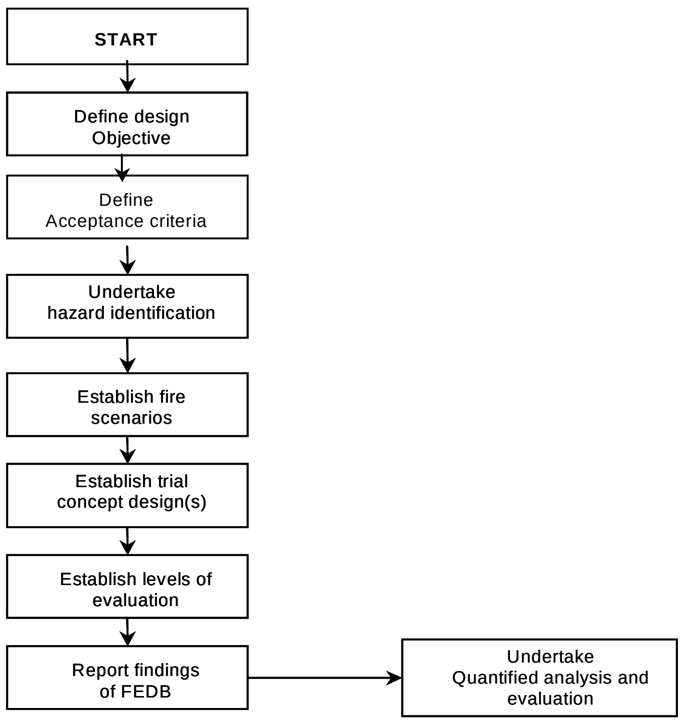

Figure 3 Fire Engineering Design Brief Development Process

The objective of the FEDB is to;

- Review the architectural proposals
- Identify potential fire hazards, and
- Define the fire safety problems in qualitative terms

All in a suitable form for detailed analysis and quantification. Another important function is to establish one or more fire protection arrangements (trial concept designs) that are considered likely to satisfy the fire safety criteria.

The key elements of the FEDB process are;

1. Secure agreement from all parties to the design objectives and acceptance criteria
2. Establish trial concept design(s) acceptable to all parties, and
3. Specify the requisite fire scenarios for analysis

Ideally, the FEDB should be established at the earliest possible stage in a building project, and the building surveyor should be one of the team members from that point.
The advantages of this are;

- The building surveyor then has good knowledge of the whole project.
- There are no surprises in the methods of assessment used when approval is sought.

The three Levels of Analysis

Level one - a component and sub-system equivalence evaluation. This level is used where it is only required to establish that a selected component or sub-system provides at least equivalent performance to that specified by regulation (ie. in the DTS)

Level two - system performance evaluation. This level of analysis takes account of the interaction between sub-systems and components. The evaluation can be on a comparative basis, eg against an acceptable prescriptive design solution, or be measured in absolute terms.

Level three - system risk evaluation. This is a probabilistic risk analysis which is very complex in quantification.

Typically, it will be the level two analysis that will be the most commonly submitted.

The FEG evaluation process

The overall FEG process of quantification and evaluation is most simply illustrated in Figure 4. Here the process is split into a number of separate parts for ease of analysis.

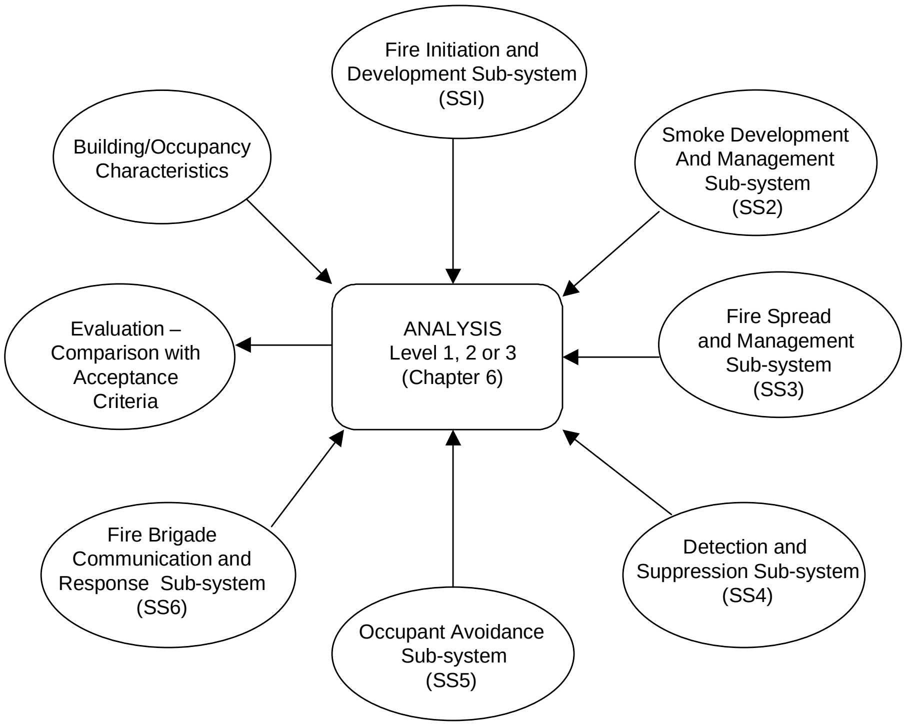

Figure 4 Fire Engineering Guidelines, System Evaluation

Evaluation of the analysis methods used

One of the central features of most Fire Engineering Reports is the "Analysis Section".

