Getting it right

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Andrew Foolkes looks at how a performance-based fire engineering design is developed

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Fire engineering designs are regularly reviewed by building control surveyors; but what methodology is used to develop a performance-based design?

Statutory requirements for fire safety throughout the world are primarily concerned with protecting people from death or injury. In many jurisdictions, compliance with life safety criteria is part of functional requirements, and is supported by design codes that provide standard approaches for common types of building.

In the majority of such supporting codes ? for example, Approved Document B (ADB), volume 2 ? one alternative to a standard approach is to use fire engineering to show that a departure from an otherwise code-compliant design still meets the functional requirements, or ? in particularly large and complex buildings ? that the code may be entirely put aside.

International Fire Engineering Guidelines (IFEGs) and BS 7974 provide disciplined frameworks and advice for the development of performance-based fire engineering designs. The process for preparing a fire engineering design under both regimes is broadly similar. The four main stages are:

1. qualitative design review (QDR)
2. quantitative analysis
3. assessment against criteria
4. reporting of results.

QDR

The main stages in QDR can be broadly summarised as:

- reviewing architectural design and occupant characteristics
- establishing fire safety objectives
- establishing fire scenarios for analysis
- identifying acceptance criteria and methods of analysis.

Building control is integral to the review.

This is reflected in *Health Technical Memorandum* 05-02, where the code recommends that representatives of approval bodies are part of the QDR process in large, complex healthcare buildings to ensure that their views receive consideration. Building control surveyors? help and advice are essential to such consultation, but it is essential that their impartiality and independence is maintained.

It is critical, therefore, that the necessary functional objectives of a performance-based design are well defined and understood by both the designer and the building control surveyor. For example, consider the following comparison.

The functional requirement relating to means of escape in Part B of Schedule 1 to the Building Regulations is well known:

> 'The building shall be designed and constructed so that there are appropriate provisions for the early warning of fire, and appropriate means of escape in case of fire from the building to a place of safety outside the building capable of rightbeing safely and effectively used at all material times.'

On the other hand, the life safety goals in National Fire Protection Association (NFPA) 101 ? the US life safety code that is also used in many other international jurisdictions ? are designed:

> 'to provide an environment for the occupants that is reasonably safe from fire by:
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> - protection of occupants not intimate with the initial fire development
> - improvement of the survivability of occupants intimate with the initial fire development'.

The NFPA recognises that it may not always be possible to prevent injury to an individual who is located close to the source of fire ? for instance, a blaze in an open-plan apartment ? but requires that people who are not in the immediate proximity of the outbreak of fire are suitably protected and able to leave the building in safety.

Therefore, it is clear that a performance-based design may be quite different when it seeks to meet the objectives of NFPA 101, rather than the functional requirement in Part B of Schedule 1 in the Building Regulations.

At this stage, the projected maximum building occupancy and any credible design fire scenarios should also be agreed. The review should consider the number, likely distribution and response characteristics of occupants, and, where appropriate, occupants who may have mobility, sensory or cognitive disabilities.

In some cases, it may be feasible to identify a particular, individual scenario that clearly represents a credible worst case. However, in a complex building such as a shopping centre, it is likely that a number of scenarios will require detailed assessment.

It is essential that building control surveyors engage in agreeing the possible fire scenarios with the design team, especially given the time and expense of any advanced modelling ? such as computational fluid dynamics ? required in quantitative analysis.

> *Building control surveyors have a key role to play in ensuring that fire engineering approaches do not rely on unrealistic or unsuitable management procedures*

The fire scenarios considered at design stage should reflect credible worst-case conditions, taking account of factors such as the rate at which it spreads, its severity and its smoke generation potential, in particular locations such as under a balcony edge.

Consideration of how the building will be used ? for example, the need for maintenance and management ? is also important in any fire engineering design. The design must not be over-complex, neither should it rely disproportionately on management actions to achieve a life safety goal. Building control surveyors therefore have an important role to play in ensuring that the fire engineering approaches do not depend on unrealistic or unsuitable management procedures.

Quantitative analysis

It may be that the QDR has identified an approach that meets the design objectives without the need for further work. However, if it has not, a quantitative analysis will then be needed.

The three criteria outlined in BS 7974 and the IFEGs against which the acceptability of a design can be considered are comparative, deterministic and probabilistic.

- Comparative approaches are commonly used to demonstrate that an alternative being used in the design provides a level of safety equivalent to that recommended by the recognised code, such as ADB vol. 2.
- A deterministic study is also commonly used to show that, on the basis of the established credible worst-case scenario(s), a defined set of conditions will not occur ? for instance, that the smoke layer will not fall below head height in a large high-bay warehouse during the evacuation period.
- In a probabilistic study, criteria are set by the fire safety engineer to ensure that the probability of a given event occurring is acceptably low. The risk criteria are usually expressed in terms of the annual likelihood of the unwanted event occurring, such as the probability of the sprinkler head failing to activate is 1 in x per annum.

Presentation of results

The report should be clearly set out and describe the basis of the design and calculation procedures used. This may sound fairly obvious, but in my experience of building control this information is often not clearly presented. Sufficient detail needs to be provided for a third party to be able to assess, and if necessary repeat, any calculations and computer modelling that have been carried out.

The study must state and justify any assumptions so that they can be readily understood by building control and the occupants. As a minimum, the designer should always provide the chosen conservative design assumptions (which offer a degree of resilience), safety factors and details of the sensitivity analysis to demonstrate the robustness of their results.

Building control surveyors have an important role to play in making sure that performance-based design is undertaken properly.

The study should form part of the fire safety information required under Building Regulation 38 in order for the occupant to understand why the passive and active measures in their building have been provided in the way that they have. If those responsible for the continued safety of the building during its operation do not understand

the fire strategy, there is little chance that they will be able to maintain it.

Building control surveyors have an important role to play in making sure that performance-based design is undertaken properly. It is critical that those who are carrying out fire strategy design seek early engagement from the approving authorities at the QDR stage, so they can make certain that any performance-based design proceeds on the basis that it can be both successfully peer-reviewed and approved.

Building control surveyors also need to be confident that the responsibility for developing a performance-based design rests with a suitably qualified and experienced person who carries appropriate professional indemnity for that design as well; they could, for example, be an engineer registered with the Engineering Council (i.e. CEng or IEng) via a professional engineering institution such as the Institution of Fire Engineers. This principle is analogous to RICS membership, in that it provides the client with confidence in the competency and capability of the surveyor whom they have engaged.

Most importantly, when reviewing performance-based designs, it is incumbent on building control surveyors to identify when a fire strategy and its supporting analyses are so complex that they are beyond their capability to review. In such cases, the surveyor should feel confident to advise the client accordingly, and take steps to agree with the client to commission an independent review from an appropriately qualified third-party fire engineer.

Andrew Foolkes is a fire engineer at Tenos

Further information

- Related competencies include Fire Safety , Legal/regulatory compliance
- Approved document B of the Building Regulations - Fire safety
- This feature is taken from the RICS *Building control* journal (June/July 2016)