In the assessment of the various sub-systems, many methods are available and applicable. It is here that the Building Surveyor must determine that:

- the methods chosen by the Fire Engineer are suitable,
- the input data used is correct, and
- the reported conclusions are soundly based on the results from the assessments

One of the key tools in a fire engineering design is the calculation methods used in the analysis. How do you determine that these methods, in particular the computer models, have been correctly applied, and more importantly, are they used within their validity?

Most of the methods used are based on research, where to a large extent, the experiments were carried out in very controlled conditions to permit repeatability of the results. The calculation methods developed from these experiments are either designed to be conservative in order to have a more general application, or are highly specific to a single application. A calculation making use of a simple correlation or a few expressions can be relatively easily referenced and checked for accuracy.

Computer Models

In general, the computer models are not much more than a collection of several simpler calculations. However, in computer models, the calculations are often not transparent and the assumptions are not clear.

Computer models now exist which describe ignition, combustion, transportation of fire products, detection of fire, effects of toxic products, effects of smoke on occupants, evacuation structural response and risk assessment. A survey carried out by Friedman in 1992, of computer models for use in fire applications discovered a total of 64 models from 10 countries.

This was broken down by type into the following categories.

- 31 zone
- 10 field
- 12 fire endurance
- 6 evacuation
- 5 detector evaluation

Since 1992, many more models have been and continue to be added.

The point is that, while it is impossible to know and understand all of the models, it is important that as Building Surveyors you are aware of the variety available, that no single model will necessarily provide the answer, and that you have a framework with which you can begin to assess whether a model has been used correctly.

What to look for in computer modelling

What are the types of questions that should be asked when assessing the computer modelling used in a building application?

In the first instance, in order to form a view on its suitability for a particular task, you should obtain evidence for the following basic information;

- the science upon which it is based
- the techniques it uses to solve the problems
- the input parameters required
- the assumptions made
- the outputs produced
- comparisons made with experimental data

Here you may not be in a position to judge the acceptability of the program, and may have to seek the opinion of others. In all cases, this list is the very least that should be provided for the use of the model to remain credible. Ideally the information should have been published, along with any validation studies.

On reviewing the outputs, further points which you should consider are;

- Do the initial conditions look reasonable?
- Do the temperature predictions appear to be sensible bearing in mind the wealth of data available on compartment fires, plumes and flashover conditions?
- Are any of the outputs way outside the range of expected values?
- Do flows in and out of openings appear to behave reasonably?
- How much experience has the operator had in analysing designs with this model?

It is important to note that one computer model cannot be validated with another, it can only be used to show that they achieve similar results.

Sensitivity Analysis

A further check, which should be carried out by the conscientious fire engineer is to include a sensitivity analysis of the results. A sensitivity analysis looks at how susceptible the model is to minor variations in the input parameters. For example, if in changing a parameter by 2% results in a 5% change to an output, then unless it changes an acceptable output to an unacceptable one, it is not likely to be beneficial attempting to refine the accuracy of the input. However, if it resulted in a 100% change to the output, then further investigation is required to determine the nature of the input requirements, and if it is possible to refine the accuracy of the input.

Worst Case Design Fires

While it may be tempting to ask for the analysis to be based on a worst case fire scenario or for over conservative calculations to be applied, these are likely to defeat the purpose of performance based design. It is important to note that a performance based design is not required to achieve higher levels of safety than those achieved in a fully DTS compliant building.

Conclusions

Many calculation methods are proposed in publications such as the FEG and the SFPE Handbook to name a couple, and it is therefore fair to assume that these methods can be relied upon as adequate for their purpose. Certainly there will be plenty of published information available to support them.

In such a rapidly developing technical field, hard and fast rules must be avoided, and a flexible and open-minded approach is needed. It is a field which highlights the need for continuing professional development in terms of understanding and keeping abreast of the developments.

It is up to the approver to keep pace with the design methods which are appearing in the literature, in order to keep pace with the progress of the fire engineered designs which are presented to them.

Conferences such as this, together with the courses now being offered by the tertiary training institutions, provide invaluable sources for some of that information. The remainder will come from experience and familiarity over time.